

Supplementary Material

Supplement to preprint version 1 of “Repeat variation and definition dependence of ECG/VCG markers: an exploratory audit of one implementation (LoopLens 10.1)”.

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Aggregate measurement dictionaries, reproducibility and transformation results, implementation checks, sensitivity analyses, controls, cohort flow, reporting limitations and retained provenance of numerical statements.

Display rounding uses four significant figures for estimates, intervals, bias, limits of agreement and P95 (at least the decimal precision of the corresponding main-text quantity), four decimal places for ICC, κ , correlations, AUC and Δ AUC, two decimal places for percentages, and integer counts with thousands separators; seeds, thresholds and constants remain exact, and corresponding main-text spellings take precedence.

All supplementary results are reported in the tables below. Marker-level estimates and availability are supplied in Supplementary Data S2 (marker files v8, dictionary v11); no separate table-extract file is required. Counts of persons or ECGs below 10 are shown as <10, and complementary cells are coarsened so that they cannot be recovered.

Main tables are numbered consecutively; supplementary tables retain descriptive identifiers. In the tables of S2c, “not estimable” marks a value or interval that the computation did not return (printed as NaN in earlier versions); the other values of the row are unchanged.

16 October 2026. Version 31. Aggregate technical results; no individual patient examples. Development, external technical comparisons and the once-only test-partition measurement replication are distinguished. Analyses added in this version after the first draft are post hoc and marked as such; where a post hoc analysis corrects an earlier number, both numbers are given.

S0. Guide to this supplement and results moved from the main text

The main text reports three core findings (repeat variation of clinical pairs, matrix and delineator dependence, boundary errors against experts). The table lists every result group, its data source, its status and where the detail sits. Analyses marked post hoc were added after the first draft and are exploratory.

Result group	Data	Status	Location
Catalog and key-measure repeat variation (ICC, bias, RC)	MIMIC-IV-ECG clinical pairs	Development, internal	Main Table 2 and Figures 1 and 2; S3, S3c-S3f; Supplementary Data S2
Stability proxy and its sensitivities (QRS-class condition, person weights)	MIMIC-IV-ECG	Post hoc	S3g
Repeat variation of the machine-reported measurements of the same pairs (QRS duration, QT, QTc, P duration, PR interval, frontal QRS-T angle, axes)	MIMIC-IV-ECG	Post hoc comparison	S3h
Circular markers (not classified in the main results): periods, angular distance D95, historical catalog values as sensitivity	MIMIC-IV-ECG	Post hoc correction	S2i; Supplementary Data S2 (v8, dictionary v11)
Repeat variation in PTB-XL pairs; QTcF band-edge recomputation; identical-pair comparison with BRAVEHEART	PTB-XL (open)	External, prespecified plus post hoc additions	Main Table 3; S14
Matrix classes (main counts exclude the 29 circular markers) and historical-set sensitivities	MIMIC-IV-ECG	Development, internal	Main Table 4; Figure S1 (historical composition); S2f, S2g
Delineator-input sensitivity	MIMIC-IV-ECG, LUDB, PTB	Prespecified	S2h
Frontal minor-area loop classes	MIMIC-IV-ECG, report-selected persons	Development	S2a-2
Boundary errors against LUDB experts (two references)	LUDB	Used in development; amplitudes normalized per lead	Main Table 5; S3b
P availability and the authorized P-boundary screen	MIMIC-IV-ECG, report-selected sample	Author judgments, not prevalence	S3a, S3a-1 to S3a-3
Frank comparison and rotation	PTB	External technical, one source	S2a to S2e
Public randomized QT controls and route differences	ECGRDVQ	Public data; route differences post hoc	Main Table 6; S6b, S6b-4
Routine-care control panel and calcium control	MIMIC-IV-ECG	Development	S6, S6a
Physiological component map	MIMIC-IV-ECG	Exploratory; T2 (i) corrected	S12, S12a-1
Test-partition replication and composition	MIMIC-IV-ECG test partition	Internal, prespecified; composition post hoc	S13; S13e
Repeat variation of adjacent windows in healthy volunteers	Autonomic Aging	Context only	S15
Flow and demographics	MIMIC-IV-ECG	Descriptive	S5a, S5b
Repair variants and search ledger	MIMIC-IV-ECG	Post hoc, retained without winner selection	S4

S6-0, S7 and S12 give routine-care, survival and physiological context for readers of the full supplement; none of the three core findings rests on them.

S0a. Additional methodological and numerical details

This section adds methodological definitions, intervals and numerical results that complement the main-text sections; it is ordered by main-text section.

Section 2.2. The reference sample of 1,500 persons with normal sinus ECG reports was selected from 43,630 eligible persons (S5).

Section 2.3. Periods were taken from the code definition of each marker (26 directed angles, 360°; one undirected loop-ellipse axis, 180°; two classical frontal-axis markers, 360°; one angle-difference marker is not periodic).

Section 2.6. A source-code comparison of the two measurement chains assigned primary and descriptive roles (S14a).

Section 2.7. D, not a comparison of significance, is the quantity of interest.

Section 3.2. Removing the QRS-class condition affected 172 of 4,768 eligible pairs. For the 26 directed circular markers, 5-35% of pairs differed by more than 90°, and the 1.96-SD rule covered only 88-98% of pairs. For the historical set of all 1,987 estimable markers, which includes 29 circular markers, the median ICC was 0.4665 [0.4591, 0.4778] (313 reached 0.75; 15.75% [14.66, 17.43]) and in the proxy 0.5242 [0.5142, 0.5457] over 1,974 markers; the contrasts and intervals in section 3.2 refer to this historical set. The loop-ellipse axis had a D95 of 42.5° [40.2, 45.1] (S2i).

Section 3.2, Figure 1 legend. The finite pairs and persons of each measure are given in Table 2 (all clinical pairs: 15,693 pairs, 10,187 persons; stability proxy: 4,596 pairs, 3,560 persons in total). QTcB is reported in Supplement S3.

Section 3.2, Figure 2 legend. Estimable means at least 30 persons and a positive ANOVA denominator. Families follow the unit and name hierarchy of S3d and not the ICC. The 95% intervals of single markers are in Supplementary Data S2 and are not drawn.

Section 3.3. Feeding inverse-Dower instead of Kors XYZ to the delineator changed QRS onset and offset by less than 1 ms (limits of agreement -0.7 to 0.7 and -1.0 to 0.9 ms). Measured Frank leads as delineator input shifted QRS duration and QT by limits of ± 0.5 and ± 3.0 ms. PR interval and P duration were available in only one of the two delineations in about 5.5% of ECGs (more than 490 evaluated), with limits of agreement of -27.1 to 25.7 ms and -21.8 to 22.2 ms where both were available. On the same selection as the boundary experiment, Dower-Kors gave 1,194 dependent and 532 conditional among 1,726 estimable outputs.

Section 3.4. Counting predictions over complete recordings reduced the markup-based positive predictive values from about 98% to 73% and 76% (S3b).

Section 3.5. Intervals for all other P95 estimates, with their historical specifications, are in S2a. The share of frontal QRS loops assigned to the minor-area class (the smaller signed-area part is at least the threshold fraction of the total area) fell from 70.41% at a 5% threshold to 31.00% at 25% (S2a-2).

Section 3.6. Six of the seven contrasts also had paired-t intervals that excluded zero.

Section 3.7. The decomposition treats the two recordings as exchangeable repeat measurements under a one-way random-effects model, with within-person variance from RC and between-person variance from the reported ICC(A,1); the within-person component contains clinical change and is not isolated measurement error. It ignores systematic differences between first and second recording and the pair weighting, and is a model illustration, not an estimate of error. The test-minus-development difference of +0.040 [0.014, 0.066] included both uncertainties. Standardizing the development pairs to the test distribution of gap class, rhythm and QRS class left the median nearly unchanged (0.467 versus 0.466). A model-dependent arithmetic decomposition suggested a similar between-person SD (median ratio 1.01) and a slightly smaller within-person SD (0.97) in the test partition; age, sex, device and the measured between-person spread of the test pairs were not analyzed (post hoc; S13e). The post hoc decomposition is a one-way random-effects illustration; the ratios 1.01 (between-person SD) and 0.97 (within-person SD) are model-dependent.

Section 4.2. Scaling by 2 and 0.5 changed the area angle by 20.8° and 28.6° (40 ECGs). Segmentation is not invariant to uniform gain: the multilead stage applies fixed millivolt floors and the wavelet stage adds signal amplitude to a time score.

Section 4.3. Against the same Frank reference, the PTB-healthy bias of inverse Dower (+15.5°) contrasted with Kors (−1.0°).

Limitations. Random misalignment of ECG and laboratory times may attenuate associations, whereas informative timing could bias them in either direction. The calcium control in S6a rests on hour-scale ECG-laboratory pairing with unverified clock alignment and is provisional.

S1. Implementation dictionary and disposition

T1 is reproduced completely for the illustrative examples in the archived audit. It is not the full 2,005-formula inventory. S2 marker descriptions provide compact exact-match catalog metadata where available; the executable formulas are part of the public release (Code availability in the main text).

T1. Neutral descriptor	Implemented quantity / measurement space	Literature/clinical term	Why not equivalent
Spatial QRS-T angle	Origin-corrected QRS and J-to-T-end area vectors; XYZ, degrees	Area/peak QRS-T angle	Area and peak formulas differ; source boundary/origin definitions must match
Near-self-approach pair statistic	Nonlocal sample distances against their adaptive percentile; XYZ	Self-intersection/folding	Counts sample-pair proximity, not anatomical intersections
Graph cycle proxy	E-V+1 with adaptive-radius edges	Scar count	Disconnected-component term omitted; no histological reference
Path/endpoint ratio	Path length / endpoint distance	Loop complexity	Open-path detour; denominator unstable near closure
Squared-increment timing	Cumulative squared successive QRS increments with duration factor	Activation energy/timing	Algorithmic timing, not mechanical energy
Native direct-eight angle	Integrated lead-space vectors	Spatial VCG angle	Different metric/space; not XYZ reconstruction twin
P-window mean-vector magnitude	Window mean vector norm, mV	Terminal P force	Not integral; $\mu\text{V}\cdot\text{ms}$ label is dimensionally inapplicable
ST magnitude curvature	Quadratic coefficient of spatial ST magnitude on normalized time, μV	Digitalis sagging	Sign-invariant by construction; not lead-specific depression
Eigenvalue fractions	$\lambda_1/\Sigma\lambda$ versus $(\lambda_2+\lambda_3)/\Sigma\lambda$	Planarity	Exact affine complement; $\rho = -1$ if nonconstant; line degeneration needs separate criterion

The complete marker inventory, original T2 rows, reasons for failed criteria and evidence record disposition remain linked through the aggregate and source ledger, prior audit sources and the provenance matrix. They include unavailable and rejected records. The executable formulas are part of the public release (Code availability in the main text); a separate dictionary with units and all source-release identifiers remains unreleased and requires a completeness review.

S1a. Additional release measurement-definition audit

One fixed, enriched index ECG per person: 2,824 training and 2,824 internal-validation candidates, with signal preparation available in 2,794 and 2,793 respectively. These are descriptive full-sample counts, without bootstrap or population confidence intervals. Internal validation had already been inspected and supplies no independent clinical test. Forty-six synthetic controls passed with no reference deviations in the bound technical audit.

Measurement check	Training	Internal validation
Eigenvalues available	2,753/2,824 (97.49%)	2,759/2,824 (97.70%)
Line-like $\lambda_2/\lambda_1 \leq 0.01$	25/2,753 (0.910%)	26/2,759 (0.94%)
Release planar among line-like	25/25 (100.00%)	26/26 (100.00%)
Planarity-deviation abstention among line-like	0/25 (0.00%)	0/26 (0.00%)
Final-20-ms P mean norm available, mV	1,230/2,824 (43.56%)	1,191/2,824 (42.17%)
Mean-norm $\times$ duration $\times 1,000$ = rectangular integral norm	1,230/1,230 (100.00%)	1,191/1,191 (100.00%)
Projected self-intersection sum changed, half native points	2,357/2,753 (85.62%)	2,392/2,759 (86.70%)
Projected self-intersection sum changed, double native points	394/2,753 (14.31%)	398/2,759 (14.43%)
Rank correlation, half native points	0.8036 (n = 2,753)	0.7930 (n = 2,759)
Rank correlation, double native points	0.9914 (n = 2,753)	0.9904 (n = 2,759)
Excess projection counts / projection segment-pair counts	1,528/22,380 (6.83%)	1,690/23,272 (7.26%)
LBBB surrogate positive / all device-labeled LBBB	29/142 (20.42%)	21/139 (15.11%)
LBBB surrogate positive / decidable device-labeled LBBB	29/>120 (22%)	21/>120 (16%)
Only V6 R-peak time >60 ms / peak-time available	33/>130 (24%)	34/>130 (25%)
Complete RBBB morphology / all device-labeled RBBB	220/231 (95.24%)	250/269 (92.94%)
Release RBBB positive / complete device-labeled RBBB	173/220 (78.64%)	196/250 (78.40%)
WHO-route a operationalization positive / same complete cases	85/220 (38.64%)	93/250 (37.20%)
WHO-route b operationalization positive / same complete cases	103/220 (46.82%)	117/250 (46.80%)
WHO-route c operationalization positive / same complete cases	124/220 (56.36%)	142/250 (56.80%)
WHO-route a versus release discordance / same complete cases	about 40% (count not shown)	about 40% (count not shown)
Posterior/anterior QRS denominator $\leq$ actual EPS (1e-10)	89/2,727 (3.26%)	98/2,714 (3.61%)
Posterior/anterior QRS ratio capped at 50 / available	70/2,638 (2.65%)	62/2,616 (2.37%)

LBBB is a release working definition: QRS ≥ 120 ms, initial q-duration <15 ms in I and V6, predominantly negative V1, <0.1 mV, and principal positive R maximum later than 60 ms in both V5 and V6; pacing or insufficient limits abstain. Device text is a morphology proxy, not a medically adjudicated diagnosis. Principal-versus-last peak definitions can change threshold decisions; no source-equivalent AHA rule is certified.

RBBB route operationalizations use common QRS ≥ 120 ms: $a = S1 \& S2$, $b = S1 \& S3$, $c = S4 \& (S2|S3)$. S1 is biphasic positive peaks with negative valley in V1 or V2 under the fixed automatic prominence rule; S2 is S longer than R in both I and V6; S3 is $S > 40$ ms in both; S4 is R-peak time > 50 ms in V1 or V2. The release uses its own V1 late-amplitude condition and deep/broad S in I or V6, with no S4 condition. These automatic WHO-route comparisons lack visual S1, rhythm, WPW and onset adjudication; they are definition comparisons, not disease sensitivity estimates.

The projected self-intersection sum counts strict interior crossings summed over the XY, XZ and YZ projections, with sample-index gap ≥ 2 and the first and last pair excluded; endpoint contact and collinearity do not count. It has no 10%-minor-area condition. That condition belongs to a separate minor-area class procedure. Excess counts are duplicate segment-index pairs across projections, not proven 3D intersections; $\sim 7\%$ excess counts does not mean only $\sim 7\%$ of ECGs have duplicates (704/2,753 and 750/2,759 do). Sampling changes the sum; the neutral name remains a sample-count descriptor.

Line-like $\lambda_2/\lambda_1 \leq 0.01$ and planar $\lambda_3/\Sigma\lambda \leq 0.01$ were fixed audit criteria, not adopted release thresholds. A line has no unique plane normal. Source planarity $= (\lambda_1 + \lambda_2)/(\Sigma\lambda + \text{EPS})$ and deviation $= \lambda_3/(\Sigma\lambda + \text{EPS})$ have an EPS term and sum only approximately to one; the separate $\lambda_1/\Sigma\lambda$ versus $(\lambda_2 + \lambda_3)/\Sigma\lambda$ exact-complement example in section 2.2 is a different formula pair.

The terminal-P marker uses the XYZ mean over the final rounded 20-ms sample window, without an extra physiological origin correction, then its norm in mV. Its $\mu\text{V}\cdot\text{ms}$ catalog label is dimensionally wrong. At 500 Hz the ten-sample rectangular integral magnitude is the mean norm times 20 ms times 1,000; a trapezoidal integral spans nine sample intervals. Neither is the complete negative V1 terminal phase. No inherited V1 clinical threshold is adopted for a nonnegative spatial norm.

RVH working ratios use origin-corrected peaks. Actual numerical EPS is $1e-10$ (docstring says $1e-12$); near-zero denominators abstain. The cap at 50 introduces ties and therefore does not strictly preserve ranks. It supplies no anatomical posterior or clinical RVH certification. No release code, diagnostic rule or cutoff was changed by this documentary incorporation.

S1b. Further measurement-definition checks

These documentary additions use an accepted aggregate audit. Both internal partitions were already inspected; PTB-XL folds 1-8 provide external technical teaching comparisons, without independent diagnostic validation.

LAFB. The accepted PTB-XL LAFB100 teaching group used the existing human-label selection, first eligible recording per person, without an additional axis window. The automatic conjunctive proxy for the WHO criteria required fusion QRS < 120 ms, integral axis $\leq -45^\circ$, rS in II, III and aVF, qR in aVL and aVL R-peak time ≥ 45 ms, with 0.02-mV amplitude criteria. It was positive in 16/92 recordings (17.39%; descriptive person-bootstrap 95% interval 9.78-25.00%, 500 draws, seed 79,010). This is label-versus-proxy agreement, not disease sensitivity. The existing medoid fails

the proxy rule; its 126-ms QRS is automated 500-Hz fusion, without a separate machine or visual QRS reference. Hypertension was not an available SCP reference; missing means unknown.

RVH. Chapter-15 area and Chapter-43 angle-arm operationalizations are different definitions. The former requires origin-closed unsigned triangle area in the right-anterior quadrant $>30\%$ and net CW. The latter uses $\text{atan2}(-Z, X) > 30^\circ$ at the spatial QRS maximum, with anterior-positive source Z; it is only the angle arm, not the complete Chapter-43 Type-A rule. Planar peaks and initial-20-ms CCW are separate sensitivities. View is transverse from above, image coordinates (X,Z), project +Z posterior; negative algebraic area is CW. Axis clipping, self-overlap treatment and denominator $> 1e-10 \text{ mV}^2$ belong to this operationalization. No full textbook equivalence or RVH diagnosis is established.

Supplementary table 003, part 1.

Row	S1b-RVH. Population	Paired / candidates	Area-/angle-	Area-/angle+	Area+/angle-	Area+/angle+
1	Training	2,754/2,824	2,619	90	24	21
2	Internal validation	2,736/2,824	2,600	91	21	24
3	PTB-XL technical, folds 1-8	598/598	566	15	12	5

Supplementary table 003, part 2.

Row	Agreement % [95% interval]	κ
1	95.86 [95.13, 96.55]	0.2518
2	95.91 [95.14, 96.67]	0.2830
3	95.48 [93.65, 96.99]	0.2471

Agreement intervals are descriptive person-bootstrap intervals (500 draws, seed 79,010); κ has no inferential interval in the source. Dominant common negatives explain why high agreement does not establish interchangeability. The Chapter-43 initial direction is not interchangeable with net rotation; neither operationalization supplies a validated release Type-A criterion.

Peak definitions. `spatial_magnitude_max` is the maximum over the entire origin-corrected VCG curve (the archived peak-magnitude implementation), without explicit QRS restriction. A T or artifact maximum may determine it; no measured frequency of that event is asserted. Projection of a spatial QRS maximum and the maximum planar QRS vector may occur at different times. Whole-curve, spatial QRS and planar QRS maxima therefore require separate names and windows; no classical LVH threshold is transported.

Additional audit boundaries. Shared fusion, age, rate and QRS selection windows partly reduced the historical NORMAL median-QRS gap (12→10→5 ms), a descriptive selection sensitivity, not a causal attribution. The identical historical machine-selection comparison is not estimable without PTB machine values. PR onset proxies and fixed-shift stress tests do not replace millisecond-adjudicated corrected P onset.

Source and reproducibility. The archived aggregate output of the measurement-definition audit supplies the PTB-XL LAFB100 counts and medoid QRS duration, the paired Chapter-15/Chapter-43

contingency cells, agreement and kappa for training, internal validation and PTB-XL folds 1-8, and the whole-curve peak definition. The source analysis is development analysis; fixed development caches were used, and PTB-XL is labeled separately. The archived analysis script produced the aggregate CSV. Full source and filter definitions remain in the archived aggregate and provenance record; no patient source was opened for this section.

S1c. P-duration definitions, Q and QS transport and signed ST

These are accepted implementation audits on inspected development data, not new calculations, healthy reference limits or independent confirmation. Historical fusion clusters source boundaries and uses weighted medians; it is not a simple lead union. P duration in the repeatability and cached-versus-fresh audit tables denotes historical multilead fusion. A union instead takes the latest available offset minus the earliest available onset.

S1c-P. Definition-specific P-duration audit

The same representative beats and release single-lead detector were used in each lead. The common finite sample comprises 224 recordings (one per person) from 234 selected audits; 10 lack at least one of the five measures. Selection was stratified by cached P duration. Selection weights refer to the age- and fold-specific P-available audit reference and do not correct informative measurement failure. The table uses pooled, all-age, selection-weighted empirical quantiles (`paired_all_weighted`), not the different unweighted quantiles.

Audit identity	Definition / source method key	P97.5 (ms) [95% interval]	Common recordings/persons; excluded
	Available boundaries across twelve leads, earliest onset/latest offset (<code>union12</code>)	186.0 [176.0, 200.0]	224; 10
	Available II/V2 boundaries, earliest onset/latest offset (<code>unionII_V2</code>)	140.0 [130, 148.0]	224; 10
	Single-lead II onset/offset (II)	120 [108.0, 122]	224; 10
	Single-lead V2 onset/offset (V2)	94 [74.00, 140.0]	224; 10
	Historical representative multilead fusion (<code>fusion</code>)	182.0 [174.0, 196.0]	224; 10

Intervals are percentile intervals from 1,000 paired, selection-stratum person draws, seed 81,069; one ECG per person. Weighted quantiles use the inverse empirical distribution, whereas raw quantiles use linear interpolation. `union12` accepts available lead boundaries; the separately reported complete-twelve-lead sensitivity is not this table. New union and single-lead boundary-error rates are non-estimable without independent adjudication. Reproduction of the detector and fusion does not establish correct boundaries. These audit quantiles are not clinical upper normal limits; no literature threshold is adopted.

S1c-Q. Release Q rule versus operationalized UDMI-4 Table 3 (Thygesen *et al* 2018)

Table 3 of the Fourth Universal Definition of Myocardial Infarction lists the electrocardiographic changes associated with prior myocardial infarction, including the Q-wave criteria (Thygesen *et al* 2018). The isolated no_depth_floor comparison removes the release's additional 0.05-mV V2/V3 depth condition. table3_q_qs also includes the fixed QS proxy. Both retain the same diagnostic curve, baseline, Q detection and the QRS, pacing and report-LBBB exclusion criteria. An independent anatomical LVH exclusion and visually adjudicated QS are absent; the R/S/T arm is not included.

Audit identity	Internal partition / method	Discordance fraction [95% interval]	Evaluable / selected persons; missing or excluded
	Training / no_depth_floor	0.0137 [0.009393, 0.018]	2,555 / 2,824; 269
	Internal validation / no_depth_floor	0.01332 [0.009401, 0.01802]	2,553 / 2,824; 271
	Training / table3_q_qs	0.01957 [0.01486, 0.02505]	2,555 / 2,824; 269
	Internal validation / table3_q_qs	0.01998 [0.01488, 0.02546]	2,553 / 2,824; 271

Approximately 1.3-2.0% discordance in the selected development audit is a rule comparison, not infarction sensitivity or specificity or full UDMI transport. Source intervals use 1,000 person-bootstrap-equivalent multinomial cell draws, seed 81098, one ECG per person. Both internal partitions were inspected; no independent test was opened.

S1c-ST. Synthetic polarity check and non-estimable clinical contrast

Signed ST level and mean signed chord deviation in II, V5 and V6 distinguished negative sagging from its positive counterpart in 29 passed synthetic tests. The baseline is median PR between P-end+10 ms and QRS-onset-10 ms (at least 10 ms); the ST window is J+20 to J+100 ms, before T onset. Linear depression can have negative level with zero curvature. Missing boundaries have no substitute; the old spatial-magnitude descriptor remains sign-invariant.

The real Digoxin group estimate is non-estimable. No exposed training pair and fewer than 10 internal-validation pairs passed bilateral measurement criteria; no estimate is reported for so few pairs. Missing PR boundaries and ST/T overlap restrict support despite the administration-time join. Technical synthetic success does not establish a clinical positive control, drug specificity or absence of biological effect.

Source and reproducibility. All S1c values are transcribed unchanged from the archived P-duration, Q/QS and signed-ST measurement-definition audit, sections 2-4. Run: development analysis; release archived development software; inputs were fixed. The archived aggregate analysis script produced the P and Q results; the archived synthetic polarity script supplied the ST checks. P selection: pooled, all ages, paired selection-weighted empirical quantiles by method, P97.5 in ms, with available and missing counts and lower and upper interval limits. Q selection: training or internal validation, by method, discordance fraction. ST: section 4 of the archived audit. No patient-level input was opened for this section.

Qualifications by pitfall (bias checks, defined in the section on inherited analytic pitfalls). F1 and F2: these are technical definitions and selected audits, with no statement about disease or healthy populations. F3 and F4: the source definitions were fixed, the question was posed after the results and multiple variants were retained, with no winner selection. F5: informative missingness of P, PR and ST remains open; losses at the Q criteria were retained. F6 and F7: the shared detector and morphology proxies are no independent medical reference; new P adjudication and full Q and QS transport remain open. F8: boundary, baseline, noise and report-proxy artifacts remain possible.

S1d. Definition-check summary

S1e. Additional findings on implemented definitions

Classical release outputs are working definitions, not adopted WHO or AHA rules. The LBBB surrogate was positive in 29/142 training and 21/139 validation device-labeled recordings. Halving the loop point counts changed the projected self-intersection sums in 2,357/2,753 and 2,392/2,759 recordings. Line-like loops occurred in 25/2,753 and 26/2,759, all with planar outputs. Terminal-P measures the XYZ-mean norm over the last 20 ms in mV; it is not a $\mu\text{V}\cdot\text{ms}$ integral or negative V1 terminal area. S1a retains RBBB comparisons and complete details on definitions and availability; no release rule was changed.

In PTB-XL, 16/92 LAFB-labeled teaching recordings met the automatic WHO surrogate (17.4%). Agreement between the RVH Chapter-15 area rule and the Chapter-43 angle arm was approximately 96%, but κ was 0.25-0.28, dominated by shared negatives. These are not interchangeable full diagnostic rules (S1b).

S1d. Fixed-release measurement chain

The fixed release separates diagnostic/morphology signals (zero-phase third-order Butterworth, 0.05-150 Hz at 500 Hz) from delineation signals (fourth-order, 0.5-40 Hz, followed by a 2-s running-median baseline correction). Powerline notch filtering uses the fixed branch setting (60 Hz for MIMIC and ECGRDVQ; 50 Hz for the LUDB reaudit), unless already applied by the recorder. Multilead R detection precedes fusion of NeuroKit2 (Makowski *et al* 2021, version 0.2.13), multilead and Kors-XYZ delineation candidates (nominal weights 0.40/0.35/0.25; 20-ms conflict setting, marker-specific tolerances and confidence-based abstention). A representative fused beat supplies boundaries; robust morphology uses aligned accepted-beat templates where supported, rather than treating every output as a simple lead median. Kors regression reconstructs XYZ from the standard leads. The dimensionless delineation-quality score combines marker confidence (0.45), accepted-beat fraction (0.25), unresolved-conflict agreement (0.20) and median accepted R-peak confidence (0.10), clipped to [0,1]; severe signal incoherence caps it at 0.45. The repeat branch requires score ≥ 0.6 on both recordings. This is an implementation quality index, not inde-

pendently validated clinical signal quality. Acquisition and global-interval standards provide context (Kligfield *et al* 2007), without certifying this implementation.

S2. Matrices, transformations, Frank transport and rotation

The computational frames (X,Y), (X,-Z), (-Z,Y) map to Cartesian image coordinates (X,-Y), (X,Z), (-Z,-Y) by reversing the second coordinate; they represent front, above and right-sagittal views. Positive computational net area therefore denotes image-CW. Historical left-sagittal tables instead use Cartesian (Z,-Y); switching sides mirrors image-x and reverses CW/CCW, without changing common-method switch counts or κ .

Historical S2c area_* values retain raw anatomical column order (X,Y), (X,Z), (Z,Y), whereas turn uses Cartesian image-height signs. Positive raw area means image-CW for frontal and left-sagittal, image-CCW for transverse. Raw area signs must not be read as a common CW label without this mapping.

The -0.063 coefficient belongs to the specified development software state dated 7 October 2026; the documentary audit does not establish its original setting date or change commit. Supporting source-page evidence comes from the appendix of Edenbrandt and Pahlm (1988, p 367) and the inverse-Dower panel of table I in Kors *et al* (1990), contrasted with Table 11.6 (p 402) of Macfarlane (2010). This page evidence is inherited and was not rechecked. Non-retrospective sign selection is therefore not asserted. Historical sign provenance and measured-Z polarity remain unresolved.

Coefficient order is V1,V2,V3,V4,V5,V6,I,II. XYZ = coefficient matrix $\times$ lead vector. Axis convention +X left, +Y inferior, +Z posterior. These are the implemented coefficients; precision and rounding are retained. Kors source: (Kors *et al* 1990); inverse Dower source: (Edenbrandt and Pahlm 1988). Table 11.6 (p 402) of Macfarlane (2010), Z/V4 +0.063, is the narrow source correction discussed in S2e-2; the implementation uses -0.063. The rounded inverse-Dower entry in table I of Kors *et al* (1990) is -0.06. Source-page evidence is inherited; original-vz polarity remains unresolved.

Supplementary table 006, part 1.

Row	Matrix row	V1	V2	V3	V4	V5
1	Kors X	-0.130	0.050	-0.010	0.140	0.060
2	Kors Y	0.060	-0.020	-0.050	0.060	-0.170
3	Kors Z	-0.430	-0.060	-0.140	-0.200	-0.110
4	Inverse Dower X	-0.172	-0.074	0.122	0.231	0.239
5	Inverse Dower Y	0.057	-0.019	-0.106	-0.022	0.041
6	Inverse Dower Z	-0.229	-0.310	-0.246	-0.063	0.055

Supplementary table 006, part 2.

Row	V6	I	II
1	0.540	0.380	-0.070
2	0.130	-0.070	0.930
3	0.310	0.110	-0.230
4	0.194	0.156	-0.010
5	0.048	-0.227	0.887
6	0.108	0.022	0.102

S2a. Full angle table: both transforms, both modes, all groups

Header-normal integral P95 intervals in rows 1 and 9 are updated using 10,000 person-bootstrap draws, seed 149007: Kors 24.03° [17.54, 35.20], inverse Dower 40.64° [30.28, 53.38], each from 51 persons with three observations above its empirical P95. Other metric/mode intervals retain their stated source specification; historical transport-class tables use their original uncertainty protocol.

Values in degrees; reconstruction minus Frank. Candidate and paired denominators differ. “Other” includes 21 unknown-header candidates. This is the re-audited angle definition; the older metric transport table below has its own definitions and intervals.

Supplementary table 007, part 1.

Row	T5/S2. Transform	Angle mode	Header group	Candidate persons	Paired persons	Bias
1	kors	integral	Header-normal control	52	51	-1.001
2	kors	integral	Myocardial infarction	147	145	2.118
3	kors	integral	other	87	86	-0.4924
4	kors	integral	overall	286	282	+0.758
5	kors	peak	Header-normal control	52	51	+0.4808
6	kors	peak	Myocardial infarction	147	145	4.768
7	kors	peak	other	87	86	-0.3470
8	kors	peak	overall	286	282	+2.433
9	inverse_dower	integral	Header-normal control	52	51	+15.51
10	inverse_dower	integral	Myocardial infarction	147	145	7.726
11	inverse_dower	integral	other	87	86	6.216
12	inverse_dower	integral	overall	286	282	+8.674
13	inverse_dower	peak	Header-normal control	52	51	+16.82
14	inverse_dower	peak	Myocardial infarction	147	145	11.89
15	inverse_dower	peak	other	87	86	3.528
16	inverse_dower	peak	overall	286	282	+10.23

Supplementary table 007, part 2.

Row	95% interval	SD	95% interval	P95 absolute difference	95% interval
1	[-4.537, 2.421]	12.72	[9.791, 15.40]	24.03	[17.54, 35.20]
2	[-1.413, 5.689]	22.42	[18.19, 26.73]	49.49	[35.44, 61.39]
3	[-6.653, 5.322]	28.52	[20.50, 36.11]	58.99	[40.48, 86.24]
4	[-2.101, 3.503]	23.12	[19.34, 26.78]	52.37	[39.14, 59.67]
5	[-2.6010, 3.6060]	11.40	[8.582, 13.94]	23.78	[15.53, 31.51]
6	[0.3729, 9.607]	29.33	[23.03, 35.38]	69.75	[42.12, 95.49]
7	[-4.19, 3.617]	18.61	[12.25, 24.40]	31.48	[24.93, 68.52]
8	[-0.4640, 5.296]	23.97	[19.69, 27.96]	50.96	[36.39, 70.56]
9	[10.93, 20.12]	16.25	[12.66, 19.47]	40.64	[30.28, 53.38]
10	[3.126, 11.95]	27.54	[22.90, 32.00]	54.06	[42.93, 73.14]
11	[-0.3374, 12.57]	30.25	[21.71, 38.62]	59.58	[47.41, 86.15]
12	[5.502, 12.030]	26.89	[22.90, 30.55]	55.96	[48.41, 68.76]
13	[11.10, 22.76]	20.99	[14.68, 26.91]	55.08	[36.56, 67.64]
14	[6.260, 17.86]	38.07	[31.36, 44.08]	84.90	[66.35, 109.5]
15	[-1.870, 8.644]	25.42	[19.71, 30.48]	57.75	[32.65, 77.12]
16	[6.404, 13.85]	32.24	[27.86, 36.26]	71.65	[61.23, 80.34]

S2a-1. Rotation definitions and coordinate conventions

The historical minor-area rule translates each projection to its first point, sums the positive and the negative consecutive cross-products and uses $\min(A+, A-)/(A++A-) \geq \text{threshold}$, with doubled-area floor $1e-6$. Closure through that translated point adds zero area; this is not geometric self-intersection. The rule is applied per projection; Table S2a-2 reports the frontal projection, and for the sagittal projection it uses right-sagittal computational $(-Z, Y)$. Historical Frank turn and raw and phase origin-net comparisons in S2b-S2d instead use left-sagittal Cartesian $(Z, -Y)$. The coefficient-only origin-net and minor-area sensitivities in S2e-2 and S2f use right-sagittal $(-Z, Y)$; these are separate source definitions. The computational frames (X, Y) , $(X, -Z)$, $(-Z, Y)$ map to Cartesian image coordinates $(X, -Y)$, (X, Z) , $(-Z, -Y)$ by reversing the second coordinate; they represent front, above and right-sagittal views. Positive computational net area therefore denotes image-CW. Historical left-sagittal tables instead use Cartesian $(Z, -Y)$; switching sides mirrors image-x and reverses CW/CCW, without changing common-method switch counts or κ .

S2a-2. Frontal loop class by minor-area threshold

Table S2a-2. Frontal QRS loop class by minor-area threshold in 1,487 report-selected persons with available loops (formerly main-text Table 5). Cells are $n/1,487$ and percentage with 95% person-bootstrap percentile interval. A loop is assigned to the minor-area class when $\min(A+, A-)/(A++A-)$ reaches the threshold; otherwise it is classed by net rotation (clockwise or counterclockwise in the front view). The rule does not test geometric self-intersection.

Minor-area threshold	Minor-area class	Clockwise	Counterclockwise
5%	1,047; 70.41% [67.85, 72.63]	340; 22.86% [20.91, 25.15]	100; 6.72% [5.51, 8.07]
10%	834; 56.09% [53.53, 58.44]	490; 32.95% [30.80, 35.44]	163; 10.96% [9.35, 12.51]
15%	704; 47.34% [44.65, 49.77]	576; 38.74% [36.52, 41.22]	207; 13.92% [12.17, 15.67]
25%	461; 31.00% [28.58, 33.29]	715; 48.08% [45.80, 50.57]	311; 20.91% [18.90, 22.93]

The minor-area class frequency fell from 70.41% at 5% to 31.00% at 25%, while clockwise loops rose from 22.86% to 48.08%. No threshold-free anatomical prevalence follows.

S2b. Historical primary transport classes

Transform	Class	Segment	n min	Empirical rule class	Release
inverse_dower	Amplitudes	p	188	nontransferable	unresolved
inverse_dower	Amplitudes	qrs	285	nontransferable	unresolved
inverse_dower	Amplitudes	t	282	nontransferable	unresolved
inverse_dower	Width/planarity	p	188	nontransferable	unresolved
inverse_dower	Width/planarity	qrs	285	nontransferable	nontransferable
inverse_dower	Width/planarity	t	282	nontransferable	nontransferable
inverse_dower	Rotation direction	p	188	nontransferable	unresolved
inverse_dower	Rotation direction	qrs	285	nontransferable	unresolved
inverse_dower	Rotation direction	t	282	nontransferable	unresolved
inverse_dower	Shape	p	188	rule met, restricted	unresolved
inverse_dower	Shape	qrs	285	rule met, restricted	unresolved
inverse_dower	Shape	t	282	rule met, restricted	unresolved
inverse_dower	Principal direction	p	188	nontransferable	unresolved
inverse_dower	Principal direction	qrs	285	nontransferable	unresolved
inverse_dower	Principal direction	qrst	282	nontransferable	unresolved
inverse_dower	Principal direction	st	209	nontransferable	unresolved
inverse_dower	Principal direction	t	282	nontransferable	unresolved
inverse_dower	Integrals/areas	p	188	nontransferable	unresolved
inverse_dower	Integrals/areas	qrs	285	nontransferable	unresolved
inverse_dower	Integrals/areas	t	282	nontransferable	unresolved
inverse_dower	Notches/bites	p	188	unresolved	unresolved
inverse_dower	Notches/bites	qrs	285	nontransferable	nontransferable
inverse_dower	Notches/bites	t	282	nontransferable	nontransferable
kors	Amplitudes	p	188	nontransferable	unresolved
kors	Amplitudes	qrs	285	nontransferable	unresolved
kors	Amplitudes	t	282	nontransferable	unresolved
kors	Width/planarity	p	188	nontransferable	unresolved
kors	Width/planarity	qrs	285	nontransferable	nontransferable
kors	Width/planarity	t	282	nontransferable	nontransferable
kors	Rotation direction	p	188	nontransferable	unresolved
kors	Rotation direction	qrs	285	conditional	unresolved
kors	Rotation direction	t	282	nontransferable	unresolved
kors	Shape	p	188	rule met, restricted	unresolved
kors	Shape	qrs	285	rule met, restricted	unresolved
kors	Shape	t	282	rule met, restricted	unresolved
kors	Principal direction	p	188	nontransferable	unresolved
kors	Principal direction	qrs	285	nontransferable	unresolved
kors	Principal direction	qrst	282	nontransferable	unresolved
kors	Principal direction	st	208	nontransferable	unresolved
kors	Principal direction	t	282	nontransferable	unresolved
kors	Integrals/areas	p	188	nontransferable	unresolved
kors	Integrals/areas	qrs	285	nontransferable	unresolved
kors	Integrals/areas	t	282	nontransferable	unresolved



Transform	Class	Segment	n min	Empirical rule class	Release
kors	Notches/bites	p	188	unresolved	unresolved
kors	Notches/bites	qrs	285	nontransferable	nontransferable
kors	Notches/bites	t	282	nontransferable	nontransferable

Supplementary table 009, part 1.

Row	Transform	Segment	Metric	n	ICC/ κ [95% interval]	Bias
1	kors	qrs	peak_magnitude	285	icc 0.9100 [0.8700, 0.9500]	0.08
2	kors	t	peak_magnitude	282	icc 0.9300 [0.9000, 0.9500]	0.04
3	kors	qrs	planarity	285	icc 0.7700 [0.6600, 0.8500]	-0.01
4	kors	qrs	width	285	icc 0.8200 [0.7700, 0.8600]	-0.02
5	kors	t	planarity	282	icc 0.7600 [0.6500, 0.8500]	0
6	kors	t	width	282	icc 0.8200 [0.7700, 0.8700]	0.01
7	kors	qrs	turn_frontal	285	kappa 0.7300 [0.6600, 0.7900]	n/a
8	kors	qrs	turn_left sagittal	285	kappa 0.6500 [0.5500, 0.7400]	n/a
9	kors	qrs	turn_transversal	285	kappa 0.7900 [0.7000, 0.8700]	n/a
10	kors	t	turn_frontal	282	kappa 0.6600 [0.5900, 0.7200]	n/a
11	kors	t	turn_left sagittal	282	kappa 0.7400 [0.6600, 0.8100]	n/a
12	kors	t	turn_transversal	282	kappa 0.6900 [0.6100, 0.7600]	n/a
13	kors	qrst	angle_integral	282	n/a	0.7600
14	kors	qrst	angle_peak	282	n/a	2.430
15	kors	qrs	inte- gral_magnitude	285	icc 0.9500 [0.9400, 0.9600]	2.700
16	kors	qrs	integral_vector	285	icc 0.9400 [0.9200, 0.9600]	2.440
17	inverse_dower	qrs	peak_magnitude	285	icc 0.7800 [0.7300, 0.8400]	0.2300
18	inverse_dower	t	peak_magnitude	282	icc 0.8500 [0.7900, 0.8900]	0.07
19	inverse_dower	qrs	planarity	285	icc 0.6600 [0.5400, 0.7500]	-0.02
20	inverse_dower	qrs	width	285	icc 0.6600 [0.5800, 0.7300]	-0.02
21	inverse_dower	t	planarity	282	icc 0.7100 [0.5900, 0.8100]	-0.01
22	inverse_dower	t	width	282	icc 0.5900 [0.5100, 0.6500]	-0.01
23	inverse_dower	qrs	turn_frontal	285	kappa 0.5200 [0.4500, 0.6000]	n/a
24	inverse_dower	qrs	turn_left sagittal	285	kappa 0.6500 [0.5600, 0.7400]	n/a
25	inverse_dower	qrs	turn_transversal	285	kappa 0.5500 [0.4300, 0.6700]	n/a
26	inverse_dower	t	turn_frontal	282	kappa 0.5300 [0.4500, 0.6000]	n/a
27	inverse_dower	t	turn_left sagittal	282	kappa 0.7500 [0.6700, 0.8200]	n/a
28	inverse_dower	t	turn_transversal	282	kappa 0.5400 [0.4600, 0.6200]	n/a
29	inverse_dower	qrst	angle_integral	282	n/a	8.670
30	inverse_dower	qrst	angle_peak	282	n/a	+10.23
31	inverse_dower	qrs	inte- gral_magnitude	285	icc 0.8900 [0.8600, 0.9100]	8.150
32	inverse_dower	qrs	integral_vector	285	icc 0.8800 [0.8500, 0.9100]	6.340

Supplementary table 009, part 2.

Row	P95 absolute difference	P95 relative difference [%]	Rule class
1	0.5100	36.85	conditional
2	0.1600	53.09	nontransferable
3	0.09	n/a	conditional
4	0.25	n/a	nontransferable
5	0.06	n/a	conditional
6	0.28	n/a	nontransferable
7	n/a	n/a	conditional
8	n/a	n/a	conditional
9	n/a	n/a	conditional
10	n/a	n/a	nontransferable
11	n/a	n/a	conditional
12	n/a	n/a	conditional
13	52.37	n/a	nontransferable
14	50.96	n/a	nontransferable
15	23.14	34.31	conditional
16	24.79	53.41	nontransferable
17	0.8900	54.09	nontransferable
18	0.28	70.94	nontransferable
19	0.1100	n/a	nontransferable
20	0.3200	n/a	nontransferable
21	0.07	n/a	nontransferable
22	0.3700	n/a	nontransferable
23	n/a	n/a	nontransferable
24	n/a	n/a	conditional
25	n/a	n/a	nontransferable
26	n/a	n/a	nontransferable
27	n/a	n/a	conditional
28	n/a	n/a	nontransferable
29	55.96	n/a	nontransferable
30	71.65	n/a	nontransferable
31	35.90	46.21	conditional
32	31.48	64.72	nontransferable

Class judgments retain their original fixed technical rule; they are not unrestricted clinical approvals. Width, planarity and notch-event classes are nontransferable. KQRS turn direction is conditional, without polarity or reference approval. Shape passes are qualified: Frobenius-normalized proper-rotation RMS is bounded by $\sqrt{2/303}$, so its 0.1 subgate is automatically satisfied; the additional unrotated criterion is not tautological. No new clinical tolerance was substituted.

S2c. Complete primary metric table, all eligible header groups

Each row retains its scope, group, method, class, segment and metric identity from the primary aggregate table. Groups with fewer than 20 persons remain outside this public table and are not treated as negative results. All overall, header-normal and infarction primary metric rows are retained. Historical metric definitions and intervals differ from the re-audited angle table S2a; values must not be merged across definitions. “unavailable” is an absent aggregate, never zero. In the last column of the tables below, the term before the slash is the empirical rule class and the

term after it the release class; “open” means that no class was assigned on that side (as “unresolved” in S2b), not a passed or failed result. Bias and LoA are in the unit shown; percentages of relative difference remain percentages.

overall, Kors, Amplitudes. Finite pairs/persons and unit by segment: p: 188/188, mV; qrs: 285/285, mV; t: 282/282, mV.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.7458 [0.6281, 0.8307]	0.007679 [0.002169, 0.01312]	[-0.06547, 0.08083]	a: 0.07545 [0.06565, 0.1068]; r: 47.45 [39.71, 63.62]	nontransferable / open
p	peak_x	0.4279 [0.2435, 0.6195]	0.01067 [0.003412, 0.01771]	[-0.08921, 0.1106]	a: 0.09519 [0.07241, 0.1124]; r: 200.00 [198.01, 200.00]	nontransferable / open
p	peak_y	0.6299 [0.4028, 0.8095]	0.004139 [-0.006389, 0.01507]	[-0.1437, 0.1520]	a: 0.1254 [0.1060, 0.1947]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	peak_z	0.6410 [0.4445, 0.7858]	-0.01012 [-0.0159, -0.004181]	[-0.09183, 0.07158]	a: 0.09338 [0.07224, 0.1164]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.9083 [0.8658, 0.9513]	0.08154 [0.04234, 0.1120]	[-0.5241, 0.6872]	a: 0.5114 [0.4356, 0.6446]; r: 36.85 [32.16, 42.35]	conditional / conditional
qrs	peak_x	0.9247 [0.8937, 0.9532]	0.01277 [-0.02348, 0.05048]	[-0.6121, 0.6376]	a: 0.4586 [0.3268, 0.7064]; r: 191.95 [110.15, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.8955 [0.8539, 0.9350]	0.07883 [0.04475, 0.1119]	[-0.4813, 0.6389]	a: 0.4733 [0.3930, 0.6330]; r: 200.00 [191.45, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.8289 [0.7595, 0.8772]	0.1650 [0.1204, 0.2070]	[-0.5662, 0.8962]	a: 0.8377 [0.6773, 1.016]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.9329 [0.9031, 0.9547]	0.03552 [0.02685, 0.0443]	[-0.1138, 0.1849]	a: 0.1598 [0.1412, 0.1839]; r: 53.09 [41.29, 58.82]	nontransferable / nontransferable
t	peak_x	0.8903 [0.7699, 0.9620]	0.02615 [0.01384, 0.04118]	[-0.2075, 0.2598]	a: 0.1657 [0.1190, 0.2543]; r: 200.00 [186.53, 200.00]	nontransferable / nontransferable
t	peak_y	0.8719 [0.8223, 0.9125]	-0.00473 [-0.01464, 0.005776]	[-0.1780, 0.1685]	a: 0.1783 [0.1432, 0.2375]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_z	0.9132 [0.8813, 0.9364]	-0.02681 [-0.03815, -0.01529]	[-0.2256, 0.1719]	a: 0.1916 [0.1646, 0.2457]; r: 200.00 [178.99, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

overall, Kors, Width/planarity. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.5317 [0.4208, 0.6290]	-0.05074 [-0.05901, -0.04317]	[-0.1585, 0.05701]	0.1339 [0.1172, 0.1492]	nontransferable / open
p	width	0.5507 [0.4506, 0.6391]	-0.04757 [-0.06662, -0.02719]	[-0.3269, 0.2317]	0.3341 [0.2619, 0.3603]	nontransferable / open
qrs	planarity	0.7686 [0.6588, 0.8465]	-0.01277 [-0.01797, -0.007632]	[-0.09882, 0.07327]	0.09489 [0.08063, 0.1055]	conditional / conditional
qrs	width	0.8193 [0.7663, 0.8634]	-0.01862 [-0.03288, -0.004346]	[-0.2560, 0.2188]	0.2499 [0.2046, 0.2921]	nontransferable / nontransferable
t	planarity	0.7565 [0.6546, 0.8499]	-0.002781 [-0.006617, 0.0013]	[-0.06941, 0.06384]	0.06442 [0.04753, 0.0802]	conditional / conditional
t	width	0.8248 [0.7739, 0.8660]	0.008515 [-0.005533, 0.0218]	[-0.2302, 0.2472]	0.2761 [0.2261, 0.3088]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

overall, Kors, Rotation direction. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.5449 [0.3842, 0.6918]	-0.01596 [-0.07447, 0.03723]	[-0.8134, 0.7815]	1.0 [1.0, 1.0]	nontransferable / open
p	turn_left sagittal	0.3335 [0.1315, 0.5292]	-0.04255 [-0.1011, 0.01064]	[-0.7964, 0.7113]	1.0 [1.0, 1.0]	nontransferable / open
p	turn_transversal	0.5270 [0.3725, 0.6613]	-0.1064 [-0.1809, -0.03191]	[-1.158, 0.9456]	1.0 [1.0, 2.0]	nontransferable / open
qrs	turn_frontal	0.7315 [0.6633, 0.7948]	0.0386 [-0.03509, 0.1158]	[-1.217, 1.294]	2.0 [1.800, 2.0]	conditional / open
qrs	turn_left sagittal	0.6456 [0.5528, 0.7382]	0.007018 [-0.05614, 0.07018]	[-1.071, 1.085]	1.0 [1.0, 2.0]	conditional / open
qrs	turn_transversal	0.7879 [0.6969, 0.8714]	-0.007018 [-0.05263, 0.0386]	[-0.7784, 0.7643]	1.0 [0, 1.800]	conditional / open
t	turn_frontal	0.6574 [0.5850, 0.7247]	-0.06383 [-0.1844, 0.05319]	[-1.945, 1.817]	2.950 [2.0, 3.000]	nontransferable / open
t	turn_left sagittal	0.7412 [0.6636, 0.8142]	-0.01418 [-0.08865, 0.06028]	[-1.284, 1.256]	2.0 [1.0, 2.0]	conditional / open
t	turn_transversal	0.6890 [0.6148, 0.7607]	-0.003546 [-0.08511, 0.08156]	[-1.431, 1.424]	2.0 [1.0, 2.0]	conditional / open

P95 relative [interval]: unavailable for every row.

overall, Kors, Shape. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.013 [0.01211, 0.01393]	[0.0004868, 0.02551]	0.02373 [0.02071, 0.03088]	rule met, restricted / open
p	rms_unrotated	0.01945 [0.01798, 0.02117]	[-0.002075, 0.04098]	0.03853 [0.0316, 0.0525]	rule met, restricted / open
qrs	rms_procrustes	0.008631 [0.00798, 0.009359]	[-0.002909, 0.02017]	0.01763 [0.01577, 0.02248]	rule met, restricted / open
qrs	rms_unrotated	0.01397 [0.01297, 0.01502]	[-0.002729, 0.03067]	0.02984 [0.02577, 0.03861]	rule met, restricted / open
t	rms_procrustes	0.007956 [0.007224, 0.008717]	[-0.004394, 0.02031]	0.02001 [0.01716, 0.02222]	rule met, restricted / open
t	rms_unrotated	0.01409 [0.01289, 0.01538]	[-0.006603, 0.03478]	0.03304 [0.02728, 0.04199]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

overall, Kors, Principal direction. Finite pairs/persons and unit by segment: p: 188/188, degrees; qrs: 285/285, degrees; qrst: 282/282, degrees; st: 208/208, degrees; t: 282/282, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	-3.706 [-8.779, 1.499]	[-94.47, 93.23]	115.0 [90.85, 139.9]	nontransferable / open
p	integral_elevation	-2.353 [-5.927, 1.351]	[-52.82, 48.12]	61.20 [36.58, 73.77]	nontransferable / open
p	peak_azimuth	-7.761 [-12.93, -2.625]	[-99.09, 80.51]	113.2 [86.88, 131.2]	nontransferable / open
p	peak_elevation	-1.354 [-5.257, 2.576]	[-57.57, 54.87]	62.19 [43.81, 95.81]	nontransferable / open
qrs	integral_azimuth	5.164 [3.214, 7.235]	[-29.97, 40.97]	40.49 [33.63, 47.81]	nontransferable / open
qrs	integral_elevation	-1.408 [-2.972, 0.2645]	[-29.03, 26.21]	31.43 [23.07, 37.00]	conditional / open
qrs	peak_azimuth	6.655 [4.721, 8.643]	[-37.09, 49.92]	44.87 [32.13, 56.85]	nontransferable / open
qrs	peak_elevation	-2.160 [-3.433, -0.8721]	[-24.34, 20.02]	23.49 [18.33, 28.22]	conditional / open
qrst	angle_integral	0.7580 [-1.960, 3.369]	[-44.55, 46.07]	52.37 [39.14, 59.67]	nontransferable / open
qrst	angle_peak	2.433 [-0.3089, 5.121]	[-44.55, 49.42]	50.96 [36.39, 71.06]	nontransferable / open
st	azimuth	1.843 [-1.561, 5.526]	[-67.70, 73.01]	91.99 [54.60, 112.7]	nontransferable / open
st	elevation	2.324 [-1.152, 5.698]	[-46.89, 51.54]	53.37 [42.60, 73.63]	nontransferable / open
t	integral_azimuth	2.371 [-0.08664, 4.750]	[-56.54, 63.32]	63.73 [42.90, 85.72]	nontransferable / open
t	integral_elevation	2.486 [0.1328, 4.851]	[-37.60, 42.58]	43.72 [31.71, 65.68]	nontransferable / open
t	peak_azimuth	1.879 [-0.4181, 4.162]	[-68.72, 67.43]	78.58 [46.03, 102.2]	nontransferable / open
t	peak_elevation	1.165 [-0.7421, 3.233]	[-32.41, 34.74]	35.66 [28.30, 46.76]	conditional / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

overall, Kors, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 188/188, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 188/188, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 285/285, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 285/285, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 282/282, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 282/282, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.7994 [0.7062, 0.8708]	0.0004173 [0.0002169, 0.0006228]	[-0.002491, 0.003325]	a: 0.003237 [0.002871, 0.004071]; r: 200.00 [121.02, 200.00]	nontransferable / open
p	area_left sagittal	0.7301 [0.6463, 0.8014]	-0.0003693 [-0.0006105, -0.0001267]	[-0.003707, 0.002969]	a: 0.003756 [0.00277, 0.004311]; r: 200.00 [188.14, 200.00]	nontransferable / open
p	area_transversal	0.6241 [0.4861, 0.7248]	0.0009247 [0.0007285, 0.001114]	[-0.001675, 0.003524]	a: 0.003158 [0.002582, 0.00407]; r: 200.00 [189.98, 200.00]	nontransferable / open
p	integral_magnitude	0.7611 [0.5649, 0.8425]	0.6365 [0.03155, 1.229]	[-7.198, 8.470]	a: 7.986 [5.872, 10.02]; r: 66.34 [45.68, 75.86]	nontransferable / open
p	integral_vector	0.7388 [0.5400, 0.8261]	0.6619 [0.02336, 1.298]	[-7.674, 8.997]	a: 8.611 [6.674, 10.13]; r: 89.48 [68.56, 97.63]	nontransferable / open
p	integral_x	0.3827 [0.1995, 0.6712]	0.5537 [-0.1617, 1.132]	[-8.643, 9.750]	a: 7.302 [5.282, 10.14]; r: 200.00 [198.83, 200.00]	nontransferable / open
p	integral_y	0.5602 [0.3140, 0.7756]	0.01872 [-0.7673, 0.8029]	[-10.72, 10.76]	a: 9.915 [6.795, 15.33]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	integral_z	0.7536 [0.3049, 0.8980]	-0.3026 [-0.7765, 0.1672]	[-6.925, 6.320]	a: 7.993 [4.387, 10.11]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.2527 [-0.0392, 0.9703]	0.06131 [-0.02075, 0.2059]	[-2.076, 2.199]	a: 0.3374 [0.2636, 0.4570]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.4911 [0.3870, 0.9215]	-0.09027 [-0.2110, -0.02055]	[-1.801, 1.621]	a: 0.3745 [0.2951, 0.5445]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_transversal	0.4345 [0.3108, 0.9373]	-0.06934 [-0.2497, 0.036]	[-2.550, 2.411]	a: 0.5773 [0.4041, 0.6791]; r: 172.83 [135.79, 200.00]	nontransferable / open
qrs	integral_magnitude	0.9520 [0.9363, 0.9632]	2.698 [1.588, 3.827]	[-16.58, 21.97]	a: 23.14 [17.78, 27.12]; r: 34.31 [28.91, 36.79]	conditional / conditional
qrs	integral_vector	0.9409 [0.9205, 0.9552]	2.436 [1.189, 3.606]	[-17.79, 22.66]	a: 24.79 [18.62, 31.03]; r: 53.41 [45.29, 55.96]	nontransferable / nontransferable
qrs	integral_x	0.9149 [0.8500, 0.9578]	-0.6110 [-1.731, 0.3919]	[-17.93, 16.71]	a: 15.83 [11.96, 22.97]; r: 161.91 [122.97, 194.84]	nontransferable / nontransferable
qrs	integral_y	0.8917 [0.8253, 0.9335]	1.830 [0.6173, 2.993]	[-18.18, 21.85]	a: 25.89 [17.16, 30.95]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_z	0.9181 [0.8856, 0.9398]	3.453 [2.092, 4.877]	[-20.01, 26.91]	a: 27.03 [22.54, 33.19]; r: 200.00 [196.04, 200.00]	nontransferable / open
t	area_frontal	0.8039 [0.6308, 0.9084]	0.003281 [0.001974, 0.004904]	[-0.02157, 0.02813]	a: 0.01739 [0.01266, 0.02837]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.8590 [0.8123, 0.9472]	-0.001595 [-0.00348, 0.0009621]	[-0.03944, 0.03625]	a: 0.01938 [0.01594, 0.02319]; r: 200.00 [172.32, 200.00]	nontransferable / open
t	area_transversal	0.9519 [0.9234, 0.9702]	0.003379 [0.002222, 0.004662]	[-0.01764, 0.0244]	a: 0.02255 [0.01817, 0.029]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	integral_magnitude	0.9056 [0.8698, 0.9324]	5.452 [4.272, 6.657]	[-15.99, 26.89]	a: 25.47 [19.50, 31.77]; r: 52.32 [45.31, 58.12]	nontransferable / nontransferable
t	integral_vector	0.9003 [0.8637, 0.9286]	5.194 [3.924, 6.513]	[-17.57, 27.96]	a: 25.75 [20.65, 31.48]; r: 70.74 [52.11, 81.78]	nontransferable / nontransferable
t	integral_x	0.8810 [0.7737, 0.9487]	2.631 [1.063, 4.374]	[-26.47, 31.73]	a: 22.70 [18.83, 31.20]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_y	0.8147 [0.7154, 0.8782]	-0.9755 [-2.485, 0.6803]	[-27.65, 25.70]	a: 27.43 [22.69, 34.16]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_z	0.9131 [0.8818, 0.9350]	-3.720 [-5.004, -2.419]	[-26.07, 18.63]	a: 25.71 [21.37, 27.71]; r: 200.00 [151.24, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

overall, Kors, Notches/bites. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	-0.5798 [-0.7500, -0.3989]	[-2.960, 1.801]	3.000 [2.0, 3.000]	open / open
p	count_60	unavailable	-0.5160 [-0.6809, -0.3457]	[-2.884, 1.852]	3.000 [2.0, 3.000]	open / open
p	count_80	unavailable	-0.3511 [-0.5213, -0.1755]	[-2.710, 2.008]	2.650 [2.0, 3.000]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	0.0000 [not estimable]	0.005319 [0, 0.01596]	[-0.1376, 0.1483]	0 [0, 0]	open / open
p	present_80	0.3795 [0.0867, 0.6153]	-0.03191 [-0.06915, 0.01064]	[-0.5645, 0.5007]	1.0 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.1544 [-0.2561, -0.05263]	[-1.884, 1.575]	2.0 [1.995, 2.0]	open / open
qrs	count_60	unavailable	-0.1298 [-0.2175, -0.04211]	[-1.620, 1.360]	1.800 [1.0, 2.0]	open / open
qrs	count_80	unavailable	0 [-0.08772, 0.09123]	[-1.462, 1.462]	1.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	0.4974 [0.0000, 1.0000]	0.007018 [0, 0.01754]	[-0.1569, 0.1709]	0 [0, 0]	nontransferable / nontransferable
qrs	present_80	0.4541 [0.2520, 0.6217]	-0.007018 [-0.04211, 0.02807]	[-0.5766, 0.5626]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	0.2553 [-0.02482, 0.5426]	[-4.433, 4.943]	5.950 [4.0, 7.000]	open / open
t	count_60	unavailable	0.01418 [-0.2021, 0.2270]	[-3.593, 3.622]	4.0 [3.000, 5.000]	open / open
t	count_80	unavailable	-0.06383 [-0.2234, 0.09574]	[-2.773, 2.645]	3.000 [2.0, 4.0]	open / open
t	present_40	0.5936 [0.4882, 0.6849]	0.02128 [-0.02837, 0.07447]	[-0.8208, 0.8634]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_60	0.5716 [0.4696, 0.6684]	-0.003546 [-0.05319, 0.04965]	[-0.8863, 0.8792]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.6580 [0.5498, 0.7520]	-0.01418 [-0.05328, 0.02491]	[-0.7152, 0.6868]	1.0 [1.0, 1.0]	conditional / conditional

P95 relative [interval]: unavailable for every row.

overall, inverse Dower, Amplitudes. Finite pairs/persons and unit by segment: p: 188/188, mV; qrs: 285/285, mV; t: 282/282, mV.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.7688 [0.6367, 0.8643]	-0.007325 [-0.01276, -0.002352]	[-0.07618, 0.06153]	a: 0.0672 [0.05509, 0.09559]; r: 45.40 [36.68, 60.15]	conditional / open
p	peak_x	0.4722 [0.2950, 0.6328]	0.002347 [-0.004028, 0.008483]	[-0.08301, 0.0877]	a: 0.08215 [0.06507, 0.1200]; r: 200.00 [173.34, 200.00]	nontransferable / open
p	peak_y	0.6909 [0.4784, 0.8630]	-0.006518 [-0.01554, 0.003019]	[-0.1338, 0.1208]	a: 0.1011 [0.07466, 0.1780]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	peak_z	0.5810 [0.3767, 0.7369]	0.009289 [0.00227, 0.01607]	[-0.08617, 0.1047]	a: 0.1041 [0.08708, 0.1181]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.7806 [0.7281, 0.8400]	0.2250 [0.1686, 0.2731]	[-0.6861, 1.136]	a: 0.8872 [0.7847, 1.206]; r: 54.09 [48.72, 65.14]	nontransferable / nontransferable
qrs	peak_x	0.8315 [0.7766, 0.8768]	-0.1010 [-0.1561, -0.04669]	[-1.038, 0.8363]	a: 0.9529 [0.7483, 1.195]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.8376 [0.7572, 0.8964]	0.09301 [0.04858, 0.1327]	[-0.6127, 0.7987]	a: 0.6836 [0.5569, 0.8130]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.6124 [0.5386, 0.6760]	0.4627 [0.3968, 0.5309]	[-0.6615, 1.587]	a: 1.458 [1.281, 1.574]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.8469 [0.7946, 0.8872]	0.07109 [0.05834, 0.08382]	[-0.1485, 0.2907]	a: 0.2778 [0.2450, 0.3156]; r: 70.94 [62.98, 81.54]	nontransferable / nontransferable
t	peak_x	0.8359 [0.7093, 0.9191]	0.03312 [0.01728, 0.05087]	[-0.2626, 0.3289]	a: 0.2850 [0.1967, 0.3791]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_y	0.8238 [0.7547, 0.8703]	-0.04081 [-0.05156, -0.02966]	[-0.2276, 0.1459]	a: 0.1960 [0.1690, 0.2649]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_z	0.8114 [0.7574, 0.8541]	-0.06092 [-0.07852, -0.0426]	[-0.3660, 0.2441]	a: 0.3132 [0.2776, 0.3740]; r: 200.00 [200.00, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

overall, inverse Dower, Width/planarity. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.6198 [0.4819, 0.7352]	-0.02364 [-0.03302, -0.01476]	[-0.1460, 0.09869]	0.1309 [0.1049, 0.1513]	nontransferable / open
p	width	0.4173 [0.3007, 0.5185]	-0.06604 [-0.08816, -0.04334]	[-0.3766, 0.2445]	0.3691 [0.3026, 0.4046]	nontransferable / open
qrs	planarity	0.6577 [0.5432, 0.7525]	-0.02261 [-0.02866, -0.01685]	[-0.1219, 0.07668]	0.1120 [0.1037, 0.1210]	nontransferable / nontransferable
qrs	width	0.6604 [0.5751, 0.7301]	-0.0156 [-0.03484, 0.003712]	[-0.3433, 0.3121]	0.3190 [0.2784, 0.3603]	nontransferable / nontransferable
t	planarity	0.7092 [0.5921, 0.8098]	-0.008067 [-0.01224, -0.003856]	[-0.07906, 0.06293]	0.06961 [0.05642, 0.1041]	nontransferable / nontransferable
t	width	0.5868 [0.5060, 0.6547]	-0.006435 [-0.02747, 0.01399]	[-0.3578, 0.3449]	0.3682 [0.3159, 0.4305]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

overall, inverse Dower, Rotation direction. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.3717 [0.2225, 0.5116]	0.09574 [0.01064, 0.1809]	[-1.035, 1.227]	1.0 [1.0, 2.0]	nontransferable / open
p	turn_left sagittal	0.4932 [0.2948, 0.6654]	0.01596 [-0.03737, 0.06915]	[-0.7281, 0.7601]	1.0 [1.0, 1.0]	nontransferable / open
p	turn_transversal	0.4367 [0.2819, 0.5732]	-0.04787 [-0.1278, 0.03191]	[-1.163, 1.068]	1.0 [1.0, 2.0]	nontransferable / open
qrs	turn_frontal	0.5241 [0.4459, 0.5989]	-0.1474 [-0.2421, -0.04912]	[-1.775, 1.480]	2.0 [2.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.6529 [0.5581, 0.7377]	0.05614 [-0.01053, 0.1193]	[-1.042, 1.154]	1.800 [1.0, 2.0]	conditional / open
qrs	turn_transversal	0.5509 [0.4320, 0.6663]	-0.03158 [-0.09123, 0.02456]	[-1.010, 0.9465]	1.0 [1.0, 2.0]	nontransferable / open
t	turn_frontal	0.5265 [0.4531, 0.6002]	-0.1028 [-0.2163, 0.01064]	[-1.966, 1.761]	2.0 [2.0, 3.000]	nontransferable / open
t	turn_left sagittal	0.7478 [0.6710, 0.8206]	-0.06028 [-0.1277, 0.007092]	[-1.194, 1.073]	2.0 [1.0, 2.0]	conditional / open
t	turn_transversal	0.5404 [0.4555, 0.6222]	-0.01773 [-0.1135, 0.07801]	[-1.608, 1.572]	2.0 [2.0, 2.0]	nontransferable / open

P95 relative [interval]: unavailable for every row.

overall, inverse Dower, Shape. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.01473 [0.01394, 0.01564]	[0.003083, 0.02638]	0.02577 [0.02256, 0.02963]	rule met, restricted / open
p	rms_unrotated	0.02206 [0.02058, 0.02388]	[-0.0005317, 0.04465]	0.04127 [0.03657, 0.04818]	rule met, restricted / open
qrs	rms_procrustes	0.01294 [0.01222, 0.01373]	[0.0002417, 0.02564]	0.02456 [0.02153, 0.0273]	rule met, restricted / open
qrs	rms_unrotated	0.02339 [0.02223, 0.02453]	[0.004075, 0.04271]	0.03939 [0.03749, 0.04716]	rule met, restricted / open
t	rms_procrustes	0.01286 [0.01192, 0.01379]	[-0.002396, 0.02812]	0.02693 [0.02434, 0.03042]	rule met, restricted / open
t	rms_unrotated	0.02304 [0.0217, 0.02442]	[0.0006512, 0.04542]	0.04448 [0.04142, 0.05101]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

overall, inverse Dower, Principal direction. Finite pairs/persons and unit by segment: p: 188/188, degrees; qrs: 285/285, degrees; qrst: 282/282, degrees; st: 209/209, degrees; t: 282/282, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	14.80 [9.257, 20.85]	[-82.46, 108.2]	118.8 [80.36, 150.8]	nontransferable / open
p	integral_elevation	0.8429 [-2.944, 4.675]	[-51.59, 53.27]	58.66 [41.74, 77.57]	nontransferable / open
p	peak_azimuth	15.20 [9.511, 21.12]	[-82.88, 114.4]	123.4 [102.5, 138.9]	nontransferable / open
p	peak_elevation	0.7643 [-2.986, 4.556]	[-52.74, 54.27]	57.09 [40.10, 79.63]	nontransferable / open
qrs	integral_azimuth	16.87 [14.45, 19.37]	[-29.34, 65.27]	52.09 [42.80, 71.75]	nontransferable / open
qrs	integral_elevation	1.046 [-0.7297, 2.763]	[-28.51, 30.61]	31.34 [24.99, 37.72]	conditional / open
qrs	peak_azimuth	19.76 [17.09, 22.47]	[-40.95, 79.25]	72.44 [53.69, 95.08]	nontransferable / open
qrs	peak_elevation	0.3711 [-1.279, 2.047]	[-28.01, 28.75]	27.80 [25.72, 34.14]	conditional / open
qrst	angle_integral	8.674 [5.553, 11.64]	[-44.03, 61.38]	55.96 [48.41, 68.76]	nontransferable / open
qrst	angle_peak	10.23 [6.599, 13.98]	[-52.96, 73.42]	71.65 [58.61, 80.34]	nontransferable / open
st	azimuth	6.710 [2.802, 10.75]	[-67.55, 80.30]	87.88 [63.66, 115.7]	nontransferable / open
st	elevation	2.055 [-1.337, 5.333]	[-47.32, 51.43]	50.11 [46.14, 72.60]	nontransferable / open
t	integral_azimuth	5.221 [2.109, 8.432]	[-62.91, 76.27]	71.41 [53.03, 80.19]	nontransferable / open
t	integral_elevation	4.894 [2.544, 7.240]	[-34.49, 44.27]	40.03 [33.30, 63.47]	nontransferable / open
t	peak_azimuth	5.620 [2.239, 9.024]	[-73.72, 81.01]	83.25 [62.69, 104.5]	nontransferable / open
t	peak_elevation	4.373 [2.217, 6.577]	[-32.39, 41.13]	37.46 [32.23, 48.44]	conditional / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

overall, inverse Dower, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 188/188, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 188/188, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 285/285, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 285/285, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 282/282, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 282/282, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.5964 [0.4881, 0.6935]	0.001322 [0.001087, 0.001567]	[-0.002032, 0.004676]	a: 0.004669 [0.003566, 0.005671]; r: 200.00 [161.53, 200.00]	nontransferable / open
p	area_left sagittal	0.7272 [0.6483, 0.8004]	0.0004514 [0.0002186, 0.000691]	[-0.002774, 0.003677]	a: 0.003627 [0.002765, 0.004313]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	area_transversal	0.6395 [0.5128, 0.7247]	5.57e-05 [-0.0001457, 0.0002513]	[-0.002666, 0.002777]	a: 0.002956 [0.002368, 0.003652]; r: 200.00 [197.84, 200.00]	nontransferable / open
p	integral_magnitude	0.7421 [0.4743, 0.8670]	-0.3579 [-0.9769, 0.2398]	[-8.404, 7.689]	a: 8.264 [5.055, 12.49]; r: 64.50 [45.08, 78.75]	nontransferable / open
p	integral_vector	0.7227 [0.4546, 0.8539]	-0.1760 [-0.8364, 0.4507]	[-8.657, 8.305]	a: 8.565 [5.537, 12.76]; r: 83.95 [67.52, 98.52]	nontransferable / open
p	integral_x	0.4201 [0.2329, 0.6771]	-0.1472 [-0.7785, 0.3700]	[-8.181, 7.887]	a: 6.256 [4.300, 9.781]; r: 200.00 [191.43, 200.00]	nontransferable / open
p	integral_y	0.5759 [0.3360, 0.7900]	-0.6820 [-1.412, 0.05983]	[-10.81, 9.441]	a: 8.557 [6.395, 15.02]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	integral_z	0.7201 [0.3426, 0.8722]	0.5302 [-0.02453, 1.018]	[-6.776, 7.837]	a: 8.289 [5.843, 10.25]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.3211 [-0.0064, 0.8810]	0.1703 [0.0882, 0.2935]	[-1.635, 1.976]	a: 0.7815 [0.5904, 0.9473]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.3231 [0.1725, 0.9070]	-0.1016 [-0.2419, -0.02418]	[-2.068, 1.865]	a: 0.5448 [0.3637, 0.7526]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_transversal	0.2901 [0.0979, 0.7866]	0.1469 [-0.05513, 0.2728]	[-2.701, 2.994]	a: 1.125 [0.8686, 1.645]; r: 200.00 [195.18, 200.00]	nontransferable / open
qrs	integral_magnitude	0.8920 [0.8627, 0.9117]	8.152 [6.563, 9.734]	[-19.31, 35.62]	a: 35.90 [29.69, 39.88]; r: 46.21 [40.49, 54.00]	conditional / conditional
qrs	integral_vector	0.8842 [0.8497, 0.9069]	6.342 [4.686, 8.003]	[-21.87, 34.55]	a: 31.48 [27.21, 42.20]; r: 64.72 [57.30, 70.60]	nontransferable / nontransferable
qrs	integral_x	0.7444 [0.6112, 0.8400]	-5.662 [-7.383, -4.033]	[-34.85, 23.52]	a: 30.18 [24.10, 41.74]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_y	0.8950 [0.8322, 0.9332]	2.369 [1.204, 3.545]	[-17.43, 22.17]	a: 24.12 [18.19, 30.94]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	integral_z	0.7983 [0.7274, 0.8474]	9.944 [7.707, 12.22]	[-27.74, 47.63]	a: 43.72 [37.90, 49.55]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	area_frontal	0.6975 [0.3958, 0.8455]	0.006657 [0.004488, 0.008956]	[-0.03098, 0.0443]	a: 0.04026 [0.03138, 0.05667]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.8145 [0.7728, 0.8994]	-0.002789 [-0.005043, 0.0001805]	[-0.04817, 0.04259]	a: 0.0246 [0.02133, 0.03739]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	area_transversal	0.8284 [0.7682, 0.8704]	0.007164 [0.004439, 0.009921]	[-0.0404, 0.05473]	a: 0.0555 [0.0441, 0.07109]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	integral_magnitude	0.8394 [0.7918, 0.8758]	9.388 [7.893, 10.94]	[-17.19, 35.97]	a: 33.89 [29.26, 44.58]; r: 70.49 [65.31, 75.91]	nontransferable / nontransferable
t	integral_vector	0.8368 [0.7897, 0.8747]	8.775 [7.202, 10.40]	[-19.17, 36.72]	a: 34.86 [30.27, 43.98]; r: 79.68 [74.13, 98.67]	nontransferable / nontransferable
t	integral_x	0.8491 [0.7428, 0.9203]	4.255 [2.490, 6.244]	[-28.83, 37.34]	a: 32.68 [24.64, 38.90]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_y	0.7842 [0.6734, 0.8562]	-5.006 [-6.582, -3.337]	[-31.47, 21.45]	a: 27.24 [22.03, 34.47]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_z	0.8175 [0.7715, 0.8541]	-8.063 [-10.02, -6.106]	[-40.82, 24.70]	a: 37.28 [33.89, 44.63]; r: 200.00 [200.00, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

overall, inverse Dower, Notches/bites. Finite pairs/persons and unit by segment: p: 188/188, dimensionless/count/category; qrs: 285/285, dimensionless/count/category; t: 282/282, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	-0.04255 [-0.2500, 0.1702]	[-2.951, 2.866]	3.000 [2.0, 3.650]	open / open
p	count_60	unavailable	-0.1809 [-0.3723, 0.01609]	[-2.862, 2.500]	3.000 [2.0, 3.000]	open / open
p	count_80	unavailable	0.01064 [-0.1649, 0.2021]	[-2.480, 2.501]	3.000 [2.0, 3.000]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	0.0000 [not estimable]	0.005319 [0, 0.01596]	[-0.1376, 0.1483]	0 [0, 0]	open / open
p	present_80	0.3666 [0.0499, 0.6156]	-0.01064 [-0.04787, 0.0266]	[-0.5067, 0.4854]	1.0 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.1509 [-0.2877, -0.01754]	[-2.384, 2.082]	2.0 [2.0, 3.000]	open / open
qrs	count_60	unavailable	-0.05614 [-0.1579, 0.05263]	[-1.824, 1.712]	2.0 [2.0, 2.0]	open / open
qrs	count_80	unavailable	0.03509 [-0.06667, 0.1368]	[-1.696, 1.767]	2.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	-0.0106 [-0.0195, 0.0000]	0 [-0.01754, 0.01754]	[-0.2849, 0.2849]	0 [0, 0]	nontransferable / nontransferable
qrs	present_80	0.1862 [0.0142, 0.3750]	0.01754 [-0.02114, 0.05614]	[-0.6291, 0.6642]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	-0.3085 [-0.6490, 0.05319]	[-6.375, 5.758]	7.950 [5.000, 9.000]	open / open
t	count_60	unavailable	-0.3191 [-0.5993, -0.0531]	[-5.027, 4.389]	5.000 [4.0, 5.950]	open / open
t	count_80	unavailable	-0.2234 [-0.4574, -0.01418]	[-4.053, 3.606]	3.000 [2.950, 4.950]	open / open
t	present_40	0.4910 [0.3817, 0.5987]	-0.02482 [-0.07801, 0.03191]	[-0.9806, 0.9310]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_60	0.4266 [0.3113, 0.5313]	-0.06383 [-0.1207, -0.003546]	[-1.062, 0.9341]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.4793 [0.3600, 0.5935]	-0.06738 [-0.1135, -0.01773]	[-0.8918, 0.7571]	1.0 [1.0, 1.0]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Header-normal control, Kors, Amplitudes. Finite pairs/persons and unit by segment: p: 47/47, mV; qrs: 52/52, mV; t: 51/51, mV.

Segment	Metric	ICC or κ [inter-val]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.7233 [0.5982, 0.8320]	0.01039 [0.004247, 0.01641]	[-0.03036, 0.05113]	a: 0.05051 [0.03086, 0.06447]; r: 37.88 [29.75, 46.24]	nontransferable / open
p	peak_x	0.5436 [0.3049, 0.7085]	0.01026 [0.002727, 0.01736]	[-0.04024, 0.06076]	a: 0.04801 [0.04088, 0.07791]; r: 194.87 [133.02, 200.00]	nontransferable / open
p	peak_y	0.8189 [0.5536, 0.9237]	0.01521 [0.005677, 0.02593]	[-0.05512, 0.08553]	a: 0.1042 [0.04459, 0.1162]; r: 176.49 [85.82, 200.00]	nontransferable / open
p	peak_z	0.6648 [0.4679, 0.7901]	-0.003697 [-0.01109, 0.003973]	[-0.05494, 0.04754]	a: 0.05293 [0.03708, 0.07135]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.9675 [0.9081, 0.9888]	0.01605 [-0.02473, 0.05691]	[-0.2687, 0.3008]	a: 0.2762 [0.1619, 0.4842]; r: 19.34 [12.14, 30.26]	rule met, restricted / rule met, restricted
qrs	peak_x	0.9532 [0.8568, 0.9879]	-0.03717 [-0.0839, 0.0253]	[-0.4405, 0.3662]	a: 0.3309 [0.1998, 0.7235]; r: 151.80 [24.98, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.9097 [0.7556, 0.9758]	0.09342 [0.04757, 0.1491]	[-0.2860, 0.4728]	a: 0.3741 [0.2075, 0.7914]; r: 110.70 [45.57, 197.71]	nontransferable / nontransferable
qrs	peak_z	0.7278 [0.5422, 0.8481]	0.07631 [-0.00749, 0.1642]	[-0.5378, 0.6904]	a: 0.6840 [0.4344, 0.9190]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.9663 [0.9163, 0.9870]	0.01453 [0.0007665, 0.02825]	[-0.08636, 0.1154]	a: 0.09463 [0.0587, 0.1888]; r: 19.73 [12.63, 42.99]	rule met, restricted / rule met, restricted
t	peak_x	0.8859 [0.6771, 0.9885]	0.01831 [-0.002145, 0.04633]	[-0.1640, 0.2006]	a: 0.09915 [0.04524, 0.4279]; r: 26.27 [15.22, 151.19]	conditional / conditional
t	peak_y	0.9054 [0.7824, 0.9577]	0.01248 [-0.0009725, 0.02678]	[-0.08727, 0.1122]	a: 0.1075 [0.06638, 0.1710]; r: 77.88 [35.32, 98.83]	nontransferable / nontransferable
t	peak_z	0.9149 [0.8479, 0.9556]	0.004379 [-0.01176, 0.02231]	[-0.1175, 0.1263]	a: 0.1229 [0.08423, 0.1763]; r: 115.87 [80.26, 165.43]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Header-normal control, Kors, Width/planarity. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.5548 [0.4282, 0.6639]	-0.04678 [-0.06044, -0.03315]	[-0.1423, 0.04871]	0.1260 [0.09117, 0.1638]	nontransferable / open
p	width	0.5525 [0.3284, 0.7420]	-0.06939 [-0.1015, -0.03549]	[-0.2915, 0.1527]	0.2478 [0.1570, 0.3869]	nontransferable / open
qrs	planarity	0.8777 [0.7850, 0.9321]	-5.823e-05 [-0.004949, 0.005234]	[-0.03747, 0.03736]	0.03785 [0.0267, 0.04946]	conditional / conditional
qrs	width	0.8261 [0.7298, 0.8902]	-0.03612 [-0.06783, -0.002368]	[-0.2803, 0.2080]	0.2381 [0.1945, 0.3140]	nontransferable / nontransferable
t	planarity	0.9189 [0.7052, 0.9486]	-0.002195 [-0.005503, 0.000744]	[-0.02472, 0.02033]	0.01891 [0.01274, 0.04511]	conditional / conditional
t	width	0.9243 [0.8854, 0.9513]	0.01589 [0.004187, 0.0279]	[-0.06836, 0.1001]	0.0876 [0.0691, 0.1229]	conditional / conditional

P95 relative [interval]: unavailable for every row.

Header-normal control, Kors, Rotation direction. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.4337 [0.0744, 0.7175]	-0.06383 [-0.2128, 0.06383]	[-1.014, 0.8863]	1.0 [0.7000, 1.700]	nontransferable / open
p	turn_left sagittal	0.4110 [0.0000, 0.7892]	-0.02128 [-0.1277, 0.06383]	[-0.6661, 0.6235]	1.0 [0, 1.0]	nontransferable / open
p	turn_transversal	0.7773 [0.3514, 1.0000]	-0.04255 [-0.1064, 0]	[-0.4425, 0.3573]	0 [0, 1.0]	conditional / open
qrs	turn_frontal	0.6199 [0.4303, 0.8060]	0.03846 [-0.1346, 0.2312]	[-1.359, 1.436]	2.0 [1.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.4851 [-0.0400, 1.0000]	0 [-0.05769, 0.05769]	[-0.3881, 0.3881]	0 [0, 1.0]	nontransferable / open
qrs	turn_transversal	-0.0196 [-0.0484, 0.0000]	-0.01923 [-0.09615, 0.03846]	[-0.4931, 0.4546]	0.4500 [0, 1.0]	nontransferable / open
t	turn_frontal	0.4681 [0.1784, 0.7160]	-0.3137 [-0.5490, -0.09804]	[-1.999, 1.372]	2.500 [1.0, 3.000]	nontransferable / open
t	turn_left sagittal	0.7871 [0.5799, 0.9499]	-0.1176 [-0.2941, 0.01961]	[-1.270, 1.035]	1.5 [0, 2.500]	conditional / open
t	turn_transversal	0.3792 [0.1766, 0.5762]	0.01961 [-0.2353, 0.2549]	[-1.798, 1.837]	2.500 [1.0, 3.000]	nontransferable / open

P95 relative [interval]: unavailable for every row.

Header-normal control, Kors, Shape. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.01131 [0.009941, 0.01292]	[0.001108, 0.02152]	0.02002 [0.01565, 0.03092]	rule met, restricted / open
p	rms_unrotated	0.01817 [0.01487, 0.02249]	[-0.007318, 0.04365]	0.03908 [0.0213, 0.07391]	rule met, restricted / open
qrs	rms_procrustes	0.007698 [0.006436, 0.009039]	[-0.002045, 0.01744]	0.01682 [0.01188, 0.02363]	rule met, restricted / open
qrs	rms_unrotated	0.0126 [0.0105, 0.01496]	[-0.003835, 0.02903]	0.03026 [0.01814, 0.04172]	rule met, restricted / open
t	rms_procrustes	0.003522 [0.00291, 0.004164]	[-0.001044, 0.008088]	0.008653 [0.006197, 0.00927]	rule met, restricted / open
t	rms_unrotated	0.009142 [0.006886, 0.01197]	[-0.009739, 0.02802]	0.02419 [0.01276, 0.04669]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Header-normal control, Kors, Principal direction. Finite pairs/persons and unit by segment: p: 47/47, degrees; qrs: 52/52, degrees; qrst: 51/51, degrees; st: 45/45, degrees; t: 51/51, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	-2.618 [-12.50, 7.173]	[-89.41, 96.21]	109.0 [43.66, 166.7]	nontransferable / open
p	integral_elevation	-7.541 [-14.05, -1.364]	[-49.54, 34.46]	57.28 [30.16, 62.83]	nontransferable / open
p	peak_azimuth	-5.316 [-14.22, 4.776]	[-84.74, 71.59]	81.19 [47.33, 137.7]	nontransferable / open
p	peak_elevation	-5.582 [-11.69, 0.01979]	[-44.80, 33.63]	45.25 [24.37, 67.82]	nontransferable / open
qrs	integral_azimuth	4.036 [0.1752, 8.276]	[-28.49, 37.35]	30.42 [19.15, 54.81]	conditional / open
qrs	integral_elevation	-4.127 [-6.647, -1.820]	[-21.96, 13.71]	21.52 [14.32, 30.19]	conditional / open
qrs	peak_azimuth	4.047 [0.5629, 7.709]	[-37.79, 49.61]	23.72 [17.28, 79.89]	conditional / open
qrs	peak_elevation	-4.438 [-6.611, -2.476]	[-19.68, 10.81]	19.06 [12.82, 26.61]	rule met, restricted / open
qrst	angle_integral	-1.001 [-4.730, 2.462]	[-25.93, 23.93]	24.03 [17.02, 35.20]	conditional / open
qrst	angle_peak	0.4808 [-2.753, 3.577]	[-21.87, 22.83]	23.78 [15.09, 31.47]	conditional / open
st	azimuth	0.7594 [-3.398, 5.764]	[-32.23, 34.58]	30.38 [21.83, 67.40]	conditional / open
st	elevation	2.327 [-1.515, 6.775]	[-26.06, 30.72]	31.44 [16.45, 54.68]	conditional / open
t	integral_azimuth	2.634 [-0.02701, 6.164]	[-25.30, 31.76]	14.97 [12.01, 62.69]	rule met, restricted / open
t	integral_elevation	0.08957 [-1.706, 2.069]	[-13.46, 13.64]	15.58 [7.139, 22.95]	rule met, restricted / open
t	peak_azimuth	1.941 [-0.5844, 5.374]	[-27.10, 32.47]	14.43 [12.31, 58.78]	rule met, restricted / open
t	peak_elevation	-0.6014 [-2.367, 1.281]	[-13.81, 12.61]	12.51 [8.737, 23.31]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Header-normal control, Kors, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 47/47, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 47/47, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 52/52, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 52/52, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 51/51, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 51/51, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.7426 [0.4901, 0.8798]	6.681e-05 [-0.0002026, 0.0003279]	[-0.001798, 0.001931]	a: 0.002365 [0.001163, 0.002461]; r: 130.27 [79.90, 200.00]	nontransferable / open
p	area_left sagittal	0.7449 [0.5400, 0.8808]	-0.0005185 [-0.0008882, -0.000181]	[-0.002979, 0.001942]	a: 0.002196 [0.001545, 0.004741]; r: 200.00 [100.49, 200.00]	nontransferable / open
p	area_transversal	0.6893 [0.5067, 0.8142]	0.0004568 [0.0001738, 0.0007262]	[-0.001372, 0.002285]	a: 0.001678 [0.001285, 0.003095]; r: 157.28 [99.54, 200.00]	nontransferable / open
p	integral_magnitude	0.7343 [0.6311, 0.8370]	0.7972 [0.3736, 1.240]	[-2.122, 3.716]	a: 3.171 [1.978, 5.188]; r: 44.00 [31.43, 54.25]	nontransferable / open
p	integral_vector	0.7301 [0.6220, 0.8345]	0.8712 [0.3783, 1.371]	[-2.431, 4.173]	a: 4.020 [2.115, 5.464]; r: 53.89 [46.27, 87.75]	nontransferable / open
p	integral_x	0.4829 [0.1393, 0.7324]	0.6473 [0.06347, 1.181]	[-3.127, 4.421]	a: 3.933 [2.385, 6.932]; r: 200.00 [118.69, 200.00]	nontransferable / open
p	integral_y	0.8434 [0.6612, 0.9209]	0.8292 [0.2533, 1.443]	[-3.271, 4.930]	a: 4.482 [3.605, 6.721]; r: 200.00 [96.34, 200.00]	nontransferable / open
p	integral_z	0.6209 [0.4520, 0.7473]	-0.1651 [-0.5752, 0.2708]	[-2.980, 2.650]	a: 2.618 [2.157, 3.916]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.8481 [0.6903, 0.9407]	0.02037 [-0.03641, 0.08139]	[-0.4026, 0.4433]	a: 0.5347 [0.2133, 0.7244]; r: 200.00 [152.55, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.8511 [0.6594, 0.9103]	0.03629 [-0.03023, 0.1033]	[-0.4378, 0.5104]	a: 0.5352 [0.2634, 0.8642]; r: 151.99 [86.61, 200.00]	nontransferable / open
qrs	area_transversal	0.8782 [0.7116, 0.9372]	-0.1010 [-0.1675, -0.03358]	[-0.5844, 0.3825]	a: 0.5805 [0.3565, 0.6663]; r: 124.39 [69.34, 186.90]	nontransferable / open
qrs	integral_magnitude	0.9446 [0.8515, 0.9765]	-1.634 [-3.113, -0.2754]	[-11.93, 8.666]	a: 13.24 [6.868, 14.74]; r: 19.40 [13.87, 29.09]	conditional / conditional
qrs	integral_vector	0.9444 [0.8891, 0.9721]	-0.3527 [-1.782, 1.030]	[-10.45, 9.741]	a: 12.42 [7.427, 14.58]; r: 33.26 [22.84, 60.12]	conditional / conditional
qrs	integral_x	0.9593 [0.9150, 0.9827]	-1.245 [-2.429, -0.1881]	[-9.468, 6.978]	a: 11.36 [4.328, 14.62]; r: 59.34 [28.71, 163.39]	nontransferable / nontransferable
qrs	integral_y	0.9260 [0.8374, 0.9725]	1.321 [0.08376, 2.707]	[-8.360, 11.00]	a: 9.850 [6.297, 16.92]; r: 142.00 [76.17, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_z	0.7937 [0.6233, 0.8872]	0.3071 [-1.680, 2.251]	[-13.68, 14.29]	a: 13.51 [9.831, 19.91]; r: 200.00 [147.01, 200.00]	nontransferable / open
t	area_frontal	0.6108 [0.2573, 0.9294]	0.004795 [0.002448, 0.008044]	[-0.01546, 0.02505]	a: 0.01343 [0.007966, 0.05151]; r: 200.00 [123.14, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.8236 [0.6235, 0.9589]	-0.004024 [-0.007063, -0.001865]	[-0.02326, 0.01521]	a: 0.01476 [0.009752, 0.04153]; r: 192.46 [113.64, 200.00]	nontransferable / open
t	area_transversal	0.8960 [0.6650, 0.9777]	0.004516 [0.001876, 0.007812]	[-0.01734, 0.02637]	a: 0.01663 [0.0116, 0.04296]; r: 200.00 [175.74, 200.00]	nontransferable / open
t	integral_magnitude	0.9598 [0.8966, 0.9839]	1.747 [-0.2756, 3.617]	[-12.49, 15.99]	a: 15.68 [9.603, 23.69]; r: 24.44 [14.32, 48.49]	conditional / conditional
t	integral_vector	0.9586 [0.8935, 0.9831]	1.473 [-0.5692, 3.427]	[-13.24, 16.18]	a: 16.03 [9.772, 24.35]; r: 25.68 [16.15, 50.93]	conditional / conditional
t	integral_x	0.8918 [0.6497, 0.9856]	2.430 [-0.1741, 5.666]	[-19.67, 24.53]	a: 14.85 [6.730, 51.40]; r: 40.40 [18.64, 169.31]	conditional / conditional
t	integral_y	0.8930 [0.7729, 0.9505]	0.5195 [-1.347, 2.376]	[-12.95, 13.99]	a: 15.39 [7.405, 22.88]; r: 91.05 [37.76, 192.04]	nontransferable / nontransferable
t	integral_z	0.9308 [0.8741, 0.9629]	0.4856 [-1.291, 2.370]	[-12.73, 13.70]	a: 12.74 [8.769, 19.11]; r: 66.68 [46.61, 146.78]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Header-normal control, Kors, Notches/bites. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	-0.5532 [-0.9574, -0.1489]	[-3.319, 2.213]	3.000 [2.0, 3.700]	open / open
p	count_60	unavailable	-0.3191 [-0.6170, -0.04255]	[-2.284, 1.645]	2.0 [1.700, 2.0]	open / open
p	count_80	unavailable	-0.4043 [-0.6170, -0.1915]	[-1.969, 1.161]	1.700 [1.0, 2.0]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_80	0.5377 [-0.0444, 1.0000]	-0.02128 [-0.08511, 0.04255]	[-0.5200, 0.4775]	0.7000 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.05769 [-0.2308, 0.1346]	[-1.425, 1.310]	1.0 [1.0, 2.0]	open / open
qrs	count_60	unavailable	0.03846 [-0.1346, 0.2115]	[-1.247, 1.324]	1.0 [1.0, 1.900]	open / open
qrs	count_80	unavailable	0.2692 [0.09615, 0.4423]	[-1.082, 1.620]	1.450 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	0.0000 [not estimable]	0.01923 [0, 0.05769]	[-0.2526, 0.2910]	0 [0, 0.4500]	open / open
qrs	present_80	0.7306 [0.0000, 1.0000]	0.03846 [0, 0.09615]	[-0.3421, 0.4191]	0 [0, 1.0]	conditional / conditional
t	count_40	unavailable	0.2353 [-0.03922, 0.5691]	[-2.002, 2.473]	2.500 [1.0, 4.500]	open / open
t	count_60	unavailable	0.1373 [-0.1176, 0.4314]	[-1.938, 2.212]	2.0 [1.0, 4.500]	open / open
t	count_80	unavailable	0.03922 [-0.1373, 0.2353]	[-1.316, 1.395]	1.5 [0, 3.000]	open / open
t	present_40	0.6265 [0.3972, 0.8355]	-0.01961 [-0.1373, 0.09804]	[-0.8503, 0.8110]	1.0 [1.0, 1.0]	conditional / conditional
t	present_60	0.5498 [0.2240, 0.8118]	0.05882 [-0.03922, 0.1569]	[-0.6652, 0.7829]	1.0 [0.5, 1.0]	nontransferable / nontransferable
t	present_80	0.6348 [-0.0200, 1.0000]	0.01961 [-0.03922, 0.09804]	[-0.4589, 0.4981]	0.5 [0, 1.0]	conditional / conditional

P95 relative [interval]: unavailable for every row.

Header-normal control, inverse Dower, Amplitudes. Finite pairs/persons and unit by segment:
p: 47/47, mV; qrs: 52/52, mV; t: 51/51, mV.

Segment	Metric	ICC or κ [inter-val]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.8317 [0.7389, 0.9064]	-0.002631 [-0.007902, 0.002228]	[-0.03677, 0.03151]	a: 0.03087 [0.02359, 0.06023]; r: 28.64 [17.36, 36.68]	conditional / open
p	peak_x	0.5507 [0.3102, 0.7153]	0.002847 [-0.00409, 0.00981]	[-0.04493, 0.05062]	a: 0.04072 [0.0337, 0.06023]; r: 180.40 [114.35, 195.31]	nontransferable / open
p	peak_y	0.8715 [0.6738, 0.9472]	0.0008099 [-0.007402, 0.0106]	[-0.06172, 0.06334]	a: 0.07996 [0.03249, 0.0983]; r: 172.84 [37.17, 200.00]	nontransferable / open
p	peak_z	0.5773 [0.3673, 0.7491]	0.01844 [0.01049, 0.02654]	[-0.03719, 0.07407]	a: 0.06279 [0.04753, 0.09791]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.8503 [0.6758, 0.9266]	0.2147 [0.1486, 0.2857]	[-0.3054, 0.7349]	a: 0.5089 [0.4449, 0.9617]; r: 35.50 [26.82, 48.35]	conditional / conditional
qrs	peak_x	0.8491 [0.6821, 0.9259]	-0.03446 [-0.1321, 0.07242]	[-0.7577, 0.6888]	a: 0.8325 [0.4341, 1.206]; r: 148.17 [61.50, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.8804 [0.7137, 0.9591]	0.1155 [0.05882, 0.1810]	[-0.3294, 0.5604]	a: 0.4896 [0.2593, 0.8423]; r: 161.74 [79.82, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.3777 [0.2025, 0.5325]	0.5516 [0.4384, 0.6767]	[-0.3513, 1.454]	a: 1.492 [1.038, 1.691]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.9379 [0.8745, 0.9666]	0.01443 [-0.006585, 0.03364]	[-0.1256, 0.1544]	a: 0.1450 [0.1075, 0.1822]; r: 29.00 [23.02, 40.94]	conditional / conditional
t	peak_x	0.8698 [0.6892, 0.9671]	0.02691 [0.003771, 0.05603]	[-0.1664, 0.2202]	a: 0.1156 [0.0927, 0.4138]; r: 35.13 [27.51, 150.89]	conditional / conditional
t	peak_y	0.8342 [0.6771, 0.9050]	-0.04992 [-0.0641, -0.03528]	[-0.1510, 0.05115]	a: 0.1319 [0.09868, 0.1601]; r: 195.38 [106.59, 200.00]	nontransferable / nontransferable
t	peak_z	0.8520 [0.7685, 0.9068]	-0.006829 [-0.03107, 0.01801]	[-0.1851, 0.1714]	a: 0.1596 [0.1308, 0.2101]; r: 200.00 [162.12, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Header-normal control, inverse Dower, Width/planarity. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.6167 [0.3615, 0.7990]	-0.02196 [-0.03872, -0.005173]	[-0.1379, 0.09398]	0.1410 [0.08794, 0.1812]	nontransferable / open
p	width	0.4211 [0.1638, 0.6402]	-0.08522 [-0.1221, -0.04773]	[-0.3352, 0.1648]	0.3191 [0.1984, 0.4049]	nontransferable / open
qrs	planarity	0.8014 [0.7253, 0.8542]	-0.01222 [-0.01784, -0.006269]	[-0.05367, 0.02922]	0.0441 [0.03451, 0.05807]	conditional / conditional
qrs	width	0.7424 [0.5985, 0.8459]	-0.01451 [-0.05242, 0.02601]	[-0.3122, 0.2832]	0.3422 [0.2190, 0.3891]	nontransferable / nontransferable
t	planarity	0.7308 [0.6327, 0.9173]	-0.004924 [-0.01057, -0.000425]	[-0.04289, 0.03304]	0.01973 [0.01458, 0.07985]	nontransferable / nontransferable
t	width	0.6750 [0.5744, 0.7548]	0.09056 [0.06785, 0.1144]	[-0.07098, 0.2521]	0.2453 [0.1888, 0.2699]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Header-normal control, inverse Dower, Rotation direction. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.2953 [0.0139, 0.5566]	0.08511 [-0.08511, 0.2553]	[-1.058, 1.229]	1.0 [1.0, 1.700]	nontransferable / open
p	turn_left sagittal	0.6994 [0.2337, 1.0000]	0.02128 [-0.04255, 0.1064]	[-0.4775, 0.5200]	0.7000 [0, 1.0]	conditional / open
p	turn_transversal	0.8327 [0.5437, 1.0000]	0.04255 [0, 0.1064]	[-0.3573, 0.4425]	0 [0, 1.0]	conditional / open
qrs	turn_frontal	0.5412 [0.3339, 0.7517]	-0.1923 [-0.3851, 0]	[-1.647, 1.262]	2.0 [1.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.4851 [-0.0196, 1.0000]	0.03846 [0, 0.09615]	[-0.3421, 0.4191]	0 [0, 1.0]	nontransferable / open
qrs	turn_transversal	-0.0196 [not estimable]	0 [-0.05769, 0.05769]	[-0.3881, 0.3881]	0 [0, 1.0]	open / open
t	turn_frontal	0.2686 [0.0000, 0.5202]	-0.4314 [-0.6863, -0.1961]	[-2.196, 1.333]	2.500 [1.5, 3.000]	nontransferable / open
t	turn_left sagittal	0.5636 [0.2499, 0.8008]	-0.1961 [-0.3529, -0.05882]	[-1.235, 0.8425]	1.5 [0, 2.0]	nontransferable / open
t	turn_transversal	0.2435 [0.0000, 0.5005]	-0.07843 [-0.2745, 0.09804]	[-1.427, 1.271]	2.0 [1.0, 2.0]	nontransferable / open

P95 relative [interval]: unavailable for every row.

Header-normal control, inverse Dower, Shape. Finite pairs/persons and unit by segment: p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.01332 [0.01185, 0.01496]	[0.002459, 0.02418]	0.02259 [0.01696, 0.0348]	rule met, restricted / open
p	rms_unrotated	0.02075 [0.01725, 0.0252]	[-0.006502, 0.04801]	0.04441 [0.02714, 0.07867]	rule met, restricted / open
qrs	rms_procrustes	0.01068 [0.009309, 0.01213]	[0.0002796, 0.02109]	0.01972 [0.01613, 0.02759]	rule met, restricted / open
qrs	rms_unrotated	0.02051 [0.01805, 0.02321]	[0.001712, 0.0393]	0.0368 [0.02831, 0.04975]	rule met, restricted / open
t	rms_procrustes	0.008403 [0.007098, 0.009733]	[-0.001121, 0.01793]	0.01792 [0.01354, 0.02102]	rule met, restricted / open
t	rms_unrotated	0.01541 [0.01323, 0.01799]	[-0.002501, 0.03332]	0.03178 [0.02081, 0.04642]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Header-normal control, inverse Dower, Principal direction. Finite pairs/persons and unit by segment: p: 47/47, degrees; qrs: 52/52, degrees; qrst: 51/51, degrees; st: 46/46, degrees; t: 51/51, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	20.91 [11.30, 30.97]	[-58.09, 102.1]	93.02 [63.48, 144.4]	nontransferable / open
p	integral_elevation	-4.385 [-11.17, 1.738]	[-47.51, 38.74]	46.04 [32.77, 66.56]	nontransferable / open
p	peak_azimuth	24.82 [16.04, 35.96]	[-51.37, 111.3]	115.8 [64.09, 160.1]	nontransferable / open
p	peak_elevation	-1.414 [-7.693, 4.185]	[-41.83, 39.00]	42.00 [25.42, 67.21]	nontransferable / open
qrs	integral_azimuth	18.66 [14.41, 23.59]	[-18.13, 56.75]	41.89 [35.65, 74.64]	nontransferable / open
qrs	integral_elevation	0.5613 [-2.334, 3.431]	[-20.61, 21.74]	20.02 [13.82, 33.45]	conditional / open
qrs	peak_azimuth	20.83 [15.76, 26.18]	[-32.75, 77.89]	54.30 [42.52, 109.8]	nontransferable / open
qrs	peak_elevation	0.4272 [-2.326, 3.076]	[-18.78, 19.63]	18.78 [13.99, 26.64]	rule met, restricted / open
qrst	angle_integral	15.51 [11.03, 20.17]	[-16.34, 47.37]	40.64 [29.85, 53.38]	nontransferable / open
qrst	angle_peak	16.82 [10.88, 22.73]	[-24.31, 57.95]	55.08 [37.44, 67.64]	nontransferable / open
st	azimuth	0.04456 [-4.860, 5.055]	[-34.41, 34.48]	35.85 [23.01, 50.10]	conditional / open
st	elevation	5.610 [2.233, 9.077]	[-18.15, 29.37]	28.38 [17.81, 36.41]	conditional / open
t	integral_azimuth	2.096 [-1.252, 5.968]	[-26.88, 31.68]	27.57 [17.56, 53.46]	conditional / open
t	integral_elevation	6.854 [4.828, 9.028]	[-8.126, 21.84]	19.51 [12.54, 28.69]	conditional / open
t	peak_azimuth	2.346 [-1.531, 6.377]	[-29.60, 35.00]	28.65 [19.36, 59.13]	conditional / open
t	peak_elevation	6.588 [4.205, 8.985]	[-10.72, 23.89]	19.02 [14.15, 32.22]	conditional / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Header-normal control, inverse Dower, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 47/47, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 47/47, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 52/52, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 52/52, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 51/51, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 51/51, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.5023 [0.2770, 0.6375]	0.0008823 [0.0005929, 0.001167]	[-0.001147, 0.002912]	a: 0.002454 [0.001847, 0.003015]; r: 188.72 [128.56, 200.00]	nontransferable / open
p	area_left sagittal	0.7508 [0.5763, 0.8603]	0.0001563 [-0.0002132, 0.000509]	[-0.002349, 0.002661]	a: 0.002038 [0.001704, 0.003927]; r: 200.00 [96.18, 200.00]	nontransferable / open
p	area_transversal	0.6362 [0.4421, 0.7896]	-0.000228 [-0.0005292, 6.939e-05]	[-0.002223, 0.001767]	a: 0.001835 [0.001314, 0.003229]; r: 161.84 [100.19, 200.00]	nontransferable / open
p	integral_magnitude	0.8441 [0.7703, 0.9075]	-0.1505 [-0.4954, 0.2182]	[-2.556, 2.256]	a: 2.499 [1.622, 3.894]; r: 31.86 [24.43, 36.26]	conditional / open
p	integral_vector	0.8449 [0.7671, 0.9135]	0.06992 [-0.3159, 0.4757]	[-2.598, 2.738]	a: 2.672 [2.042, 4.326]; r: 47.36 [31.58, 72.98]	conditional / open
p	integral_x	0.5582 [0.2085, 0.7882]	0.03371 [-0.4456, 0.4915]	[-3.099, 3.166]	a: 3.095 [1.752, 5.382]; r: 185.38 [103.72, 200.00]	nontransferable / open
p	integral_y	0.8898 [0.7686, 0.9410]	0.09255 [-0.4075, 0.6233]	[-3.477, 3.662]	a: 4.211 [2.661, 5.260]; r: 200.00 [86.23, 200.00]	nontransferable / open
p	integral_z	0.4425 [0.1325, 0.6700]	0.8843 [0.3529, 1.412]	[-2.781, 4.550]	a: 5.175 [2.324, 5.447]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.7418 [0.5937, 0.8540]	0.1862 [0.1151, 0.2593]	[-0.3363, 0.7086]	a: 0.6884 [0.4404, 0.9589]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.9051 [0.6372, 0.9797]	-0.01996 [-0.08333, 0.03129]	[-0.4385, 0.3986]	a: 0.2828 [0.2089, 0.7431]; r: 155.12 [72.85, 200.00]	nontransferable / open
qrs	area_transversal	0.7576 [0.5521, 0.8267]	0.2715 [0.1817, 0.3704]	[-0.4166, 0.9597]	a: 0.7635 [0.6041, 1.146]; r: 115.53 [64.44, 179.52]	nontransferable / open
qrs	integral_magnitude	0.8874 [0.7242, 0.9456]	5.031 [3.134, 6.997]	[-9.170, 19.23]	a: 15.21 [11.91, 24.48]; r: 31.46 [19.09, 36.43]	conditional / conditional
qrs	integral_vector	0.8792 [0.7766, 0.9311]	4.715 [2.932, 6.573]	[-8.976, 18.41]	a: 15.62 [13.94, 19.82]; r: 46.92 [34.67, 59.07]	conditional / conditional
qrs	integral_x	0.9078 [0.8581, 0.9363]	-2.090 [-3.792, -0.4275]	[-14.55, 10.37]	a: 13.28 [10.02, 17.55]; r: 165.34 [54.38, 200.00]	nontransferable / nontransferable
qrs	integral_y	0.9222 [0.8297, 0.9694]	2.000 [0.7482, 3.473]	[-7.785, 11.78]	a: 9.631 [5.954, 17.43]; r: 174.63 [116.11, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_z	0.4911 [0.2874, 0.6590]	10.46 [7.624, 13.57]	[-11.65, 32.57]	a: 29.69 [23.52, 42.76]; r: 200.00 [165.24, 200.00]	nontransferable / open
t	area_frontal	0.4564 [0.1426, 0.7404]	0.009318 [0.006067, 0.01385]	[-0.0192, 0.03784]	a: 0.03564 [0.01594, 0.06374]; r: 200.00 [176.65, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.7190 [0.5090, 0.8912]	-0.008742 [-0.01303, -0.00582]	[-0.03423, 0.01675]	a: 0.02418 [0.01851, 0.05447]; r: 195.66 [121.56, 200.00]	nontransferable / open
t	area_transversal	0.6898 [0.4656, 0.7777]	0.01936 [0.01395, 0.02596]	[-0.02449, 0.06321]	a: 0.06246 [0.03702, 0.09885]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	integral_magnitude	0.9357 [0.8554, 0.9696]	3.349 [0.7469, 5.814]	[-14.23, 20.93]	a: 19.80 [14.14, 24.74]; r: 29.32 [23.13, 49.39]	conditional / conditional
t	integral_vector	0.9356 [0.8531, 0.9700]	2.642 [-0.00266, 5.115]	[-15.46, 20.74]	a: 19.96 [13.58, 25.60]; r: 32.96 [26.87, 52.22]	conditional / conditional
t	integral_x	0.8818 [0.6739, 0.9707]	4.436 [1.750, 7.738]	[-17.94, 26.81]	a: 17.09 [10.69, 49.36]; r: 47.15 [29.38, 169.06]	conditional / conditional
t	integral_y	0.8135 [0.6530, 0.8848]	-6.394 [-8.218, -4.674]	[-19.00, 6.215]	a: 15.67 [11.87, 24.59]; r: 200.00 [107.96, 200.00]	nontransferable / nontransferable
t	integral_z	0.8758 [0.7902, 0.9279]	-1.979 [-4.432, 0.6646]	[-20.55, 16.59]	a: 17.29 [13.82, 24.64]; r: 120.12 [62.27, 171.13]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Header-normal control, inverse Dower, Notches/bites. Finite pairs/persons and unit by segment:
p: 47/47, dimensionless/count/category; qrs: 52/52, dimensionless/count/category; t: 51/51, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	0.08511 [-0.3617, 0.5532]	[-3.023, 3.193]	3.000 [2.0, 3.000]	open / open
p	count_60	unavailable	0.02128 [-0.3404, 0.3830]	[-2.447, 2.490]	2.0 [2.0, 2.700]	open / open
p	count_80	unavailable	0.1064 [-0.1702, 0.3830]	[-1.906, 2.118]	2.0 [1.0, 3.000]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_80	0.4835 [0.0000, 1.0000]	0.04255 [0, 0.1064]	[-0.3573, 0.4425]	0 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.1154 [-0.3654, 0.1538]	[-2.003, 1.772]	2.0 [1.0, 2.450]	open / open
qrs	count_60	unavailable	0.07692 [-0.1538, 0.3082]	[-1.737, 1.891]	2.0 [1.0, 2.450]	open / open
qrs	count_80	unavailable	0.2115 [0, 0.4231]	[-1.357, 1.780]	1.450 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	0.0000 [not estimable]	0.01923 [0, 0.05769]	[-0.2526, 0.2910]	0 [0, 0.4500]	open / open
qrs	present_80	0.4611 [-0.0484, 0.8785]	0.03846 [-0.03846, 0.1154]	[-0.5051, 0.5821]	1.0 [0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	0.6667 [0.2941, 1.118]	[-2.387, 3.720]	4.500 [2.0, 5.500]	open / open
t	count_60	unavailable	0.2157 [-0.07843, 0.5686]	[-2.147, 2.578]	2.500 [1.0, 5.000]	open / open
t	count_80	unavailable	0.1569 [-0.03922, 0.4510]	[-1.655, 1.969]	1.0 [0, 4.0]	open / open
t	present_40	0.5234 [0.2644, 0.7264]	0.07843 [-0.05882, 0.2157]	[-0.8691, 1.026]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_60	0.3272 [-0.0092, 0.6304]	0.03922 [-0.07843, 0.1569]	[-0.8339, 0.9123]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.5584 [-0.0268, 0.8982]	0.03922 [-0.03922, 0.1176]	[-0.5097, 0.5881]	1.0 [0, 1.0]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Myocardial infarction, Kors, Amplitudes. Finite pairs/persons and unit by segment: p: 105/105, mV; qrs: 146/146, mV; t: 145/145, mV.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.8094 [0.6856, 0.8822]	0.008232 [0.001435, 0.01472]	[-0.06291, 0.07937]	a: 0.07622 [0.06371, 0.1032]; r: 50.52 [37.47, 78.10]	nontransferable / open
p	peak_x	0.4563 [0.2217, 0.7129]	0.0127 [0.001538, 0.02243]	[-0.09575, 0.1212]	a: 0.09429 [0.07068, 0.1137]; r: 200.00 [160.35, 200.00]	nontransferable / open
p	peak_y	0.5450 [0.2290, 0.8186]	-0.0009214 [-0.0188, 0.01689]	[-0.1765, 0.1746]	a: 0.1909 [0.08323, 0.3747]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	peak_z	0.6605 [0.3306, 0.8281]	-0.007669 [-0.01592, 0.000819]	[-0.09435, 0.07901]	a: 0.09395 [0.07208, 0.1261]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.8746 [0.7951, 0.9229]	0.1172 [0.08674, 0.1504]	[-0.2826, 0.5170]	a: 0.4900 [0.3846, 0.5590]; r: 39.95 [35.67, 51.55]	conditional / conditional
qrs	peak_x	0.9318 [0.8848, 0.9651]	0.02848 [-0.003347, 0.06164]	[-0.3697, 0.4267]	a: 0.4443 [0.2791, 0.6600]; r: 200.00 [106.34, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.9162 [0.8508, 0.9575]	0.07152 [0.04049, 0.1028]	[-0.3179, 0.4609]	a: 0.3997 [0.2995, 0.5082]; r: 200.00 [184.08, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.8175 [0.7602, 0.8608]	0.1814 [0.1319, 0.2343]	[-0.4541, 0.8168]	a: 0.7912 [0.6009, 0.8831]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.8590 [0.8076, 0.9070]	0.04269 [0.03118, 0.05566]	[-0.1091, 0.1944]	a: 0.1600 [0.1399, 0.2049]; r: 54.87 [41.62, 59.81]	nontransferable / nontransferable
t	peak_x	0.9147 [0.8590, 0.9540]	0.01897 [0.007852, 0.031]	[-0.1224, 0.1603]	a: 0.1565 [0.09515, 0.2475]; r: 200.00 [187.98, 200.00]	nontransferable / nontransferable
t	peak_y	0.8328 [0.7283, 0.9120]	-0.006946 [-0.01987, 0.007232]	[-0.1726, 0.1587]	a: 0.1691 [0.1011, 0.2460]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_z	0.8764 [0.8156, 0.9218]	-0.04308 [-0.05969, -0.0275]	[-0.2425, 0.1564]	a: 0.1913 [0.1592, 0.2643]; r: 200.00 [200.00, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Myocardial infarction, Kors, Width/planarity. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.5050 [0.3467, 0.6540]	-0.05605 [-0.0677, -0.04538]	[-0.1714, 0.05928]	0.1411 [0.1186, 0.1844]	nontransferable / open
p	width	0.5492 [0.4107, 0.6696]	-0.04854 [-0.07574, -0.02048]	[-0.3401, 0.2430]	0.3444 [0.2660, 0.3807]	nontransferable / open
qrs	planarity	0.6939 [0.5609, 0.7982]	-0.02259 [-0.03096, -0.01432]	[-0.1264, 0.08118]	0.1055 [0.09249, 0.1551]	nontransferable / nontransferable
qrs	width	0.8025 [0.7217, 0.8631]	-0.02495 [-0.04445, -0.003924]	[-0.2706, 0.2207]	0.2649 [0.1982, 0.3095]	nontransferable / nontransferable
t	planarity	0.6748 [0.5142, 0.8223]	-0.006269 [-0.01267, 0.0003616]	[-0.0855, 0.07296]	0.0737 [0.04753, 0.09124]	nontransferable / nontransferable
t	width	0.7358 [0.6513, 0.8026]	-0.003603 [-0.02846, 0.01878]	[-0.2960, 0.2888]	0.2877 [0.2621, 0.3849]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Myocardial infarction, Kors, Rotation direction. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.6125 [0.3733, 0.8025]	-0.009524 [-0.07619, 0.05714]	[-0.7022, 0.6832]	1.0 [0, 1.0]	conditional / open
p	turn_left sagittal	0.3875 [0.1164, 0.6418]	-0.01905 [-0.09548, 0.05714]	[-0.8336, 0.7955]	1.0 [0.8000, 1.0]	nontransferable / open
p	turn_transversal	0.4656 [0.2814, 0.6503]	-0.1048 [-0.2190, 0.009524]	[-1.318, 1.108]	1.800 [1.0, 2.0]	nontransferable / open
qrs	turn_frontal	0.7695 [0.6755, 0.8507]	0.08904 [-0.0137, 0.1918]	[-1.127, 1.305]	2.0 [1.0, 2.0]	conditional / open
qrs	turn_left sagittal	0.6493 [0.5238, 0.7590]	0.0274 [-0.06849, 0.1233]	[-1.145, 1.200]	2.0 [1.0, 2.0]	conditional / open
qrs	turn_transversal	0.7940 [0.6578, 0.9067]	0.02055 [-0.04795, 0.09589]	[-0.8243, 0.8654]	1.0 [0, 2.0]	conditional / open
t	turn_frontal	0.6469 [0.5502, 0.7430]	0.06207 [-0.1103, 0.2345]	[-1.968, 2.092]	3.000 [2.0, 3.000]	nontransferable / open
t	turn_left sagittal	0.7509 [0.6529, 0.8458]	-0.03448 [-0.1379, 0.06897]	[-1.287, 1.218]	2.0 [1.0, 2.0]	conditional / open
t	turn_transversal	0.7595 [0.6597, 0.8471]	-0.01379 [-0.1310, 0.1103]	[-1.437, 1.410]	2.0 [1.0, 3.000]	conditional / open

P95 relative [interval]: unavailable for every row.

Myocardial infarction, Kors, Shape. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.01343 [0.01231, 0.01476]	[0.0006932, 0.02617]	0.02302 [0.02005, 0.03186]	rule met, restricted / open
p	rms_unrotated	0.01995 [0.0181, 0.02222]	[-0.0009955, 0.04089]	0.03295 [0.02796, 0.06166]	rule met, restricted / open
qrs	rms_procrustes	0.009262 [0.008548, 0.01002]	[0.0001468, 0.01838]	0.01636 [0.01479, 0.02132]	rule met, restricted / open
qrs	rms_unrotated	0.01466 [0.01354, 0.01581]	[0.0007858, 0.02854]	0.02747 [0.02265, 0.03205]	rule met, restricted / open
t	rms_procrustes	0.01001 [0.008956, 0.01125]	[-0.00348, 0.0235]	0.02213 [0.01785, 0.0275]	rule met, restricted / open
t	rms_unrotated	0.01596 [0.01443, 0.01775]	[-0.003394, 0.03532]	0.03277 [0.02696, 0.0374]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Myocardial infarction, Kors, Principal direction. Finite pairs/persons and unit by segment: p: 105/105, degrees; qrs: 146/146, degrees; qrst: 145/145, degrees; st: 99/99, degrees; t: 145/145, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	-3.376 [-10.40, 3.540]	[-92.05, 84.77]	105.9 [75.46, 130.6]	nontransferable / open
p	integral_elevation	2.612 [-2.832, 8.071]	[-50.46, 55.68]	61.49 [33.96, 84.83]	nontransferable / open
p	peak_azimuth	-6.447 [-13.90, 0.3966]	[-101.4, 85.24]	121.3 [84.71, 131.2]	nontransferable / open
p	peak_elevation	1.526 [-4.607, 7.678]	[-60.18, 63.23]	72.01 [37.25, 108.1]	nontransferable / open
qrs	integral_azimuth	5.711 [3.081, 8.335]	[-27.27, 38.97]	38.77 [29.92, 49.63]	conditional / open
qrs	integral_elevation	-0.9198 [-3.405, 1.407]	[-28.89, 27.05]	32.94 [23.29, 38.49]	conditional / open
qrs	peak_azimuth	6.704 [3.810, 9.674]	[-42.62, 53.35]	44.77 [32.21, 74.31]	nontransferable / open
qrs	peak_elevation	-1.391 [-3.423, 0.7613]	[-26.25, 23.47]	24.02 [19.49, 29.50]	conditional / open
qrst	angle_integral	2.118 [-1.445, 5.755]	[-41.83, 46.06]	49.49 [35.32, 61.39]	nontransferable / open
qrst	angle_peak	4.768 [0.06351, 9.408]	[-52.72, 62.26]	69.75 [46.27, 95.49]	nontransferable / open
st	azimuth	1.938 [-3.649, 7.585]	[-69.92, 78.92]	82.13 [45.90, 120.2]	nontransferable / open
st	elevation	1.296 [-4.140, 6.597]	[-51.33, 53.92]	54.54 [40.91, 82.16]	nontransferable / open
t	integral_azimuth	-0.4543 [-4.132, 3.170]	[-66.37, 66.18]	62.53 [41.76, 112.7]	nontransferable / open
t	integral_elevation	2.658 [-1.333, 6.368]	[-43.74, 49.05]	52.31 [37.11, 79.26]	nontransferable / open
t	peak_azimuth	-0.8002 [-4.766, 3.057]	[-91.09, 80.48]	100.8 [67.49, 167.9]	nontransferable / open
t	peak_elevation	1.612 [-1.785, 4.799]	[-38.38, 41.60]	42.64 [29.98, 59.95]	nontransferable / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Myocardial infarction, Kors, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 105/105, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 105/105, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 146/146, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 146/146, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 145/145, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 145/145, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.8549 [0.7563, 0.9176]	0.0005867 [0.0003364, 0.0008466]	[-0.00203, 0.003203]	a: 0.003213 [0.002753, 0.003755]; r: 200.00 [108.38, 200.00]	nontransferable / open
p	area_left sagittal	0.7574 [0.6649, 0.8343]	-0.0003689 [-0.0006698, -4.06e-05]	[-0.003708, 0.002971]	a: 0.003644 [0.00255, 0.004329]; r: 200.00 [156.36, 200.00]	nontransferable / open
p	area_transversal	0.5179 [0.3651, 0.6375]	0.001138 [0.0008932, 0.001368]	[-0.001323, 0.0036]	a: 0.002954 [0.002479, 0.004157]; r: 200.00 [156.80, 200.00]	nontransferable / open
p	integral_magnitude	0.8268 [0.6428, 0.8657]	0.7572 [0.02265, 1.526]	[-6.965, 8.479]	a: 7.993 [5.541, 9.793]; r: 69.73 [43.88, 76.63]	nontransferable / open
p	integral_vector	0.8099 [0.6194, 0.8541]	0.7783 [-0.0109, 1.581]	[-7.433, 8.990]	a: 8.431 [6.479, 9.815]; r: 89.71 [65.13, 114.82]	nontransferable / open
p	integral_x	0.4170 [0.1960, 0.7715]	0.5143 [-0.5928, 1.371]	[-9.958, 10.99]	a: 6.940 [4.257, 10.43]; r: 200.00 [183.34, 200.00]	nontransferable / open
p	integral_y	0.4735 [0.0975, 0.8032]	-0.3128 [-1.488, 0.9084]	[-12.38, 11.75]	a: 10.12 [6.404, 21.54]; r: 200.00 [199.47, 200.00]	nontransferable / open
p	integral_z	0.8401 [0.3823, 0.9295]	0.07787 [-0.5194, 0.7318]	[-6.561, 6.716]	a: 8.446 [4.407, 11.92]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.9804 [0.9512, 0.9923]	-0.01845 [-0.03371, -0.004443]	[-0.2027, 0.1658]	a: 0.1994 [0.1362, 0.2572]; r: 200.00 [153.67, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.8555 [0.8104, 0.8854]	-0.04392 [-0.06461, -0.02182]	[-0.3061, 0.2183]	a: 0.2800 [0.2304, 0.3741]; r: 200.00 [198.35, 200.00]	nontransferable / open
qrs	area_transversal	0.9041 [0.8478, 0.9387]	0.06456 [0.03739, 0.09028]	[-0.2477, 0.3768]	a: 0.3344 [0.2874, 0.4035]; r: 147.28 [113.75, 188.25]	nontransferable / open
qrs	integral_magnitude	0.9126 [0.8698, 0.9431]	3.796 [2.399, 5.312]	[-14.23, 21.82]	a: 19.10 [15.15, 25.23]; r: 36.09 [33.30, 39.23]	conditional / conditional
qrs	integral_vector	0.8887 [0.8375, 0.9270]	3.284 [1.716, 4.937]	[-16.14, 22.71]	a: 21.23 [15.19, 30.74]; r: 55.41 [45.69, 58.79]	nontransferable / nontransferable
qrs	integral_x	0.9273 [0.8635, 0.9711]	-0.01232 [-1.143, 1.107]	[-13.89, 13.86]	a: 11.25 [8.886, 16.43]; r: 153.81 [93.95, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_y	0.8414 [0.7504, 0.9126]	2.003 [0.5193, 3.627]	[-16.66, 20.66]	a: 23.04 [12.45, 34.47]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	integral_z	0.8399 [0.8016, 0.8759]	4.550 [2.522, 6.557]	[-19.38, 28.48]	a: 26.91 [21.35, 35.05]; r: 200.00 [151.09, 200.00]	nontransferable / open
t	area_frontal	0.9481 [0.9050, 0.9695]	0.0002769 [-0.0004367, 0.0009845]	[-0.008196, 0.00875]	a: 0.009037 [0.00616, 0.01296]; r: 200.00 [182.82, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.9246 [0.8635, 0.9576]	-0.001814 [-0.003235, -0.0005516]	[-0.01838, 0.01475]	a: 0.01672 [0.01475, 0.01931]; r: 192.81 [141.82, 200.00]	nontransferable / open
t	area_transversal	0.8888 [0.7947, 0.9517]	0.002817 [0.001329, 0.004456]	[-0.01631, 0.02194]	a: 0.01846 [0.01203, 0.02505]; r: 200.00 [179.68, 200.00]	nontransferable / open
t	integral_magnitude	0.8345 [0.7841, 0.8781]	6.329 [4.697, 8.092]	[-15.25, 27.91]	a: 26.83 [19.29, 31.75]; r: 54.47 [45.17, 58.07]	nontransferable / nontransferable
t	integral_vector	0.8274 [0.7805, 0.8690]	6.008 [4.238, 7.935]	[-16.79, 28.81]	a: 26.87 [20.02, 31.02]; r: 73.26 [56.20, 93.05]	nontransferable / nontransferable
t	integral_x	0.8761 [0.7702, 0.9483]	1.714 [-0.05793, 3.460]	[-20.05, 23.48]	a: 20.13 [12.54, 24.73]; r: 200.00 [183.13, 200.00]	nontransferable / nontransferable
t	integral_y	0.7411 [0.5594, 0.8757]	-0.7441 [-2.818, 1.590]	[-28.39, 26.91]	a: 24.84 [20.27, 34.13]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_z	0.8618 [0.7947, 0.9089]	-5.046 [-7.040, -3.150]	[-28.78, 18.69]	a: 24.23 [19.39, 29.18]; r: 200.00 [188.26, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Myocardial infarction, Kors, Notches/bites. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	-0.6000 [-0.8193, -0.3810]	[-2.835, 1.635]	2.0 [2.0, 3.000]	open / open
p	count_60	unavailable	-0.4762 [-0.7238, -0.2381]	[-2.939, 1.987]	3.000 [2.0, 3.000]	open / open
p	count_80	unavailable	-0.1905 [-0.4286, 0.0381]	[-2.530, 2.149]	2.0 [2.0, 3.000]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	0.0000 [not estimable]	0.009524 [0, 0.02857]	[-0.1818, 0.2008]	0 [0, 0]	open / open
p	present_80	0.4706 [-0.0234, 0.7953]	-0.01905 [-0.06667, 0.02857]	[-0.4883, 0.4502]	0.8000 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.2466 [-0.3904, -0.09589]	[-2.096, 1.603]	2.0 [1.750, 2.0]	open / open
qrs	count_60	unavailable	-0.2192 [-0.3562, -0.08219]	[-1.871, 1.433]	2.0 [1.0, 2.0]	open / open
qrs	count_80	unavailable	-0.1507 [-0.2671, -0.0274]	[-1.576, 1.275]	1.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_80	0.2918 [-0.0308, 0.5636]	-0.0274 [-0.07534, 0.02055]	[-0.5887, 0.5339]	1.0 [0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	-0.04138 [-0.4484, 0.3586]	[-4.989, 4.907]	6.000 [4.0, 7.800]	open / open
t	count_60	unavailable	-0.2759 [-0.5862, 0.02759]	[-3.961, 3.409]	4.0 [2.0, 6.000]	open / open
t	count_80	unavailable	-0.2000 [-0.4414, 0.01379]	[-2.919, 2.519]	2.800 [1.995, 4.0]	open / open
t	present_40	0.4740 [0.3105, 0.6313]	0.01379 [-0.05517, 0.08966]	[-0.8804, 0.9080]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_60	0.5500 [0.4048, 0.6859]	-0.04138 [-0.1174, 0.02759]	[-0.9617, 0.8790]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.6086 [0.4527, 0.7481]	-0.04138 [-0.1034, 0.02069]	[-0.8031, 0.7204]	1.0 [1.0, 1.0]	conditional / conditional

P95 relative [interval]: unavailable for every row.

Myocardial infarction, inverse Dower, Amplitudes. Finite pairs/persons and unit by segment: p: 105/105, mV; qrs: 146/146, mV; t: 145/145, mV.

Segment	Metric	ICC or κ [inter-val]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	peak_magnitude	0.8331 [0.7305, 0.9026]	-0.007378 [-0.01392, -0.001124]	[-0.07337, 0.05862]	a: 0.07131 [0.05193, 0.08813]; r: 47.47 [34.53, 60.44]	conditional / open
p	peak_x	0.5043 [0.2691, 0.7040]	0.00594 [-0.002975, 0.01446]	[-0.08527, 0.09715]	a: 0.08811 [0.06338, 0.1499]; r: 200.00 [153.42, 200.00]	nontransferable / open
p	peak_y	0.6040 [0.2832, 0.8614]	-0.0107 [-0.02617, 0.004913]	[-0.1637, 0.1423]	a: 0.1088 [0.06649, 0.2186]; r: 200.00 [200.00, 200.00]	nontransferable / open
p	peak_z	0.5499 [0.1905, 0.7565]	0.01256 [0.002688, 0.02301]	[-0.09408, 0.1192]	a: 0.1042 [0.09109, 0.1418]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	peak_magnitude	0.7100 [0.5760, 0.8054]	0.2426 [0.1959, 0.2935]	[-0.3599, 0.8451]	a: 0.7967 [0.7097, 0.8228]; r: 62.02 [47.51, 66.83]	nontransferable / nontransferable
qrs	peak_x	0.8356 [0.7535, 0.8985]	-0.1037 [-0.1593, -0.04857]	[-0.7625, 0.5552]	a: 0.7288 [0.5104, 1.137]; r: 200.00 [196.32, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.8526 [0.7655, 0.9132]	0.07164 [0.02961, 0.1130]	[-0.4624, 0.6057]	a: 0.6504 [0.4315, 0.8010]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.6027 [0.5094, 0.6831]	0.3971 [0.3155, 0.4779]	[-0.6133, 1.408]	a: 1.276 [1.089, 1.471]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	peak_magnitude	0.6790 [0.5855, 0.7623]	0.09354 [0.07558, 0.1129]	[-0.1399, 0.3270]	a: 0.2883 [0.2492, 0.3658]; r: 80.62 [67.29, 90.70]	nontransferable / nontransferable
t	peak_x	0.8545 [0.7864, 0.9100]	0.01256 [-0.003766, 0.02748]	[-0.1859, 0.2110]	a: 0.2211 [0.1364, 0.3481]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_y	0.7705 [0.6525, 0.8568]	-0.0341 [-0.04968, -0.01818]	[-0.2242, 0.1560]	a: 0.2089 [0.1341, 0.2875]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	peak_z	0.7262 [0.6399, 0.7925]	-0.08179 [-0.1090, -0.05477]	[-0.4151, 0.2515]	a: 0.3368 [0.2822, 0.3778]; r: 200.00 [200.00, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Myocardial infarction, inverse Dower, Width/planarity. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	planarity	0.6019 [0.3990, 0.7642]	-0.02491 [-0.03812, -0.01232]	[-0.1593, 0.1095]	0.1362 [0.1042, 0.2121]	nontransferable / open
p	width	0.4013 [0.2431, 0.5407]	-0.06504 [-0.09632, -0.03326]	[-0.3947, 0.2646]	0.3826 [0.3041, 0.4096]	nontransferable / open
qrs	planarity	0.5651 [0.4288, 0.6874]	-0.03392 [-0.0431, -0.02464]	[-0.1511, 0.08326]	0.1203 [0.1102, 0.1655]	nontransferable / nontransferable
qrs	width	0.6168 [0.4963, 0.7060]	-0.03702 [-0.06355, -0.009052]	[-0.3720, 0.2980]	0.3271 [0.2795, 0.3730]	nontransferable / nontransferable
t	planarity	0.6767 [0.4691, 0.8176]	-0.01363 [-0.0199, -0.007118]	[-0.09025, 0.063]	0.07407 [0.05812, 0.1084]	nontransferable / nontransferable
t	width	0.4599 [0.3428, 0.5696]	-0.05777 [-0.09026, -0.02605]	[-0.4500, 0.3344]	0.4261 [0.3502, 0.4862]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Myocardial infarction, inverse Dower, Rotation direction. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	turn_frontal	0.4916 [0.2804, 0.6790]	0.08571 [-0.009524, 0.1905]	[-0.9354, 1.107]	1.0 [1.0, 2.0]	nontransferable / open
p	turn_left sagittal	0.4478 [0.1802, 0.6738]	0.02857 [-0.05714, 0.1143]	[-0.8073, 0.8644]	1.0 [1.0, 1.0]	nontransferable / open
p	turn_transversal	0.3127 [0.1243, 0.4902]	-0.04762 [-0.1714, 0.06667]	[-1.275, 1.179]	1.0 [1.0, 2.0]	nontransferable / open
qrs	turn_frontal	0.5670 [0.4465, 0.6746]	-0.1096 [-0.2397, 0.006849]	[-1.690, 1.471]	2.0 [2.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.6359 [0.5181, 0.7454]	0.08219 [-0.02055, 0.1849]	[-1.189, 1.354]	2.0 [1.0, 2.0]	conditional / open
qrs	turn_transversal	0.5807 [0.4013, 0.7385]	-0.0274 [-0.1096, 0.05479]	[-1.003, 0.9477]	1.0 [1.0, 2.0]	nontransferable / open
t	turn_frontal	0.5730 [0.4651, 0.6765]	-0.006897 [-0.1586, 0.1379]	[-1.804, 1.790]	2.0 [2.0, 2.800]	nontransferable / open
t	turn_left sagittal	0.8026 [0.7086, 0.8919]	-0.05517 [-0.1517, 0.03448]	[-1.228, 1.118]	2.0 [0.8000, 2.0]	conditional / open
t	turn_transversal	0.5471 [0.4378, 0.6550]	0.02069 [-0.1241, 0.1724]	[-1.776, 1.817]	2.0 [2.0, 3.000]	nontransferable / open

P95 relative [interval]: unavailable for every row.

Myocardial infarction, inverse Dower, Shape. Finite pairs/persons and unit by segment: p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	rms_procrustes	0.01504 [0.01403, 0.01612]	[0.004004, 0.02608]	0.0253 [0.02178, 0.02934]	rule met, restricted / open
p	rms_unrotated	0.02265 [0.02067, 0.0249]	[0.0008353, 0.04447]	0.04049 [0.03147, 0.05027]	rule met, restricted / open
qrs	rms_procrustes	0.01382 [0.01292, 0.01474]	[0.002732, 0.02491]	0.02393 [0.02121, 0.02863]	rule met, restricted / open
qrs	rms_unrotated	0.02397 [0.02254, 0.02532]	[0.007322, 0.04062]	0.03911 [0.03612, 0.04187]	rule met, restricted / open
t	rms_procrustes	0.01519 [0.01393, 0.01658]	[-0.0006112, 0.03099]	0.02952 [0.025, 0.0326]	rule met, restricted / open
t	rms_unrotated	0.02524 [0.02351, 0.02711]	[0.004274, 0.04621]	0.04387 [0.04138, 0.04956]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Myocardial infarction, inverse Dower, Principal direction. Finite pairs/persons and unit by segment: p: 105/105, degrees; qrs: 146/146, degrees; qrst: 145/145, degrees; st: 99/99, degrees; t: 145/145, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	integral_azimuth	13.01 [5.074, 21.63]	[-91.04, 108.9]	113.6 [71.98, 146.4]	nontransferable / open
p	integral_elevation	5.684 [0.2927, 11.34]	[-48.12, 59.49]	61.37 [39.99, 84.53]	nontransferable / open
p	peak_azimuth	14.51 [6.011, 23.51]	[-94.58, 121.1]	125.7 [98.99, 142.8]	nontransferable / open
p	peak_elevation	3.733 [-2.128, 9.887]	[-56.18, 63.65]	65.54 [36.63, 102.7]	nontransferable / open
qrs	integral_azimuth	15.06 [11.80, 18.23]	[-30.46, 62.19]	50.92 [37.07, 68.42]	nontransferable / open
qrs	integral_elevation	1.402 [-1.113, 3.868]	[-27.82, 30.63]	34.24 [25.32, 38.86]	conditional / open
qrs	peak_azimuth	19.46 [15.69, 23.42]	[-50.51, 85.72]	91.84 [51.75, 115.6]	nontransferable / open
qrs	peak_elevation	1.428 [-1.133, 4.186]	[-31.65, 34.51]	32.57 [26.14, 37.07]	conditional / open
qrst	angle_integral	7.726 [3.442, 12.10]	[-46.24, 61.70]	54.06 [43.38, 73.14]	nontransferable / open
qrst	angle_peak	11.89 [5.610, 17.93]	[-62.73, 86.50]	84.90 [66.30, 109.5]	nontransferable / open
st	azimuth	5.814 [-0.07859, 11.75]	[-64.68, 78.15]	91.16 [53.85, 119.4]	nontransferable / open
st	elevation	-0.4878 [-6.033, 4.921]	[-54.95, 53.97]	51.47 [44.74, 87.20]	nontransferable / open
t	integral_azimuth	1.017 [-4.075, 5.842]	[-76.45, 87.02]	76.32 [59.50, 159.5]	nontransferable / open
t	integral_elevation	3.702 [-0.2398, 7.355]	[-42.13, 49.54]	50.65 [33.31, 71.84]	nontransferable / open
t	peak_azimuth	0.8125 [-5.140, 6.203]	[-98.45, 94.28]	115.9 [80.27, 166.0]	nontransferable / open
t	peak_elevation	3.856 [0.2002, 7.242]	[-40.78, 48.49]	48.46 [35.01, 60.12]	nontransferable / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

Myocardial infarction, inverse Dower, Integrals/areas. Finite pairs/persons and unit by segment: p (area_frontal, area_left sagittal, area_transversal): 105/105, mV2; p (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 105/105, mV_ms; qrs (area_frontal, area_left sagittal, area_transversal): 146/146, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 146/146, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 145/145, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 145/145, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
p	area_frontal	0.6480 [0.5101, 0.7512]	0.001461 [0.001157, 0.001786]	[-0.00178, 0.004702]	a: 0.004687 [0.003532, 0.005934]; r: 200.00 [150.78, 200.00]	nontransferable / open
p	area_left sagittal	0.6865 [0.5941, 0.7868]	0.0005217 [0.0001899, 0.0008714]	[-0.003103, 0.004146]	a: 0.004095 [0.002847, 0.005415]; r: 200.00 [192.52, 200.00]	nontransferable / open
p	area_transversal	0.6318 [0.4279, 0.7630]	0.0001609 [-8.915e-05, 0.0003997]	[-0.0023, 0.002622]	a: 0.002448 [0.002032, 0.003164]; r: 200.00 [168.44, 200.00]	nontransferable / open
p	integral_magnitude	0.8389 [0.6527, 0.8979]	-0.1546 [-0.8619, 0.5673]	[-7.535, 7.226]	a: 8.506 [5.576, 12.65]; r: 64.73 [44.92, 79.66]	nontransferable / open
p	integral_vector	0.8258 [0.6452, 0.8871]	0.01874 [-0.7154, 0.7752]	[-7.746, 7.784]	a: 8.735 [5.556, 13.18]; r: 84.00 [54.14, 117.03]	nontransferable / open
p	integral_x	0.4737 [0.2354, 0.7837]	0.009924 [-0.9754, 0.7579]	[-8.996, 9.016]	a: 6.143 [3.757, 9.945]; r: 200.00 [175.18, 200.00]	nontransferable / open
p	integral_y	0.4870 [0.1112, 0.8050]	-0.9531 [-2.074, 0.2092]	[-12.32, 10.41]	a: 9.306 [6.355, 20.73]; r: 200.00 [195.84, 200.00]	nontransferable / open
p	integral_z	0.7941 [0.3682, 0.9100]	0.9363 [0.2334, 1.695]	[-6.589, 8.462]	a: 8.311 [5.872, 10.25]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_frontal	0.9418 [0.8611, 0.9738]	0.04219 [0.01713, 0.06683]	[-0.2707, 0.3551]	a: 0.3158 [0.2517, 0.4918]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.8274 [0.7465, 0.8894]	-0.02508 [-0.05219, 0.003112]	[-0.3538, 0.3037]	a: 0.3389 [0.3162, 0.4377]; r: 200.00 [200.00, 200.00]	nontransferable / open
qrs	area_transversal	0.6931 [0.5931, 0.7624]	0.2167 [0.1608, 0.2766]	[-0.4648, 0.8983]	a: 0.8802 [0.6305, 1.124]; r: 200.00 [166.88, 200.00]	nontransferable / open
qrs	integral_magnitude	0.8353 [0.7594, 0.8871]	8.369 [6.467, 10.27]	[-14.64, 31.38]	a: 29.37 [22.96, 38.97]; r: 53.81 [45.03, 58.38]	nontransferable / nontransferable
qrs	integral_vector	0.8146 [0.7321, 0.8712]	6.399 [4.410, 8.575]	[-18.75, 31.55]	a: 27.94 [23.94, 42.66]; r: 70.52 [63.86, 79.97]	nontransferable / nontransferable
qrs	integral_x	0.8420 [0.7586, 0.9012]	-4.020 [-5.559, -2.521]	[-23.36, 15.32]	a: 21.42 [15.55, 29.09]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	integral_y	0.8588 [0.7779, 0.9168]	2.169 [0.7930, 3.732]	[-15.41, 19.74]	a: 21.02 [11.80, 31.94]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	integral_z	0.7421 [0.6812, 0.7913]	9.368 [6.810, 12.04]	[-22.37, 41.10]	a: 40.60 [31.66, 45.75]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	area_frontal	0.8227 [0.7265, 0.8749]	0.001858 [0.000408, 0.003414]	[-0.0162, 0.01992]	a: 0.01829 [0.01187, 0.03219]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.8340 [0.7631, 0.8931]	-0.00182 [-0.003825, 0.0001158]	[-0.02744, 0.0238]	a: 0.02459 [0.01928, 0.03645]; r: 200.00 [169.67, 200.00]	nontransferable / open
t	area_transversal	0.7926 [0.6652, 0.8701]	0.00149 [-0.001326, 0.004177]	[-0.03155, 0.03453]	a: 0.03579 [0.02505, 0.05224]; r: 200.00 [200.00, 200.00]	nontransferable / open
t	integral_magnitude	0.7099 [0.6167, 0.7879]	11.59 [9.514, 13.90]	[-15.27, 38.45]	a: 35.57 [29.22, 47.25]; r: 73.49 [68.14, 90.53]	nontransferable / nontransferable
t	integral_vector	0.7076 [0.6158, 0.7821]	10.65 [8.396, 13.06]	[-18.02, 39.32]	a: 37.24 [29.42, 47.75]; r: 87.98 [76.04, 119.12]	nontransferable / nontransferable
t	integral_x	0.8429 [0.7411, 0.9192]	1.666 [-0.3823, 3.562]	[-23.31, 26.64]	a: 22.61 [16.72, 33.08]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_y	0.7161 [0.5224, 0.8469]	-3.699 [-5.835, -1.259]	[-31.81, 24.41]	a: 24.40 [19.84, 37.00]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
t	integral_z	0.7363 [0.6624, 0.7947]	-9.792 [-12.64, -6.994]	[-44.64, 25.06]	a: 37.90 [34.60, 47.56]; r: 200.00 [200.00, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

Myocardial infarction, inverse Dower, Notches/bites. Finite pairs/persons and unit by segment:
p: 105/105, dimensionless/count/category; qrs: 146/146, dimensionless/count/category; t: 145/145, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
p	count_40	unavailable	-0.07619 [-0.3619, 0.1905]	[-2.897, 2.744]	3.000 [2.0, 4.0]	open / open
p	count_60	unavailable	-0.1619 [-0.4286, 0.09524]	[-2.854, 2.531]	2.800 [2.0, 3.000]	open / open
p	count_80	unavailable	0.07619 [-0.1714, 0.3143]	[-2.455, 2.607]	3.000 [2.0, 3.000]	open / open
p	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
p	present_60	0.0000 [not estimable]	0.009524 [0, 0.02857]	[-0.1818, 0.2008]	0 [0, 0]	open / open
p	present_80	0.4706 [-0.0234, 0.7953]	-0.01905 [-0.06667, 0.02857]	[-0.4883, 0.4502]	0.8000 [0, 1.0]	nontransferable / open
qrs	count_40	unavailable	-0.3014 [-0.5137, -0.1026]	[-2.763, 2.160]	3.000 [2.0, 3.000]	open / open
qrs	count_60	unavailable	-0.1849 [-0.3288, -0.0411]	[-1.953, 1.583]	2.0 [1.0, 2.0]	open / open
qrs	count_80	unavailable	-0.0274 [-0.1712, 0.1301]	[-1.854, 1.799]	2.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	0.0000 [not estimable]	-0.0137 [-0.03425, 0]	[-0.2423, 0.2149]	0 [0, 0]	open / open
qrs	present_80	0.2271 [-0.0463, 0.5267]	-0.006849 [-0.04795, 0.03425]	[-0.5465, 0.5328]	1.0 [0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	-0.9793 [-1.545, -0.4690]	[-7.362, 5.403]	+8.0 [5.000, 9.000]	open / open
t	count_60	unavailable	-0.7448 [-1.138, -0.4000]	[-5.258, 3.768]	4.800 [3.800, 7.000]	open / open
t	count_80	unavailable	-0.4276 [-0.7588, -0.1655]	[-4.056, 3.201]	3.000 [2.0, 5.000]	open / open
t	present_40	0.3569 [0.1989, 0.5095]	-0.08966 [-0.1724, -0.006897]	[-1.121, 0.9412]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_60	0.3702 [0.2172, 0.5207]	-0.1241 [-0.2138, -0.03448]	[-1.180, 0.9314]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.4169 [0.2341, 0.5834]	-0.08966 [-0.1588, -0.01379]	[-0.9818, 0.8025]	1.0 [1.0, 1.0]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

unknown, Kors, Amplitudes. Finite pairs/persons and unit by segment: qrs: 21/21, mV; t: 21/21, mV.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	peak_magnitude	0.8515 [0.7824, 0.9847]	-0.09819 [-0.5031, 0.1587]	[-1.776, 1.580]	a: 0.6611 [0.2460, 3.711]; r: 35.64 [11.49, 51.30]	conditional / conditional
qrs	peak_x	0.9098 [0.8123, 0.9675]	0.2333 [-0.05861, 0.5981]	[-1.320, 1.786]	a: 1.727 [0.2239, 2.899]; r: 124.19 [40.62, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.8107 [0.6201, 0.9584]	-0.03061 [-0.3623, 0.2394]	[-1.475, 1.414]	a: 1.661 [0.3559, 2.218]; r: 200.00 [90.08, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.6015 [0.1560, 0.8841]	0.1818 [-0.1788, 0.4815]	[-1.345, 1.709]	a: 1.196 [0.9702, 2.600]; r: 200.00 [160.18, 200.00]	nontransferable / open
t	peak_magnitude	0.9828 [0.9359, 0.9946]	-0.008107 [-0.03466, 0.01898]	[-0.1330, 0.1168]	a: 0.1386 [0.06343, 0.1467]; r: 24.91 [17.48, 58.35]	rule met, restricted / rule met, restricted
t	peak_x	0.9793 [0.9425, 0.9939]	0.007015 [-0.01202, 0.02605]	[-0.08388, 0.09791]	a: 0.09284 [0.05947, 0.1192]; r: 160.72 [47.01, 193.78]	nontransferable / nontransferable
t	peak_y	0.8604 [0.8022, 0.9528]	0.001154 [-0.05041, 0.07169]	[-0.3025, 0.3048]	a: 0.1785 [0.08015, 0.6096]; r: 200.00 [64.52, 200.00]	nontransferable / nontransferable
t	peak_z	0.9360 [0.8917, 0.9714]	-0.004647 [-0.05478, 0.06011]	[-0.2839, 0.2746]	a: 0.1782 [0.1111, 0.5121]; r: 200.00 [79.47, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

unknown, Kors, Width/planarity. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	planarity	0.7797 [0.3933, 0.9200]	-0.0008998 [-0.0157, 0.01384]	[-0.06927, 0.06747]	0.07331 [0.03051, 0.08411]	conditional / conditional
qrs	width	0.6953 [0.2001, 0.9046]	0.003559 [-0.0496, 0.07299]	[-0.2779, 0.2850]	0.2468 [0.1374, 0.4478]	nontransferable / nontransferable
t	planarity	0.8887 [0.7819, 0.9756]	0.008764 [0.001924, 0.01742]	[-0.02884, 0.04637]	0.02598 [0.01478, 0.07895]	conditional / conditional
t	width	0.8861 [0.7723, 0.9436]	0.02009 [-0.0267, 0.06659]	[-0.1948, 0.2350]	0.2151 [0.1107, 0.2232]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

unknown, Kors, Rotation direction. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	turn_frontal	0.4615 [0.1515, 0.7539]	-0.09524 [-0.4762, 0.2857]	[-1.838, 1.647]	2.0 [1.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.6613 [0.3668, 0.9041]	-0.3333 [-0.7143, -0.04762]	[-1.893, 1.226]	2.0 [0, 3.000]	conditional / open
qrs	turn_transversal	0.6744 [0.0000, 1.0000]	-0.04762 [-0.2857, 0.1429]	[-1.023, 0.9277]	1.0 [0, 2.0]	conditional / open
t	turn_frontal	0.6599 [0.3891, 0.9087]	-0.04762 [-0.4286, 0.2857]	[-1.742, 1.647]	2.0 [0, 3.000]	conditional / open
t	turn_left sagittal	0.6056 [0.2575, 0.8986]	0.1429 [-0.1905, 0.5238]	[-1.530, 1.816]	2.0 [0, 3.000]	conditional / open
t	turn_transversal	0.5059 [-0.0328, 0.8772]	0.1905 [0.04762, 0.3810]	[-0.5982, 0.9791]	1.0 [0, 1.0]	nontransferable / open

P95 relative [interval]: unavailable for every row.

unknown, Kors, Shape. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	rms_procrustes	0.01149 [0.007095, 0.01729]	[-0.01317, 0.03614]	0.02868 [0.01434, 0.0578]	rule met, restricted / open
qrs	rms_unrotated	0.01695 [0.01226, 0.02264]	[-0.00823, 0.04213]	0.03437 [0.02257, 0.05967]	rule met, restricted / open
t	rms_procrustes	0.008233 [0.006135, 0.0104]	[-0.001931, 0.0184]	0.01793 [0.011, 0.02001]	rule met, restricted / open
t	rms_unrotated	0.01409 [0.01029, 0.01876]	[-0.00613, 0.0343]	0.02618 [0.01761, 0.04947]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

unknown, Kors, Principal direction. Finite pairs/persons and unit by segment: qrs: 21/21, degrees; qrst: 21/21, degrees; t: 21/21, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	integral_azimuth	1.080 [-8.056, 11.66]	[-44.34, 47.39]	42.87 [22.19, 66.18]	nontransferable / open
qrs	integral_elevation	-0.9603 [-5.530, 3.920]	[-23.66, 21.74]	22.61 [12.58, 23.05]	conditional / open
qrs	peak_azimuth	6.792 [-1.827, 15.45]	[-34.74, 48.06]	47.11 [24.19, 55.49]	nontransferable / open
qrs	peak_elevation	-2.930 [-9.732, 2.561]	[-31.79, 25.93]	25.16 [9.284, 56.24]	conditional / open
qrst	angle_integral	9.576 [-1.527, 20.88]	[-44.51, 63.66]	55.08 [31.26, 67.17]	nontransferable / open
qrst	angle_peak	4.172 [-2.587, 10.23]	[-25.58, 33.92]	30.02 [21.39, 31.96]	conditional / open
t	integral_azimuth	9.988 [-0.1892, 23.18]	[-52.55, 78.70]	70.89 [23.77, 121.5]	nontransferable / open
t	integral_elevation	5.896 [-2.316, 14.70]	[-35.76, 47.55]	35.46 [21.56, 66.87]	conditional / open
t	peak_azimuth	6.004 [0.4508, 12.92]	[-23.55, 36.10]	36.79 [10.93, 51.97]	conditional / open
t	peak_elevation	1.489 [-4.493, 8.235]	[-29.44, 32.41]	30.19 [13.98, 47.82]	conditional / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

unknown, Kors, Integrals/areas. Finite pairs/persons and unit by segment: qrs (area_frontal, area_left sagittal, area_transversal): 21/21, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 21/21, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 21/21, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 21/21, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	area_frontal	-0.0997 [-0.2164, 0.9826]	0.8486 [-0.2239, 2.690]	[-6.965, 8.662]	a: 2.531 [0.2671, 18.05]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.3895 [0.3145, 0.9738]	-0.6855 [-2.136, 0.1505]	[-6.879, 5.508]	a: 1.681 [0.2899, 14.34]; r: 200.00 [161.10, 200.00]	nontransferable / open
qrs	area_transversal	0.2571 [0.2004, 0.9583]	-1.262 [-3.463, 0.03574]	[-10.10, 7.577]	a: 6.560 [0.3326, 19.90]; r: 200.00 [94.84, 200.00]	nontransferable / open
qrs	integral_magnitude	0.9439 [0.8797, 0.9764]	-2.143 [-7.026, 2.676]	[-25.01, 20.72]	a: 25.86 [11.32, 27.68]; r: 32.99 [18.12, 34.53]	conditional / conditional
qrs	integral_vector	0.9409 [0.8708, 0.9806]	-1.106 [-5.791, 3.860]	[-23.75, 21.54]	a: 29.39 [8.850, 31.36]; r: 46.22 [16.79, 46.88]	conditional / conditional
qrs	integral_x	0.9400 [0.8804, 0.9813]	1.360 [-1.696, 5.011]	[-14.27, 16.99]	a: 15.92 [7.016, 26.74]; r: 158.57 [30.03, 163.09]	nontransferable / nontransferable
qrs	integral_y	0.9397 [0.7529, 0.9836]	0.8506 [-3.592, 4.673]	[-18.56, 20.26]	a: 17.16 [10.53, 30.71]; r: 155.09 [150.42, 186.47]	nontransferable / nontransferable
qrs	integral_z	0.8994 [0.6356, 0.9649]	4.400 [-1.774, 11.21]	[-26.03, 34.83]	a: 38.32 [16.70, 39.21]; r: 147.58 [47.60, 200.00]	nontransferable / open
t	area_frontal	0.8621 [0.7326, 0.9554]	0.01042 [0.003283, 0.02083]	[-0.03263, 0.05348]	a: 0.03559 [0.009725, 0.09554]; r: 200.00 [125.82, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.8071 [0.7636, 0.9618]	0.01186 [-0.005223, 0.04099]	[-0.1107, 0.1344]	a: 0.03142 [0.01796, 0.2800]; r: 200.00 [95.54, 200.00]	nontransferable / open
t	area_transversal	0.9749 [0.8802, 0.9917]	0.002588 [-0.002579, 0.007724]	[-0.0216, 0.02677]	a: 0.0291 [0.01303, 0.03174]; r: 200.00 [92.57, 200.00]	nontransferable / open
t	integral_magnitude	0.9750 [0.9370, 0.9890]	-0.3929 [-3.685, 2.688]	[-15.04, 14.26]	a: 16.44 [6.174, 18.64]; r: 45.81 [15.14, 47.41]	conditional / conditional
t	integral_vector	0.9672 [0.9051, 0.9855]	-0.8154 [-4.580, 2.916]	[-17.87, 16.24]	a: 19.46 [9.348, 21.44]; r: 48.29 [20.42, 79.95]	conditional / conditional
t	integral_x	0.9511 [0.8531, 0.9835]	0.8753 [-2.234, 4.185]	[-14.47, 16.22]	a: 18.80 [8.503, 19.25]; r: 200.00 [129.59, 200.00]	nontransferable / nontransferable
t	integral_y	0.8728 [0.6515, 0.9195]	-2.295 [-8.146, 3.802]	[-31.36, 26.77]	a: 27.45 [17.17, 41.14]; r: 200.00 [121.11, 200.00]	nontransferable / nontransferable
t	integral_z	0.9396 [0.8178, 0.9680]	-4.123 [-9.204, 1.595]	[-29.49, 21.25]	a: 27.54 [12.58, 30.66]; r: 136.63 [96.90, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

unknown, Kors, Notches/bites. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	count_40	unavailable	-0.1905 [-0.4762, 0.09524]	[-1.523, 1.142]	1.0 [1.0, 1.0]	open / open
qrs	count_60	unavailable	-0.1905 [-0.4762, 0.09524]	[-1.523, 1.142]	1.0 [1.0, 2.0]	open / open
qrs	count_80	unavailable	0.1905 [-0.1429, 0.5238]	[-1.404, 1.785]	2.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_80	0.4615 [0.0000, 1.0000]	0.09524 [0, 0.2381]	[-0.4943, 0.6848]	1.0 [0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	1.619 [0.3333, 2.906]	[-4.500, 7.738]	7.000 [3.000, 10.00]	open / open
t	count_60	unavailable	1.429 [0.6667, 2.286]	[-2.615, 5.473]	4.0 [3.000, 7.000]	open / open
t	count_80	unavailable	0.5238 [-0.09524, 1.286]	[-2.792, 3.840]	3.000 [1.0, 6.000]	open / open
t	present_40	0.6182 [0.0000, 1.0000]	0.09524 [0, 0.2381]	[-0.4943, 0.6848]	1.0 [0, 1.0]	nontransferable / nontransferable
t	present_60	0.8000 [0.5000, 1.0000]	0.09524 [0, 0.2381]	[-0.4943, 0.6848]	1.0 [0, 1.0]	nontransferable / nontransferable
t	present_80	0.7149 [0.3823, 1.0000]	0.04762 [-0.09524, 0.1905]	[-0.7054, 0.8007]	1.0 [0, 1.0]	conditional / conditional

P95 relative [interval]: unavailable for every row.

unknown, inverse Dower, Amplitudes. Finite pairs/persons and unit by segment: qrs: 21/21, mV; t: 21/21, mV.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	peak_magnitude	0.7102 [0.6022, 0.9353]	-0.06457 [-0.6099, 0.3291]	[-2.317, 2.188]	a: 1.380 [0.5351, 4.616]; r: 68.08 [37.34, 70.23]	nontransferable / nontransferable
qrs	peak_x	0.8586 [0.7988, 0.9358]	0.1713 [-0.1565, 0.6228]	[-1.713, 2.056]	a: 1.017 [0.6751, 3.882]; r: 200.00 [50.92, 200.00]	nontransferable / nontransferable
qrs	peak_y	0.6909 [0.2540, 0.9030]	-0.03785 [-0.4598, 0.2918]	[-1.858, 1.783]	a: 2.281 [0.4151, 2.852]; r: 200.00 [197.84, 200.00]	nontransferable / nontransferable
qrs	peak_z	0.4850 [0.1165, 0.8014]	0.4654 [0.09222, 0.8873]	[-1.356, 2.287]	a: 2.000 [1.066, 2.916]; r: 200.00 [186.15, 200.00]	nontransferable / open
t	peak_magnitude	0.9571 [0.8211, 0.9849]	0.02443 [-0.01431, 0.06629]	[-0.1665, 0.2153]	a: 0.1765 [0.1138, 0.2455]; r: 39.91 [31.91, 81.63]	conditional / conditional
t	peak_x	0.7274 [0.3216, 0.9509]	0.01873 [-0.07216, 0.08877]	[-0.3762, 0.4137]	a: 0.2621 [0.1775, 0.7595]; r: 200.00 [138.96, 200.00]	nontransferable / nontransferable
t	peak_y	0.8887 [0.7305, 0.9171]	-0.03124 [-0.07915, 0.03188]	[-0.3017, 0.2392]	a: 0.1963 [0.1039, 0.4717]; r: 200.00 [108.98, 200.00]	nontransferable / nontransferable
t	peak_z	0.9145 [0.6455, 0.9661]	-0.04042 [-0.09936, 0.02144]	[-0.3334, 0.2526]	a: 0.2951 [0.1912, 0.3140]; r: 200.00 [94.24, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

unknown, inverse Dower, Width/planarity. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	planarity	0.7282 [0.3294, 0.8722]	-0.005118 [-0.02183, 0.01108]	[-0.08122, 0.07098]	0.06977 [0.04652, 0.0895]	nontransferable / nontransferable
qrs	width	0.4740 [-0.0124, 0.7681]	0.04467 [-0.03397, 0.1337]	[-0.3428, 0.4322]	0.2618 [0.2046, 0.5809]	nontransferable / nontransferable
t	planarity	0.8593 [0.7297, 0.9264]	0.003665 [-0.005122, 0.0129]	[-0.03973, 0.04706]	0.03785 [0.0279, 0.04603]	conditional / conditional
t	width	0.6559 [0.4341, 0.8254]	0.01955 [-0.05605, 0.0938]	[-0.3408, 0.3799]	0.3425 [0.2055, 0.3687]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

unknown, inverse Dower, Rotation direction. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	turn_frontal	0.2527 [-0.0286, 0.5354]	0 [-0.4286, 0.4286]	[-2.056, 2.056]	2.0 [1.0, 2.0]	nontransferable / open
qrs	turn_left sagittal	0.4836 [0.1370, 0.7709]	-0.1429 [-0.5238, 0.1905]	[-1.816, 1.530]	2.0 [1.0, 2.0]	nontransferable / open
qrs	turn_transversal	0.7083 [0.4615, 1.0000]	-0.1905 [-0.4762, 0]	[-1.370, 0.9886]	2.0 [0, 2.0]	conditional / open
t	turn_frontal	0.4596 [0.2222, 0.7296]	-0.09524 [-0.5238, 0.2857]	[-1.945, 1.754]	2.0 [1.0, 3.000]	nontransferable / open
t	turn_left sagittal	0.6971 [0.3000, 1.0000]	0 [-0.2381, 0.1905]	[-1.074, 1.074]	1.0 [0, 2.0]	conditional / open
t	turn_transversal	0.5625 [0.1472, 0.8923]	0.09524 [-0.09524, 0.2857]	[-0.7602, 0.9507]	1.0 [0, 1.0]	nontransferable / open

P95 relative [interval]: unavailable for every row.

unknown, inverse Dower, Shape. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	rms_procrustes	0.01585 [0.01169, 0.02144]	[-0.007444, 0.03915]	0.02778 [0.01919, 0.06064]	rule met, restricted / open
qrs	rms_unrotated	0.02598 [0.02034, 0.03205]	[-0.00248, 0.05444]	0.04543 [0.03873, 0.06535]	rule met, restricted / open
t	rms_procrustes	0.0128 [0.009747, 0.01606]	[-0.002208, 0.0278]	0.02695 [0.01815, 0.03026]	rule met, restricted / open
t	rms_unrotated	0.02277 [0.01825, 0.02767]	[0.0005914, 0.04494]	0.04235 [0.02971, 0.05109]	rule met, restricted / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

unknown, inverse Dower, Principal direction. Finite pairs/persons and unit by segment: qrs: 21/21, degrees; qrst: 21/21, degrees; t: 21/21, degrees.

Segment	Metric	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	integral_azimuth	15.40 [5.613, 26.40]	[-32.08, 63.27]	49.27 [37.01, 76.40]	nontransferable / open
qrs	integral_elevation	2.811 [-2.367, 8.644]	[-23.96, 29.58]	31.36 [13.48, 34.31]	conditional / open
qrs	peak_azimuth	11.01 [0.5228, 22.72]	[-40.32, 62.93]	43.77 [31.15, 78.29]	nontransferable / open
qrs	peak_elevation	-1.519 [-9.481, 5.645]	[-36.04, 33.00]	36.62 [10.34, 54.97]	conditional / open
qrst	angle_integral	12.58 [0.1751, 25.78]	[-48.41, 73.56]	57.17 [43.40, 83.07]	nontransferable / open
qrst	angle_peak	3.969 [-7.155, 14.61]	[-48.96, 56.90]	43.27 [26.68, 77.45]	nontransferable / open
t	integral_azimuth	18.23 [6.468, 31.11]	[-38.52, 75.58]	65.69 [36.54, 82.10]	nontransferable / open
t	integral_elevation	7.336 [-1.547, 16.48]	[-36.74, 51.41]	38.72 [27.48, 63.97]	conditional / open
t	peak_azimuth	18.07 [8.704, 27.68]	[-26.98, 63.83]	55.82 [35.96, 71.65]	nontransferable / open
t	peak_elevation	3.246 [-3.721, 10.46]	[-30.63, 37.12]	32.25 [18.40, 48.44]	conditional / open

ICC or κ [interval]: unavailable for every row. P95 relative [interval]: unavailable for every row.

unknown, inverse Dower, Integrals/areas. Finite pairs/persons and unit by segment: qrs (area_frontal, area_left sagittal, area_transversal): 21/21, mV2; qrs (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 21/21, mV_ms; t (area_frontal, area_left sagittal, area_transversal): 21/21, mV2; t (integral_magnitude, integral_vector, integral_x, integral_y, integral_z): 21/21, mV_ms.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute; relative (%)	Rule / release
qrs	area_frontal	-0.1181 [-0.2744, 0.8439]	0.8539 [-0.1391, 2.400]	[-5.541, 7.249]	a: 3.420 [1.027, 14.49]; r: 200.00 [200.00, 200.00]	nontransferable / nontransferable
qrs	area_left sagittal	0.1657 [0.0941, 0.8943]	-0.8881 [-2.527, 0.03143]	[-7.964, 6.188]	a: 1.052 [0.7526, 16.53]; r: 200.00 [187.91, 200.00]	nontransferable / open
qrs	area_transversal	0.0040 [-0.0635, 0.8026]	-0.8963 [-3.258, 0.4893]	[-10.84, 9.049]	a: 2.371 [0.6183, 22.73]; r: 200.00 [106.02, 200.00]	nontransferable / open
qrs	integral_magnitude	0.8954 [0.7859, 0.9615]	2.753 [-4.120, 10.23]	[-30.99, 36.50]	a: 37.72 [14.40, 42.48]; r: 50.21 [28.76, 65.23]	nontransferable / nontransferable
qrs	integral_vector	0.9060 [0.7964, 0.9644]	2.185 [-3.952, 9.211]	[-29.37, 33.75]	a: 32.08 [14.69, 45.91]; r: 49.40 [38.75, 85.05]	conditional / conditional
qrs	integral_x	0.7674 [0.5694, 0.8895]	-7.775 [-14.70, -1.134]	[-39.31, 23.75]	a: 34.79 [18.27, 44.74]; r: 128.81 [101.68, 200.00]	nontransferable / nontransferable
qrs	integral_y	0.9439 [0.7480, 0.9873]	1.111 [-3.404, 4.899]	[-18.43, 20.65]	a: 19.17 [9.708, 30.86]; r: 186.11 [128.29, 188.27]	nontransferable / nontransferable
qrs	integral_z	0.7386 [0.0747, 0.9526]	10.09 [0.3968, 22.71]	[-41.42, 61.61]	a: 38.62 [17.53, 102.1]; r: 164.26 [72.90, 200.00]	nontransferable / open
t	area_frontal	0.8889 [0.4481, 0.9358]	0.008386 [-0.004987, 0.02078]	[-0.05121, 0.06798]	a: 0.08339 [0.02729, 0.09065]; r: 200.00 [197.64, 200.00]	nontransferable / nontransferable
t	area_left sagittal	0.7829 [0.7354, 0.9705]	0.01424 [-0.004456, 0.04669]	[-0.1217, 0.1502]	a: 0.02531 [0.0204, 0.3125]; r: 200.00 [77.21, 200.00]	nontransferable / open
t	area_transversal	0.7884 [0.4519, 0.9579]	-0.00125 [-0.01824, 0.01202]	[-0.07244, 0.06994]	a: 0.05883 [0.02513, 0.1274]; r: 200.00 [82.74, 200.00]	nontransferable / open
t	integral_magnitude	0.9337 [0.8037, 0.9716]	3.554 [-1.364, 8.400]	[-19.14, 26.25]	a: 19.83 [16.37, 27.85]; r: 33.95 [29.95, 68.98]	conditional / conditional
t	integral_vector	0.9148 [0.7447, 0.9647]	3.764 [-1.816, 9.184]	[-22.44, 29.97]	a: 23.44 [17.06, 34.84]; r: 48.81 [35.30, 103.96]	conditional / conditional
t	integral_x	0.7841 [0.3862, 0.9489]	3.539 [-4.293, 10.37]	[-31.37, 38.45]	a: 32.09 [21.30, 55.44]; r: 200.00 [126.14, 200.00]	nontransferable / nontransferable
t	integral_y	0.8638 [0.5711, 0.9208]	-5.803 [-11.31, 0.1759]	[-34.38, 22.78]	a: 27.32 [16.62, 33.36]; r: 200.00 [144.14, 200.00]	nontransferable / nontransferable
t	integral_z	0.8874 [0.6065, 0.9567]	-9.800 [-15.68, -3.261]	[-39.62, 20.02]	a: 31.12 [24.60, 36.64]; r: 200.00 [95.14, 200.00]	nontransferable / open

P95 a: absolute [interval], in the stated unit; r: relative [interval], %.

unknown, inverse Dower, Notches/bites. Finite pairs/persons and unit by segment: qrs: 21/21, dimensionless/count/category; t: 21/21, dimensionless/count/category.

Segment	Metric	ICC or κ [interval]	Bias [interval]	[LoA lower, upper]	P95 absolute [interval]	Rule / release
qrs	count_40	unavailable	0.04762 [-0.2857, 0.4286]	[-1.647, 1.742]	1.0 [1.0, 3.000]	open / open
qrs	count_60	unavailable	-0.2381 [-0.6190, 0.09643]	[-1.981, 1.505]	2.0 [1.0, 2.0]	open / open
qrs	count_80	unavailable	-0.1905 [-0.6190, 0.2381]	[-2.210, 1.829]	2.0 [1.0, 2.0]	open / open
qrs	present_40	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_60	not estimable	0 [0, 0]	[0, 0]	0 [0, 0]	open / open
qrs	present_80	-0.1667 [-0.2963, 0.0000]	0 [-0.2381, 0.2381]	[-1.074, 1.074]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	count_40	unavailable	0.6667 [-0.6190, 2.095]	[-5.814, 7.148]	5.000 [3.000, 10.00]	open / open
t	count_60	unavailable	0.6190 [-0.3333, 1.619]	[-3.997, 5.236]	5.000 [3.000, 5.000]	open / open
t	count_80	unavailable	0.2381 [-0.3333, 0.8583]	[-2.728, 3.204]	3.000 [1.0, 4.0]	open / open
t	present_40	0.5772 [-0.0380, 1.0000]	-0.04762 [-0.2381, 0.09524]	[-0.8007, 0.7054]	1.0 [0, 1.0]	nontransferable / nontransferable
t	present_60	0.5205 [0.1287, 0.8108]	-0.04762 [-0.2857, 0.1429]	[-1.023, 0.9277]	1.0 [1.0, 1.0]	nontransferable / nontransferable
t	present_80	0.5161 [0.1289, 0.8108]	-0.1429 [-0.3333, 0.04762]	[-1.080, 0.7942]	1.0 [1.0, 1.0]	nontransferable / nontransferable

P95 relative [interval]: unavailable for every row.

Metadata: n / persons denotes finite pairs / persons; Unit is retained in the segment notes.

S2d. Rotation: all planes, both transforms, all three definitions

The last column applies only the $\geq 90\%$ point-agreement rule to each displayed row, not the historical multidimensional class rule or a new clinical approval. turn, phase-origin-net and raw-origin-net have distinct class sets; high agreement can accompany low κ under skewed marginals. Direction views for S2b, S2c and S2d: frontal Cartesian (X,-Y), transverse (X,Z), left sagittal (Z,-Y). These are distinct from the right-sagittal coefficient-only sensitivity below. Intervals: 2,000-person percentile bootstrap, seed 57057.

Key dimensions: Population / transform / segment / plane / definition. **Supplementary table 011, part 1.**

Row	Population	Transform	Segment	Plane	Definition	Paired persons
1	primary all	kors	qrs	frontal	turn	285
2	primary all	kors	qrs	frontal	origin_net_phase	285
3	primary all	kors	qrs	frontal	origin_net_raw	285
4	primary all	kors	qrs	transversal	turn	285
5	primary all	kors	qrs	transversal	origin_net_phase	285
6	primary all	kors	qrs	transversal	origin_net_raw	285
7	primary all	kors	qrs	left sagittal	turn	285
8	primary all	kors	qrs	left sagittal	origin_net_phase	285
9	primary all	kors	qrs	left sagittal	origin_net_raw	285
10	primary all	kors	t	frontal	turn	282
11	header-normal	kors	t	frontal	turn	51
12	primary all	kors	t	frontal	origin_net_phase	282
13	header-normal	kors	t	frontal	origin_net_phase	51
14	primary all	kors	t	frontal	origin_net_raw	282
15	header-normal	kors	t	frontal	origin_net_raw	51
16	primary all	kors	t	transversal	turn	282
17	header-normal	kors	t	transversal	turn	51
18	primary all	kors	t	transversal	origin_net_phase	282
19	header-normal	kors	t	transversal	origin_net_phase	51
20	primary all	kors	t	transversal	origin_net_raw	282
21	header-normal	kors	t	transversal	origin_net_raw	51
22	primary all	kors	t	left sagittal	turn	282
23	header-normal	kors	t	left sagittal	turn	51
24	primary all	kors	t	left sagittal	origin_net_phase	282
25	header-normal	kors	t	left sagittal	origin_net_phase	51
26	primary all	kors	t	left sagittal	origin_net_raw	282
27	header-normal	kors	t	left sagittal	origin_net_raw	51
28	primary all	kors	p	frontal	turn	188
29	primary all	kors	p	frontal	origin_net_phase	188
30	primary all	kors	p	frontal	origin_net_raw	188
31	primary all	kors	p	transversal	turn	188
32	primary all	kors	p	transversal	origin_net_phase	188
33	primary all	kors	p	transversal	origin_net_raw	188
34	primary all	kors	p	left sagittal	turn	188
35	primary all	kors	p	left sagittal	origin_net_phase	188
36	primary all	kors	p	left sagittal	origin_net_raw	188
37	primary all	inverse_dower	qrs	frontal	turn	285
38	primary all	inverse_dower	qrs	frontal	origin_net_phase	285
39	primary all	inverse_dower	qrs	frontal	origin_net_raw	285
40	primary all	inverse_dower	qrs	transversal	turn	285
41	primary all	inverse_dower	qrs	transversal	origin_net_phase	285
42	primary all	inverse_dower	qrs	transversal	origin_net_raw	285
43	primary all	inverse_dower	qrs	left sagittal	turn	285
44	primary all	inverse_dower	qrs	left sagittal	origin_net_phase	285
45	primary all	inverse_dower	qrs	left sagittal	origin_net_raw	285
46	primary all	inverse_dower	t	frontal	turn	282

Row	Population	Transform	Segment	Plane	Definition	Paired persons
47	header-normal	inverse_dower	t	frontal	turn	51
48	primary all	inverse_dower	t	frontal	origin_net_phase	282
49	header-normal	inverse_dower	t	frontal	origin_net_phase	51
50	primary all	inverse_dower	t	frontal	origin_net_raw	282
51	header-normal	inverse_dower	t	frontal	origin_net_raw	51
52	primary all	inverse_dower	t	transversal	turn	282
53	header-normal	inverse_dower	t	transversal	turn	51
54	primary all	inverse_dower	t	transversal	origin_net_phase	282
55	header-normal	inverse_dower	t	transversal	origin_net_phase	51
56	primary all	inverse_dower	t	transversal	origin_net_raw	282
57	header-normal	inverse_dower	t	transversal	origin_net_raw	51
58	primary all	inverse_dower	t	left sagittal	turn	282
59	header-normal	inverse_dower	t	left sagittal	turn	51
60	primary all	inverse_dower	t	left sagittal	origin_net_phase	282
61	header-normal	inverse_dower	t	left sagittal	origin_net_phase	51
62	primary all	inverse_dower	t	left sagittal	origin_net_raw	282
63	header-normal	inverse_dower	t	left sagittal	origin_net_raw	51
64	primary all	inverse_dower	p	frontal	turn	188
65	primary all	inverse_dower	p	frontal	origin_net_phase	188
66	primary all	inverse_dower	p	frontal	origin_net_raw	188
67	primary all	inverse_dower	p	transversal	turn	188
68	primary all	inverse_dower	p	transversal	origin_net_phase	188
69	primary all	inverse_dower	p	transversal	origin_net_raw	188
70	primary all	inverse_dower	p	left sagittal	turn	188
71	primary all	inverse_dower	p	left sagittal	origin_net_phase	188
72	primary all	inverse_dower	p	left sagittal	origin_net_raw	188

Supplementary table 011, part 2.

Row	Agreement [95% inter-val], %	κ [95% interval]	90% point criterion
1	83.16 [78.38, 87.06]	0.7315 [0.6598, 0.7963]	not met
2	86.67 [82.23, 90.13]	0.7502 [0.6777, 0.8192]	not met
3	86.67 [82.23, 90.13]	0.7502 [0.6777, 0.8192]	not met
4	94.04 [90.66, 96.24]	0.7879 [0.6906, 0.8715]	met, no clinical release
5	95.09 [91.92, 97.05]	0.7792 [0.6646, 0.8733]	met, no clinical release
6	95.09 [91.92, 97.05]	0.7762 [0.6586, 0.8729]	met, no clinical release
7	85.26 [80.68, 88.91]	0.6456 [0.5506, 0.7329]	not met
8	88.77 [84.58, 91.93]	0.6479 [0.5353, 0.7463]	not met
9	88.42 [84.18, 91.64]	0.6374 [0.5254, 0.7349]	not met
10	79.08 [73.96, 83.42]	0.6574 [0.5831, 0.7248]	not met
11	82.35 [69.75, 90.43]	0.4681 [0.1947, 0.7048]	not met
12	82.27 [77.39, 86.28]	0.6819 [0.6064, 0.7547]	not met
13	86.27 [74.28, 93.19]	0.4811 [0.1774, 0.7510]	not met
14	82.27 [77.39, 86.28]	0.6819 [0.6064, 0.7547]	not met
15	86.27 [74.28, 93.19]	0.4811 [0.1774, 0.7510]	not met
16	82.98 [78.16, 86.91]	0.6890 [0.6178, 0.7587]	not met
17	74.51 [61.13, 84.45]	0.3792 [0.1848, 0.5820]	not met
18	85.46 [80.87, 89.10]	0.7132 [0.6337, 0.7868]	not met
19	76.47 [63.24, 86.00]	0.4280 [0.1953, 0.6465]	not met
20	85.46 [80.87, 89.10]	0.7132 [0.6337, 0.7868]	not met
21	76.47 [63.24, 86.00]	0.4280 [0.1953, 0.6465]	not met
22	87.23 [82.83, 90.63]	0.7412 [0.6684, 0.8130]	not met
23	92.16 [81.50, 96.91]	0.7871 [0.5840, 0.9461]	met, no clinical release
24	89.72 [85.62, 92.74]	0.7796 [0.7049, 0.8494]	not met
25	90.20 [79.02, 95.74]	0.7276 [0.5137, 0.9219]	met, no clinical release
26	90.07 [86.02, 93.04]	0.7869 [0.7140, 0.8534]	met, no clinical release
27	90.20 [79.02, 95.74]	0.7276 [0.5137, 0.9219]	met, no clinical release
28	88.30 [82.92, 92.14]	0.5449 [0.3848, 0.6983]	not met
29	93.09 [88.53, 95.91]	0.4283 [0.1969, 0.6336]	met, no clinical release
30	93.09 [88.53, 95.91]	0.4283 [0.1969, 0.6336]	met, no clinical release
31	85.64 [79.91, 89.94]	0.5270 [0.3866, 0.6647]	not met
32	89.89 [84.76, 93.43]	0.2413 [0.0592, 0.4187]	not met
33	89.89 [84.76, 93.43]	0.2413 [0.0592, 0.4187]	not met
34	88.30 [82.92, 92.14]	0.3335 [0.1218, 0.5265]	not met
35	90.43 [85.37, 93.86]	0.1222 [-0.0162, 0.3029]	met, no clinical release
36	90.43 [85.37, 93.86]	0.1222 [-0.0162, 0.3029]	met, no clinical release
37	71.58 [66.08, 76.50]	0.5241 [0.4409, 0.6041]	not met
38	77.89 [72.72, 82.32]	0.5686 [0.4820, 0.6516]	not met
39	77.89 [72.72, 82.32]	0.5686 [0.4820, 0.6516]	not met
40	87.72 [83.40, 91.04]	0.5509 [0.4294, 0.6659]	not met
41	90.88 [86.97, 93.70]	0.5738 [0.4266, 0.7049]	met, no clinical release
42	90.88 [86.97, 93.70]	0.5676 [0.4169, 0.7031]	met, no clinical release
43	84.21 [79.53, 87.99]	0.6529 [0.5660, 0.7369]	not met
44	88.07 [83.79, 91.34]	0.6515 [0.5469, 0.7506]	not met
45	87.72 [83.40, 91.04]	0.6416 [0.5364, 0.7427]	not met
46	71.28 [65.74, 76.24]	0.5265 [0.4500, 0.6024]	not met
47	78.43 [65.37, 87.51]	0.2686 [0.0000, 0.5264]	not met
48	73.40 [67.96, 78.22]	0.5290 [0.4435, 0.6073]	not met
49	84.31 [71.99, 91.83]	0.3419 [0.0000, 0.6450]	not met
50	73.40 [67.96, 78.22]	0.5290 [0.4435, 0.6073]	not met
51	84.31 [71.99, 91.83]	0.3419 [0.0000, 0.6450]	not met
52	74.82 [69.45, 79.53]	0.5404 [0.4545, 0.6192]	not met

Row	Agreement [95% interval], %	κ [95% interval]	90% point criterion
53	76.47 [63.24, 86.00]	0.2435 [0.0000, 0.4830]	not met
54	78.37 [73.20, 82.78]	0.5648 [0.4702, 0.6562]	not met
55	76.47 [63.24, 86.00]	0.2093 [0.0000, 0.4660]	not met
56	78.37 [73.20, 82.78]	0.5648 [0.4702, 0.6562]	not met
57	76.47 [63.24, 86.00]	0.2093 [0.0000, 0.4660]	not met
58	87.94 [83.62, 91.24]	0.7478 [0.6709, 0.8191]	not met
59	86.27 [74.28, 93.19]	0.5636 [0.2654, 0.8166]	not met
60	87.59 [83.23, 90.94]	0.7257 [0.6396, 0.8058]	not met
61	86.27 [74.28, 93.19]	0.5388 [0.2049, 0.7988]	not met
62	87.94 [83.62, 91.24]	0.7330 [0.6470, 0.8123]	not met
63	86.27 [74.28, 93.19]	0.5388 [0.2049, 0.7988]	not met
64	78.72 [72.33, 83.97]	0.3717 [0.2236, 0.5093]	not met
65	90.43 [85.37, 93.86]	0.3982 [0.1822, 0.5839]	met, no clinical release
66	90.43 [85.37, 93.86]	0.3982 [0.1822, 0.5839]	met, no clinical release
67	80.32 [74.05, 85.37]	0.4367 [0.2819, 0.5736]	not met
68	86.17 [80.51, 90.38]	0.2435 [0.0571, 0.4180]	not met
69	86.17 [80.51, 90.38]	0.2435 [0.0571, 0.4180]	not met
70	88.83 [83.53, 92.58]	0.4932 [0.2941, 0.6629]	not met
71	88.83 [83.53, 92.58]	0.1521 [-0.0317, 0.3424]	not met
72	88.83 [83.53, 92.58]	0.1521 [-0.0317, 0.3424]	not met

S2e. Peak-Z and coefficient sensitivity

Transform	Segment	n	Sign agreement [interval]	ICC [interval]	Joint criterion
kors	qrs	285	84.21% [79.53%, 87.99%]	0.8289 [0.7613, 0.8774]	not met
kors	t	282	91.84% [88.06%, 94.50%]	0.9132 [0.8814, 0.9360]	not met
inverse_dower	qrs	285	78.95% [73.85%, 83.28%]	0.6124 [0.5410, 0.6738]	not met
inverse_dower	t	282	88.30% [84.02%, 91.54%]	0.8114 [0.7573, 0.8519]	not met

All joint criteria failed (sign $\geq 95\%$ and ICC ≥ 0.9). The held B-half RMSE medians were 0.1838 mV (-0.063) and 0.2109 mV ($+0.063$); the median paired difference is 0.0178 mV [0.0112, 0.0285], not the difference of the two marginal medians. The 12-channel coefficient -0.0953 [-0.1488 , 0.0782] and eight-channel sensitivity -0.1002 [-0.1510 , 0.0713] both include zero. Split A/B = 142/143, centered QRS and equal person weighting; 2,000-person bootstrap. This does not identify original polarity or validate T/ST boundaries.

S2e-1. Coefficient and measured-Z narrative

S2e-2. Coefficient sign, measured-Z transport and source correction

For the inverse Dower matrix, Table 11.6 (p 402) of Macfarlane (2010) prints Z/V4 $+0.063$, whereas its forward and inverse relation, the appendix of Edenbrandt and Pahlm (1988, p 367) and the inverse-Dower panel of table I in Kors *et al* (1990) (rounded -0.06) support the implemented -0.063 . The inherited source correction does not establish measured-vz polarity. The -0.063 coefficient belongs to the specified development software state dated 7 October 2026; the documen-

tary audit does not establish the date on which it was originally set or the commit that changed it. Supporting source-page evidence comes from the inherited appendix of Edenbrandt and Pahlm and from Kors Table I, in contrast to Table 11.6 of Macfarlane (2010); it was not rechecked for this report. Non-retrospective sign selection is therefore not asserted. Historical sign provenance and measured-Z polarity remain unresolved.

The local held-B QRS-centered residual comparison favored -0.063 by median paired RMSE 0.0178 mV $[0.0112, 0.0285]$; V4 regression intervals included zero. Residual means reconstructed Z minus Frank-Z after centering within the QRS window; collinearity and channel-median non-commutation constrain interpretation. Kors Peak-Z agreement was 84.21% for QRS and 91.84% for T; both failed the joint sign and ICC criteria. Original Z/V4 provenance and measured-Z transport remain open.

The coefficient-only change gave mean segment-integral angle differences of -1.2122° in training, -1.2842° in validation and -0.4522° in PTB, with P95 absolute changes of 8.492° , 8.487° and 9.012° ; S2f supplies paired denominators and intervals. Right-sagittal computational $(-Z, Y)$ origin-net QRS switches were 122/2,715, 136/2,705 and 16/285, respectively; $\geq 15\%$ minor-area switches were 231/2,715, 255/2,705 and 29/285. X and Y integrals and frontal classes were invariant. S2f distinguishes 77 complete PTB reprocessings from 209 retained original segments and 17 fast-path checks; these are technical sensitivity analyses.

S2f. Supplementary class and coefficient sensitivities

The supplementary class audit resampled persons separately within each fold (1,000 draws; seeds 77010 and 77011), recalculating ranks, quintiles, estimability and the worse-fold class. Pointwise percentile intervals describe uncertainty of classification on the fixed marker universe, not clinical interchangeability. Proportions use the estimable denominator from the same draw. Symmetric normalization uses $\sqrt{((\text{Var}(\text{Kors}) + \text{Var}(\text{Dower}))/2)}$ on identical finite method pairs. A fixed Cartesian grid of 729 six-criterion rules per normalization evaluated sensitivity without choosing a favorable rule; grid results are point estimates. Ten markers with the highest minimum fold correlation were ranked with lexicographic tie resolution; stability frequencies retain all 1,000 draws, including nonestimable draws. Original raw differences for signed periodic descriptors were retained. For the 29 markers on a circular scale (S2i) the classes therefore partly reflect coordinate-cut dependence; they are flagged in Supplementary Data S2, were not re-derived, and are not valid circular classifications. In the main text these 29 markers are not classified and the main counts exclude them (1,045 dependent and 684 conditional of 1,729 non-identical estimable outputs); the counts in S2f and S2g and Figure S1 (1,071 and 684 of 1,755) are the historical set, which contains 26 of the 29 circular markers (the other three were identical under both matrices and lie outside it) and serve as sensitivity. The bootstrap intervals in S2f and S2g are historical intervals of this historical set; no intervals exist for the adjusted main count. The class label matrix `independent_identical` in Supplementary Data S2 denotes nonconstant outputs that were

exactly equal under both matrices at shared, partly Kors-assisted fiducials; it does not denote independence from the matrix at the delineation step (S2h).

T3c. Full class denominators and uncertainty

Key dimensions: Normalization / universe / class. **Supplementary table 013, part 1.**

Row	Normalization	Universe	Class	Fixed universe / point estimable	Count [95% interval]	Share of fixed universe, % [95% interval]
1	Kors_SD	catalog	Identical nonconstant at shared fiducials	2,005/1,972	217 [215, 217]	10.82 [10.72, 10.82]
2	Kors_SD	catalog	Conditional	2,005/1,972	684 [647, 702]	34.12 [32.32, 35.01]
3	Kors_SD	catalog	Transformation-dependent	2,005/1,972	1,071 [1,053; 1,108]	53.4 [52.52, 55.26]
4	Kors_SD	catalog	not estimable	2,005/1,972	31 [27, 38]	1.55 [1.35, 1.90]
5	Kors_SD	catalog	constant and identical	2,005/1,972	1 [1, 1]	0.05 [0.05, 0.05]
6	Kors_SD	catalog	not testable	2,005/1,972	1 [1, 1]	0.05 [0.05, 0.05]
7	Kors_SD	matrix-dependent	Stable	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]
8	Kors_SD	matrix-dependent	Conditional	1,786/1,755	684 [647, 702]	38.30 [36.28, 39.31]
9	Kors_SD	matrix-dependent	Transformation-dependent	1,786/1,755	1,071 [1,053; 1,108]	59.97 [58.96, 62.04]
10	Kors_SD	matrix-dependent	not estimable	1,786/1,755	31 [27, 36]	1.74 [1.51, 2.02]
11	Kors_SD	matrix-dependent	constant and identical	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]
12	Kors_SD	matrix-dependent	not testable	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]
13	pooled_SD	catalog	Identical nonconstant at shared fiducials	2,005/1,972	217 [215, 217]	10.82 [10.72, 10.82]
14	pooled_SD	catalog	Conditional	2,005/1,972	676 [628, 701]	33.72 [31.32, 34.96]
15	pooled_SD	catalog	Transformation-dependent	2,005/1,972	1,079 [1,054; 1,129]	53.82 [52.57, 56.31]
16	pooled_SD	catalog	not estimable	2,005/1,972	31 [27, 38]	1.55 [1.35, 1.90]
17	pooled_SD	catalog	constant and identical	2,005/1,972	1 [1, 1]	0.05 [0.05, 0.05]
18	pooled_SD	catalog	not testable	2,005/1,972	1 [1, 1]	0.05 [0.05, 0.05]
19	pooled_SD	matrix-dependent	Stable	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]
20	pooled_SD	matrix-dependent	Conditional	1,786/1,755	676 [628, 701]	37.85 [35.16, 39.25]
21	pooled_SD	matrix-dependent	Transformation-dependent	1,786/1,755	1,079 [1,054; 1,129]	60.41 [59.02, 63.21]
22	pooled_SD	matrix-dependent	not estimable	1,786/1,755	31 [27, 36]	1.74 [1.51, 2.02]
23	pooled_SD	matrix-dependent	constant and identical	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]
24	pooled_SD	matrix-dependent	not testable	1,786/1,755	0 [0, 0]	0.00 [0.00, 0.00]

Supplementary table 013, part 2.

Row	Share of draw-estimable, % [95% interval]	Bootstrap estimable min-max
1	11.00 [10.93, 11.02]	1,954-1,976
2	34.69 [32.81, 35.58]	1,954-1,976
3	54.3 [53.45, 56.19]	1,954-1,976
4	not applicable	1,954-1,976
5	not applicable	1,954-1,976
6	not applicable	1,954-1,976
7	0.00 [0.00, 0.00]	1,747-1,759
8	39.0 [36.87, 39.95]	1,747-1,759
9	61.0 [60.05, 63.13]	1,747-1,759
10	not applicable	1,747-1,759
11	not applicable	1,747-1,759
12	not applicable	1,747-1,759
13	11.00 [10.93, 11.02]	1,954-1,976
14	34.28 [31.79, 35.55]	1,954-1,976
15	54.72 [53.45, 57.20]	1,954-1,976
16	not applicable	1,954-1,976
17	not applicable	1,954-1,976
18	not applicable	1,954-1,976
19	0.00 [0.00, 0.00]	1,747-1,759
20	38.52 [35.73, 39.94]	1,747-1,759
21	61.48 [60.06, 64.27]	1,747-1,759
22	not applicable	1,747-1,759
23	not applicable	1,747-1,759
24	not applicable	1,747-1,759

Displayed bootstrap count limits are rounded outward to integers (floor lower, ceil upper; 647.975→647); raw interpolated percentile values remain in the source ledger. Counts and fractions have distinct percentile intervals; count intervals are not divided by a fixed denominator to manufacture proportion intervals. Nominal matrix-dependent stable count 0 [0, 0] does not prove zero in every draw: the marker frequencies below retain all 1,000 draws. Constants are not credited as stable measurements. The 217 identical nonconstant catalog entries (historical count; 214 without the three circular markers among them) are exactly identical outputs at shared, partly Kors-assisted fiducials; this is not independence from the matrix at the delineation step (S2h). The total identical at shared fiducials is 218 including the separate constant. The full-catalog estimable denominator is 1,972, whereas non-identical estimable is 1,755.

Ten highest minimum-fold correlations

Marker	Minimum fold ρ	Original class	Stable frequency Kors / pooled	Nonestimable frequency
loop_graph_cycle_count_proxy	0.9912	Conditional	0 / 0	0
st_smoothness_index	0.9893	Transformation-dependent	0 / 0	0
p_smoothness_index	0.9891	Conditional	0 / 0	0
origin_cone_confidence	0.9876	Conditional	0.005 / 0.005	0
t_upstroke_smoothness_index	0.9875	Conditional	0 / 0	0
pr_velocity_integral	0.9869	Conditional	0 / 0	0
p_loop_frontal_xy_perimeter	0.9867	Conditional	0 / 0	0
p_loop_sagittal_yz_perimeter	0.9857	Conditional	0 / 0	0
st_loop_frontal_xy_perimeter	0.9856	Conditional	0 / 0	0
st_t_jerk_energy	0.9854	Conditional	0 / 0	0

The fixed 729-rule grid per normalization produced 0-500 switches and 0-1 matrix-dependent stable markers; no optimized rule was selected. Individual rule tuples are retained in the aggregate source ledger. Fold and pool sensitivities below are descriptive and do not change the worse-fold primary rule; their stable counts include entries identical at shared fiducials.

Key dimensions: Normalization / fold.

Normalization	Fold	Switches vs. worse-fold summary	Stable / conditional / dependent	Not estimable / constant / not testable
Kors_SD	train	78	217/761/998	27/1/1
Kors_SD	validation	25	217/709/1,046	31/1/1
Kors_SD	pool	59	219/741/1,018	25/1/1
pooled_SD	train	91	217/765/994	27/1/1
pooled_SD	validation	57	217/703/1,052	31/1/1
pooled_SD	pool	67	219/732/1,027	25/1/1

T3d. Fixed angle-threshold stress-tests

A specification fixed before calculation set $>105^\circ$ (equality stays below), with 90° and 120° as additional fixed stress points. This is a literature-motivated stress-test of same-ECG matrix substitu-

tion, not an adopted clinical cutoff. Young *et al* used Kors peak and mean angles, QRS end as T start, and different origin and buffer rules (Young *et al* 2021); our area-vector windows and origin definition differ. Mean and integral directions coincide only for identical windows and origins. Clinical definition transport and its literature judgment remain unresolved.

Key dimensions: Population / fold / marker / threshold, °. **Supplementary table 016, part 1.**

Row	Population	Fold	Marker	Threshold, °	Candidates	Finite ECG/person method pairs
1	Fixed variants	train	spatial_qrs_t_angle_deg	> 105	2,824	2,668/2,668
2	Fixed variants	train	spatial_qrs_t_angle_deg	> 90	2,824	2,668/2,668
3	Fixed variants	train	spatial_qrs_t_angle_deg	> 120	2,824	2,668/2,668
4	Fixed variants	train	spatial_peak_qrs_t_angle_deg	> 105	2,824	2,635/2,635
5	Fixed variants	train	spatial_peak_qrs_t_angle_deg	> 90	2,824	2,635/2,635
6	Fixed variants	train	spatial_peak_qrs_t_angle_deg	> 120	2,824	2,635/2,635
7	Fixed variants	validation	spatial_qrs_t_angle_deg	> 105	2,824	2,639/2,639
8	Fixed variants	validation	spatial_qrs_t_angle_deg	> 90	2,824	2,639/2,639
9	Fixed variants	validation	spatial_qrs_t_angle_deg	> 120	2,824	2,639/2,639
10	Fixed variants	validation	spatial_peak_qrs_t_angle_deg	> 105	2,824	2,615/2,615
11	Fixed variants	validation	spatial_peak_qrs_t_angle_deg	> 90	2,824	2,615/2,615
12	Fixed variants	validation	spatial_peak_qrs_t_angle_deg	> 120	2,824	2,615/2,615
13	Fixed variants	pool	spatial_qrs_t_angle_deg	> 105	5,648	5,307/5,307
14	Fixed variants	pool	spatial_qrs_t_angle_deg	> 90	5,648	5,307/5,307
15	Fixed variants	pool	spatial_qrs_t_angle_deg	> 120	5,648	5,307/5,307
16	Fixed variants	pool	spatial_peak_qrs_t_angle_deg	> 105	5,648	5,250/5,250
17	Fixed variants	pool	spatial_peak_qrs_t_angle_deg	> 90	5,648	5,250/5,250
18	Fixed variants	pool	spatial_peak_qrs_t_angle_deg	> 120	5,648	5,250/5,250

Row	Population	Fold	Marker	Threshold, °	Candidates	Finite ECG/person method pairs
19	Historical 60 training partitions	train	spatial_qrs_t_angle_deg	> 105	12,035	11,529/11,529
20	Historical 60 training partitions	train	spatial_qrs_t_angle_deg	> 90	12,035	11,529/11,529
21	Historical 60 training partitions	train	spatial_qrs_t_angle_deg	> 120	12,035	11,529/11,529
22	Historical 60 training partitions	train	spatial_peak_qrs_t_angle_deg	> 105	12,035	11,412/11,412
23	Historical 60 training partitions	train	spatial_peak_qrs_t_angle_deg	> 90	12,035	11,412/11,412
24	Historical 60 training partitions	train	spatial_peak_qrs_t_angle_deg	> 120	12,035	11,412/11,412

Supplementary table 016, part 2.

Row	Switch count	Switch %, 95% interval
1	360	13.49 [12.18, 14.77]
2	365	13.68 [12.52, 14.92]
3	323	12.11 [10.98, 13.31]
4	329	12.49 [11.20, 13.70]
5	336	12.75 [11.42, 14.04]
6	299	11.35 [10.21, 12.49]
7	350	13.26 [11.97, 14.51]
8	406	15.39 [13.98, 16.79]
9	284	10.76 [9.59, 11.90]
10	326	12.47 [11.24, 13.73]
11	349	13.35 [12.08, 14.61]
12	293	11.21 [10.10, 12.43]
13	710	13.379 [12.455, 14.321]
14	771	14.53 [13.57, 15.47]
15	607	11.44 [10.63, 12.31]
16	655	12.48 [11.60, 13.37]
17	685	13.05 [12.17, 13.96]
18	592	11.28 [10.44, 12.17]
19	1,468	12.733 [12.187, 13.340]
20	1,692	14.68 [14.05, 15.33]
21	1,181	10.24 [9.69, 10.81]
22	1,303	11.42 [10.82, 11.99]
23	1,428	12.51 [11.94, 13.10]
24	1,174	10.29 [9.74, 10.82]

Same-ECG method pairs are not clinical repeat pairs. Historical and variant denominators are not added. No disease-reference sensitivity or specificity was estimated.

Key dimensions: $>105^\circ$ area-angle population / fold.

Population	Fold	Direction of substitution	Finite method pairs	Switches	Switch %, patient 95% interval
Fixed variants	train	Kors $\leq 105^\circ \rightarrow$ Dower $>105^\circ$	2,668	280	10.50 [9.33, 11.69]
Fixed variants	train	Kors $>105^\circ \rightarrow$ Dower $\leq 105^\circ$	2,668	80	3.00 [2.36, 3.67]
Fixed variants	validation	Kors $\leq 105^\circ \rightarrow$ Dower $>105^\circ$	2,639	277	10.50 [9.36, 11.67]
Fixed variants	validation	Kors $>105^\circ \rightarrow$ Dower $\leq 105^\circ$	2,639	73	2.77 [2.12, 3.41]
Fixed variants	pool	Kors $\leq 105^\circ \rightarrow$ Dower $>105^\circ$	5,307	557	10.50 [9.65, 11.33]
Fixed variants	pool	Kors $>105^\circ \rightarrow$ Dower $\leq 105^\circ$	5,307	153	2.88 [2.43, 3.36]
Historical 60 training partitions	train	Kors $\leq 105^\circ \rightarrow$ Dower $>105^\circ$	11,529	1,197	10.38 [9.90, 10.96]
Historical 60 training partitions	train	Kors $>105^\circ \rightarrow$ Dower $\leq 105^\circ$	11,529	271	2.35 [2.10, 2.61]

Directions use the existing clinical_threshold aggregate and the same finite population as each all-switch row; opposite directional counts sum to all switches.

Z/ sign sensitivity

Only the inverse-Dower Z/V4 coefficient was changed from -0.063 to $+0.063$, retaining other coefficients, original availability, segment limits and origin region. Areas used trapezoidal integration in mV·ms; the explicit QRS/T segment-integral angle was kept separate from the catalog QRST-minus-QRS area angle. Coefficient-only computational net signed area and minor-area classes (primary threshold 15%; additional 5%, 10% and 25%) used frontal (X,Y), transverse (X,-Z) and right-sagittal (-Z,Y) views, with a $1e-6$ mV² doubled-total-area criterion and an absolute-net $<1e-12$ tie rule; positive net area is CW under that implementation definition. This right-sagittal view differs from the left-sagittal view in the historical Frank direction comparison. Person-bootstrap intervals quantify coefficient sensitivity without selecting a sign by favorable agreement.

Key dimensions: Population / fold / metric.

Population	Fold	Metric	Finite pairs / persons	Unit	Mean plus-minus [95% interval]	P95 absolute change
PTB technical external	external technical	integral_angle	282 / 282	°	-0.4522 [-1.0117, 0.0568]	9.012
PTB technical external	external technical	peak_angle	282 / 282	°	-1.282 [-2.723, -0.0469]	14.00
PTB technical external	external technical	qrs_area_Z	285 / 285	mV·ms	0.1164 [-0.4951, 0.75]	11.11
PTB technical external	external technical	qrs_area_direction_deg	285 / 285	°	3.256 [2.900, 3.598]	9.944
PTB technical external	external technical	qrs_area_norm	285 / 285	mV·ms	-1.011 [-1.469, -0.5554]	7.093
PTB technical external	external technical	t_area_Z	282 / 282	mV·ms	3.865 [3.069, 4.642]	15.75
PTB technical external	external technical	t_area_direction_deg	282 / 282	°	4.827 [4.493, 5.164]	9.324
PTB technical external	external technical	t_area_norm	282 / 282	mV·ms	-3.209 [-3.688, -2.751]	10.46
Fixed variants	train	integral_angle	2,626 / 2,626	°	-1.2122 [-1.3655, -1.0400]	8.492
Fixed variants	train	peak_angle	2,626 / 2,626	°	-1.32 [-1.891, -0.7266]	15.35
Fixed variants	train	qrs_area_Z	2,715 / 2,715	mV·ms	-0.3237 [-0.4933, -0.1577]	9.642
Fixed variants	train	qrs_area_direction_deg	2,715 / 2,715	°	3.271 [3.158, 3.375]	8.419
Fixed variants	train	qrs_area_norm	2,715 / 2,715	mV·ms	-0.5413 [-0.6537, -0.4301]	6.216
Fixed variants	train	t_area_Z	2,640 / 2,640	mV·ms	2.754 [2.600, 2.915]	10.27
Fixed variants	train	t_area_direction_deg	2,640 / 2,640	°	4.676 [4.543, 4.805]	9.930
Fixed variants	train	t_area_norm	2,640 / 2,640	mV·ms	-1.518 [-1.619, -1.416]	6.356
Fixed variants	validation	integral_angle	about 2,610 / about 2,610	°	-1.2842 [-1.4488, -1.1259]	8.487
Fixed variants	validation	peak_angle	about 2,610 / about 2,610	°	-1.444 [-2.010, -0.9192]	16.38
Fixed variants	validation	qrs_area_Z	2,705 / 2,705	mV·ms	-0.1409 [-0.3085, 0.0294]	9.257
Fixed variants	validation	qrs_area_direction_deg	2,705 / 2,705	°	3.253 [3.139, 3.359]	8.581
Fixed variants	validation	qrs_area_norm	2,705 / 2,705	mV·ms	-0.5294 [-0.6360, -0.4252]	5.634

Population	Fold	Metric	Finite pairs / persons	Unit	Mean plus-minus [95% interval]	P95 absolute change
Fixed variants	validation	t_area_Z	2,622 / 2,622	mV·ms	2.938 [2.768, 3.092]	10.13
Fixed variants	validation	t_area_direction_deg	2,622 / 2,622	°	4.904 [4.761, 5.034]	10.28
Fixed variants	validation	t_area_norm	2,622 / 2,622	mV·ms	-1.554 [-1.645, -1.448]	6.257

The PTB reconstruction-minus-Frank integral-angle bias was 8.6741° [5.6238, 11.8355] at -0.063 and 8.2219° [5.2202, 11.2912] at $+0.063$, with 282/286 paired persons. These supplementary intervals are separate from S2a's earlier resampling. The sign cannot be chosen from this small bias difference. QRS/T explicit segment-integral angles here differ from the catalog QRST-minus-QRS area definition. Only coefficient sensitivity was recomputed; retained original segments are not independently reconstructed negative-matrix measurements.

Native signed Z components and area-vector norms use $\text{mV}\cdot\text{ms}$; signed projected loop areas used by direction classes use mV^2 . Direction angles use degrees. X and Y area changes and frontal switches were exactly zero. Of 286 PTB candidates, 77 were completely reprocessed and 209 retained original segments for the exact V4 correction. Seventeen fast-path versus full-processing comparisons had maximum discrepancy 0.0. No medical boundary adjudication was added.

Key dimensions: Population / fold / segment / view. **Supplementary table 019, part 1.**

Row	Population	Fold	Segment	View	Classification	Finite pairs / persons
1	PTB technical external	external technical	qrs	frontal/front	minor area $\geq$ 15.00%	285/285
2	PTB technical external	external technical	qrs	frontal/front	origin-net	285/285
3	PTB technical external	external technical	qrs	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	285/285
4	PTB technical external	external technical	qrs	right-sagittal (-Z,Y)	origin-net	285/285
5	PTB technical external	external technical	qrs	transverse/above	minor area $\geq$ 15.00%	285/285
6	PTB technical external	external technical	qrs	transverse/above	origin-net	285/285
7	PTB technical external	external technical	t	frontal/front	minor area $\geq$ 15.00%	282/282
8	PTB technical external	external technical	t	frontal/front	origin-net	282/282
9	PTB technical external	external technical	t	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	282/282
10	PTB technical external	external technical	t	right-sagittal (-Z,Y)	origin-net	282/282
11	PTB technical external	external technical	t	transverse/above	minor area $\geq$ 15.00%	282/282
12	PTB technical external	external technical	t	transverse/above	origin-net	282/282
13	Fixed variants	train	qrs	frontal/front	minor area $\geq$ 15.00%	2,715/2,715
14	Fixed variants	train	qrs	frontal/front	origin-net	2,715/2,715
15	Fixed variants	train	qrs	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	2,715/2,715
16	Fixed variants	train	qrs	right-sagittal (-Z,Y)	origin-net	2,715/2,715
17	Fixed variants	train	qrs	transverse/above	minor area $\geq$ 15.00%	2,715/2,715
18	Fixed variants	train	qrs	transverse/above	origin-net	2,715/2,715
19	Fixed variants	train	t	frontal/front	minor area $\geq$ 15.00%	2,640/2,640
20	Fixed variants	train	t	frontal/front	origin-net	2,640/2,640
21	Fixed variants	train	t	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	2,640/2,640
22	Fixed variants	train	t	right-sagittal (-Z,Y)	origin-net	2,640/2,640
23	Fixed variants	train	t	transverse/above	minor area $\geq$ 15.00%	2,640/2,640
24	Fixed variants	train	t	transverse/above	origin-net	2,640/2,640
25	Fixed variants	validation	qrs	frontal/front	minor area $\geq$ 15.00%	2,705/2,705
26	Fixed variants	validation	qrs	frontal/front	origin-net	2,705/2,705
27	Fixed variants	validation	qrs	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	2,705/2,705
28	Fixed variants	validation	qrs	right-sagittal (-Z,Y)	origin-net	2,705/2,705
29	Fixed variants	validation	qrs	transverse/above	minor area $\geq$ 15.00%	2,705/2,705

Row	Population	Fold	Segment	View	Classification	Finite pairs / persons
30	Fixed variants	validation	qrs	transverse/above	origin-net	2,705/2,705
31	Fixed variants	validation	t	frontal/front	minor area $\geq$ 15.00%	2,622/2,622
32	Fixed variants	validation	t	frontal/front	origin-net	2,622/2,622
33	Fixed variants	validation	t	right-sagittal (-Z,Y)	minor area $\geq$ 15.00%	2,622/2,622
34	Fixed variants	validation	t	right-sagittal (-Z,Y)	origin-net	2,622/2,622
35	Fixed variants	validation	t	transverse/above	minor area $\geq$ 15.00%	2,622/2,622
36	Fixed variants	validation	t	transverse/above	origin-net	2,622/2,622

Supplementary table 019, part 2.

Row	Switches	Switch %, 95% interval
1	0	0.00 [0.00, 0.00]
2	0	0.00 [0.00, 0.00]
3	29	10.18 [6.67, 13.68]
4	16	5.61 [3.16, 8.42]
5	3	1.05 [0.00, 2.46]
6	2	0.70 [0.00, 1.75]
7	0	0.00 [0.00, 0.00]
8	0	0.00 [0.00, 0.00]
9	9	3.19 [1.42, 5.32]
10	7	2.48 [0.71, 4.61]
11	5	1.77 [0.36, 3.55]
12	2	0.71 [0.00, 2.13]
13	0	0.00 [0.00, 0.00]
14	0	0.00 [0.00, 0.00]
15	231	8.51 [7.48, 9.61]
16	122	4.49 [3.76, 5.30]
17	29	1.07 [0.66, 1.47]
18	11	0.41 [0.18, 0.66]
19	0	0.00 [0.00, 0.00]
20	0	0.00 [0.00, 0.00]
21	52	1.97 [1.48, 2.50]
22	86	3.26 [2.65, 3.94]
23	38	1.44 [1.02, 1.89]
24	31	1.17 [0.80, 1.59]
25	0	0.00 [0.00, 0.00]
26	0	0.00 [0.00, 0.00]
27	255	9.43 [8.43, 10.61]
28	136	5.03 [4.25, 5.88]
29	31	1.15 [0.78, 1.55]
30	16	0.59 [0.33, 0.92]
31	0	0.00 [0.00, 0.00]
32	0	0.00 [0.00, 0.00]
33	43	1.64 [1.18, 2.17]
34	75	2.86 [2.25, 3.51]
35	38	1.45 [0.99, 1.95]
36	25	0.95 [0.61, 1.34]

These class frequencies condition on projections measurable under both coefficient signs. Minor-area $\geq 15\%$ and origin-net are different estimands. Additional fixed 5%, 10% and 25% checks remain in the source aggregates. Availability remains explicit:

Key dimensions: Population / fold / segment / view.

Population	Fold	Segment	View	Candidates	Minus / plus / both available	Both unavailable / minus-only / plus-only
PTB technical external	external technical	qrs	frontal/front	286	285/285/285	1/0/0
PTB technical external	external technical	qrs	right-sagittal (-Z,Y)	286	285/285/285	1/0/0
PTB technical external	external technical	qrs	transverse/above	286	285/285/285	1/0/0
PTB technical external	external technical	t	frontal/front	286	282/282/282	4/0/0
PTB technical external	external technical	t	right-sagittal (-Z,Y)	286	282/282/282	4/0/0
PTB technical external	external technical	t	transverse/above	286	282/282/282	4/0/0
Fixed variants	train	qrs	frontal/front	2,824	2,715/2,715/2,715	109/0/0
Fixed variants	train	qrs	right-sagittal (-Z,Y)	2,824	2,715/2,715/2,715	109/0/0
Fixed variants	train	qrs	transverse/above	2,824	2,715/2,715/2,715	109/0/0
Fixed variants	train	t	frontal/front	2,824	2,640/2,640/2,640	184/0/0
Fixed variants	train	t	right-sagittal (-Z,Y)	2,824	2,640/2,640/2,640	184/0/0
Fixed variants	train	t	transverse/above	2,824	2,640/2,640/2,640	184/0/0
Fixed variants	validation	qrs	frontal/front	2,824	2,705/2,705/2,705	119/0/0
Fixed variants	validation	qrs	right-sagittal (-Z,Y)	2,824	2,705/2,705/2,705	119/0/0
Fixed variants	validation	qrs	transverse/above	2,824	2,705/2,705/2,705	119/0/0
Fixed variants	validation	t	frontal/front	2,824	2,622/2,622/2,622	202/0/0
Fixed variants	validation	t	right-sagittal (-Z,Y)	2,824	2,622/2,622/2,622	202/0/0
Fixed variants	validation	t	transverse/above	2,824	2,622/2,622/2,622	202/0/0

Optional no-Kors-boundary-fusion comparison

A prespecified hash-selected subset of 50 PTB persons was resegmented with VCG fusion weight zero and no XYZ input to boundary fusion. A remaining VCG R-peak hint had no boundary weight. Common new limits were used for Frank, Kors and Dower; 47 identically available persons contributed per angle and matrix comparison. The origin region still used Kors, so removing fusion assistance does not create a fully matrix-independent or medically adjudicated reference.

Key dimensions: Matrix / angle mode.

Matrix	Angle mode	Selected / same persons	Old $\rightarrow$ no-fusion bias, °	Bias difference, ° [95% interval]
inverse_dower	integral	50 / 47	10.80 $\rightarrow$ 11.63	0.8262 [-5.326, 7.202]
inverse_dower	peak	50 / 47	13.33 $\rightarrow$ 14.20	0.8703 [-5.170, 7.464]
kors	integral	50 / 47	+1.383 $\rightarrow$ 4.693	3.310 [-4.188, 11.60]
kors	peak	50 / 47	3.346 $\rightarrow$ 5.264	1.919 [-6.754, 12.38]

Removing Kors boundary-fusion assistance increased the Kors integral bias from +1.383° to +4.693° on the same 47 persons (50 selected); paired Δ +3.31° [-4.19, 11.60]. The direction is consistent

with fusion assistance favoring Kors, but the interval includes zero. The origin region still derives from Kors; this is not a matrix-independent gold standard (S2f).

All intervals quantify paired changes of comparison bias. A zero-containing interval does not establish equivalence, and remaining origin dependence and the absence of medical annotation preclude describing the reference as a neutral gold standard.

S2f-1. Pilot and class-uncertainty details

The 37 historical twins matched on scalar values and availability under a call without wideband, which does not establish identity of the full primary context and metadata. A complete pilot falsely treated QC abstentions without worker marker fields as adapter discrepancies; correction reran all 100 cases under the unchanged 99% criterion. Final admission was 2,004/2,005, one excluded. One admitted marker later differed from historical Kors in 83/5,648 recordings. S2 retains the exclusions and the limits of the definitions; no prior reproduction screening is substituted.

The point denominator was 1,755 of 1,786 matrix-dependent identifiers; the bootstrap estimable denominator ranged from 1,747 to 1,759. Pooled-SD normalization changed 40 summary classes. Across 729 fixed rules per normalization, class switches ranged from 0 to 500 and counts of stable matrix-dependent markers from 0 to 1. Under nominal rules the stable count and its 95% interval were 0 [0, 0]; among the ten highest-correlation markers, origin-cone confidence had a stability frequency of 0.005 under either normalization and the remaining nine had 0. These are different summaries; a degenerate percentile interval does not prove zero stability in every draw or universal instability. S2f reports frequencies and sensitivity by fold and pooled.

S2g. Post-result technical benchmark, conversion and sampling

Figure S2 compares the boundary benchmark, affine conversion and matrix/repeat ratio.

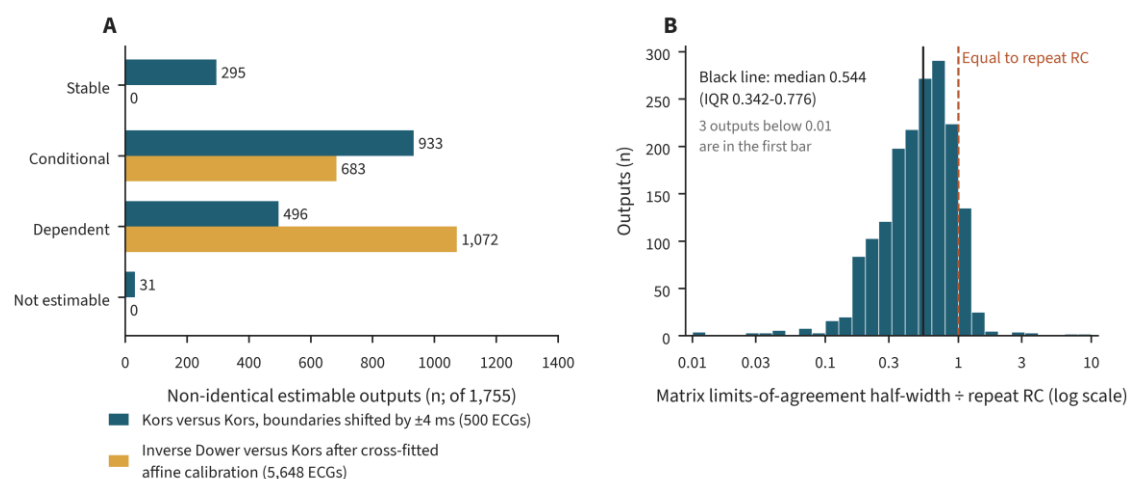


Figure S2. Matrix context of the technical classes. (A) Number of the 1,755 non-identical estimable outputs in each class under the unchanged technical rules: Kors versus Kors with QRS-onset, QRS-offset and T-offset shifted by ± 4 ms (worst direction and fold; 500 ECGs; 31 outputs not estimable) and inverse Dower versus Kors after cross-fitted affine calibration (5,648 ECGs; no output not estimable). Counts are point estimates without uncertainty intervals; the classes are technical rules, not clinical tolerances. (B) Distribution of the ratio of the matrix limits-of-agreement half-width (inverse Dower versus Kors) to the repeatability coefficient

from clinical ECG pairs (all pairs) for the same outputs ($n = 1,755$; log scale; three outputs below 0.01 are drawn in the first bar). The dashed line marks equality; the solid line marks the median. The two quantities come from different samples and the repeat coefficient includes clinical change, so the ratio does not isolate instrument noise.

These additional sensitivities use inspected development data; they do not supply independent confirmation.

We benchmarked the technical rules using identical Kors signals with separate ± 4 -ms shifts of QRS onset, QRS offset and T offset in 500 fixed development ECGs (250 per fold). Across the original 1,755 non-identical estimable outputs, the conservative worst-direction classification was 295 stable, 933 conditional, 496 dependent, 0 constant-identical and 31 not estimable. These rules therefore quantify sensitivity to a technical perturbation rather than clinical equivalence.

Selection used SHA-256 ranking, seed 20261012, 250 ECGs per fold. Fewer than 10 baseline recordings abstained at QC. The worst-direction/fold summary combines separate onset, QRS-offset and T-offset shifts in both directions. Only 295/1,724 estimable near-comparison outputs (17.11%) passed; this is a strict benchmark. On the same smaller selection, Dower-Kors yielded 1,194 dependent, 532 conditional and 29 non-estimable outputs. Dependence in the Kors/Kors benchmark denotes boundary sensitivity, not a matrix effect.

Cross-fitted affine calibration, fitted in one development fold and evaluated in the other, changed 20 of 1,071 dependent outputs to conditional and 0 to stable under the unchanged rules; 21 initially conditional outputs became dependent. A conditional reclassification indicates reduced scale-related disagreement, not complete interchangeability. Positive affine calibration preserves ranks and cannot remove rank discordance.

OLS fitted Kors = intercept+slope×Dower in one fold and evaluated the other, requiring ≥ 100 finite fit pairs and positive variances. Pooling out-of-fold predictions is descriptive. Negative slopes, periodic cuts and categorical values limit interpretation as scale conversion. Final classes were 1,072 dependent and 683 conditional.

Fold classifications agreed for 1,656/1,755 outputs (94.4%; Cohen's $\kappa = 0.884$). Of 1,071 outputs classified as dependent by the worse-fold rule, 99 were dependent in only one fold. Pooling the 5,648 ECGs classified 1,018 outputs as dependent; this is a descriptive sensitivity analysis.

Table S2g-1. Fold concordance among the original 1,755 matrix-sensitive estimable outputs.

Fold 1 (training) class / Fold 2 (validation) columns	Stable	Conditional	Dependent
stable	0	0	0
conditional	0	684	74
dependent	0	25	972

In 1,755 non-identical estimable outputs with an available positive repeat RC, the median ratio of matrix LoA half-width to repeat RC was 0.544 (IQR 0.342-0.776). For the area angle the ratio was 0.484. These ratios compare different development samples and include clinical change in the repeat denominator; they do not isolate instrument noise.

The boundary panel comprised 116 outputs across all 11 registry families. Single shifts corresponding to LUDB SDs were realized as $\pm 14/12/32$ ms on the 500-Hz grid; this is not a joint correlated error simulation.

A controlled sampling-rate sensitivity analysis compared more than 490 identical 500-Hz recordings with their anti-aliased 250-Hz versions using an 81-tap Kaiser FIR filter (112.5-Hz cutoff) and unchanged release algorithms at the respective sampling rates. Discrete Fréchet coupling had ICC(A,1) 0.977 (about 460 pairs; LoA -0.317 to 0.362), whereas the area angle had ICC 0.746 (about 470 pairs; LoA -68.18° to 67.52°). Full re-delineation and fixed-fiducial results for 116 outputs are distinguished in Supplementary Data S2; these findings do not establish general sampling-rate invariance.

The 81-tap Kaiser filter used $\beta = 8.6$ and cutoff 112.5 Hz, with phase-compensated polyphase decimation. Full reruns and fixed rounded fiducials have different finite denominators; their difference is not a causal variance decomposition.

Table S2g-2. Controlled 250-minus-500-Hz comparisons. LoA describe dispersion.

Marker identifier	mode	Finite pairs	ICC(A,1)	bias	LoA lower	LoA upper
qrs_duration_ms	Full re-delineation	>490	0.9718	3.463	-5.308	12.24
qrs_duration_ms	Fixed fiducials	>490	0.9946	0.3821	-4.43	5.195
qrs_t_frechet_be at_median	Full re-delineation	>490	0.9891	0.00302	-0.2137	0.2197
qrs_t_frechet_be at_median	Fixed fiducials	>490	0.9979	0.01552	-0.07581	0.1068
qrs_t_normalized _discrete_frechet	Full re-delineation	about 460	0.9771	0.02293	-0.3166	0.3624
qrs_t_normalized _discrete_frechet	Fixed fiducials	about 470	0.993	0.02757	-0.1553	0.2104
qrs_t_normalized _dtw_distance	Full re-delineation	about 470	0.9775	-0.00162	-0.07367	0.07044
qrs_t_normalized _dtw_distance	Fixed fiducials	about 470	0.9876	-0.00381	-0.05645	0.04882
qtc_fridericia_ms	Full re-delineation	about 450	0.9588	2.78	-17.22	22.78
qtc_fridericia_ms	Fixed fiducials	about 460	0.9988	0.1467	-3.408	3.702
spa- tial_qrs_t_angle_ deg	Full re-delineation	about 470	0.7462	-0.3258	-68.18	67.52
spa- tial_qrs_t_angle_ deg	Fixed fiducials	about 470	0.9096	-1.55	-41.8	38.69

On the same fixed 5,648-record catalog sample, 5,307 finite area-angle pairs showed Spearman 0.909, bias $+9.593^\circ$ and LoA -30.312° to $+49.498^\circ$. Substituting inverse Dower for Kors switched the $>105^\circ$ stress-test label in 710/5,307 pairs (13.38%). These estimates supersede the historical training-subsample example for comparison with main Table 4.

The older training-only twin table in S2 is historical context. Its confidence intervals must not be attached to the new common-sample estimates.

Table S2g-3. Cross-tabulation of the primary 5,648-ECG matrix class and the conservative ± 4 -ms boundary-shift class in the 500-ECG subset; both refer to the original 1,755 non-identical estimable outputs. These are different sample sizes, not a matched class-change experiment.

Primary matrix class (5,648 ECGs)	Boundary dependent	Boundary conditional	Boundary stable	Boundary not estimable	Total
Dependent	330	561	157	23	1,071
Conditional	166	372	138	8	684
Total	496	933	295	31	1,755

On the identical 500-ECG selection (250 per development fold), Dower-Kors yielded 1,194 dependent, 532 conditional, no stable and 29 non-estimable outputs within the same 1,755-output universe. The boundary benchmark yielded 496 dependent, 933 conditional, 295 stable and 31 non-estimable outputs. More than 490 signal baselines were reproduced and fewer than 10 recordings abstained at QC; 500 is the fixed selection denominator. Boundary dependence denotes sensitivity to delineation/implementation, not a matrix effect. Sampling and finite-pair availability also affect technical classes; the full-sample matrix count of 1,071 must not be directly compared with the 500-ECG boundary count.

S2g-4. The two groups of 31 not estimable outputs

Two different groups of 31 outputs appear in the matrix analyses and must not be equated.

- Thirty-one catalog markers were not estimable in the full 5,648-ECG comparison (main Table 4). They lie outside the historical set of 1,755 non-identical estimable outputs. The aggregate marker file (Supplementary Data S2) shows that all 31 had fewer than 100 finite Kors-Dower pairs in at least one development fold (27 of them in both folds), which is the rule of the classification (the classification used the exact counts; because the counts in the file are rounded to the nearest 10, a few of these markers show 100); none of them is a circular marker. By family: 9 counters and flags, 6 ratios, 5 durations, 5 angles, 5 amplitudes and areas, 1 shape descriptor.
- Thirty-one outputs of the historical set of 1,755 were not estimable in the ± 4 -ms Kors/Kors boundary-shift experiment (500 ECGs, 250 per fold), which left 295 stable, 933 conditional and 496 dependent among 1,724. Here “not estimable” means that at least one of the six shifts (QRS onset, QRS offset and T offset, each plus and minus 4 ms) in at least one of the two folds could not be classified. The aggregate marker file shows that 30 of the 31 had fewer than 100 finite pairs in at least one shift-by-fold cell (for two markers at least one cell had no finite pairs), and one (a binary flag) was constant in the second fold under all shifts (no variation in that fold); no marker failed for another reason. By family: 11 ampli-

tudes and areas, 7 angles, 6 shape descriptors, 4 ratios, 2 durations, 1 flag. Group (b) is disjoint from group (a) by construction (group (a) lies outside the historical set).

Rule priority for group (b): the six shifts and two folds give twelve cells per marker. A marker with at least one cell that is neither stable, conditional nor dependent (not estimable or constant) is counted as not estimable, even if other cells could be classified; otherwise the worst class over the twelve cells applies (stable, then conditional, then dependent). The classifiable cells of the 31 markers that were not counted comprised 61 stable, 21 conditional and 3 dependent cells. A cell with fewer than 10 finite pairs is suppressed in the aggregate file and counted as fewer than 100. The aggregation script reproduces 295, 933, 496 and 31 and the 31 of group (a); it is part of the public analysis scripts (Code availability in the main text).

The reasons for the 29 outputs not estimable in the Dower-Kors comparison of the same 500 ECGs are not tabulated in the aggregate file and were not checked.

S2h. Delineator input sensitivity and uniform gain

Both matrices share one fusion delineation, which includes Kors-XYZ candidates (nominal weight 0.25) and uses the Kors loop direction to resolve ambiguous P candidates. Native outputs that are identical in main Table 4 are therefore identical at shared fiducials only. A prespecified check (criterion fixed and hashed before the first delineation; seed 20261014; development data only, no test-partition data) delineated the same recordings with Kors XYZ (production), inverse-Dower XYZ and no XYZ input. The arms were more than 490 evaluable development ECGs (about 260 training, about 230 validation) from a hash-ranked selection of 500 ECGs of the fixed catalog sample, the 200 LUDB recordings and 290 PTB persons (first recording per person; measured Frank leads as a further input). The Kors variant reproduced the stored values of the five native markers in all evaluable ECGs and all 8,110 stored LUDB landmark rows.

Shifts were Dower minus Kors on pairs with a value in both variants. The reference scale of each boundary was the SD of its LUDB error in Table S3b-1 (for intervals, the root of the summed squares of the two boundary SDs). Practically independent required $|\text{bias}| < 0.10$ scale, LoA half-width < 0.5 scale and discordant availability $< 2\%$; practically dependent required $|\text{bias}| \geq 0.25$ scale, half-width ≥ 1.0 scale or discordant availability $\geq 5\%$; limited dependence was the remainder. Availability discordance below 2% is shown as <2 so that counts below 10 ECGs cannot be recovered; other availability discordances are shown to the nearest whole percent, except those of PR interval and P duration, whose class depends on the 5% threshold.

Table S2h-1. Inverse-Dower minus Kors input to the delineator, more than 490 MIMIC development ECGs. LoA describe dispersion.

Quantity	Available in one delineation only, %	Bias, ms	LoA, ms	Class under the fixed criterion
QRS duration	<2	-0.06	-1.3 to 1.2	practically independent
QT	<2	0.00	-4.8 to 4.8	practically independent
QTcF (descriptive, QT scale)	3	0.01	-14.5 to 14.6	limited
PR interval	5.5	-0.70	-27.1 to 25.7	practically dependent
P duration	5.5	0.21	-21.8 to 22.2	practically dependent
P onset	4	1.32	-27.5 to 30.1	limited
P offset	4	0.08	-5.8 to 6.0	limited
QRS onset	<2	0.00	-0.7 to 0.7	practically independent
QRS offset	<2	-0.06	-1.0 to 0.9	practically independent
T offset	<2	-0.02	-4.9 to 4.8	practically independent

QRS duration and QT interval were practically independent of the delineator's VCG input in all three databases (LUDB per recording: LoA -2.7 to 2.5 ms and -4.3 to 4.7 ms; PTB: -0.3 to 0.3 ms and -2.6 to 2.7 ms). PR interval and P duration were classed practically dependent in MIMIC, triggered by the availability criterion (about 5.5% against a 5% threshold; Wilson 95% interval about 4 to 8%); where both delineations gave a value, the shifts were limited and the bias near 0 ms. The classification therefore rests on a threshold close to the point estimate. In LUDB, P duration reached the dependent class by availability at 5.0% and PR was limited; in PTB (recordings of 38 to 120 s), PR was practically independent and P duration limited. No overall label is assigned. Per beat, P onset changed in 12 to 19% of beats (86.0% identical in MIMIC, 88.0% in PTB, 80.9% in LUDB), with LoA of about ± 59 ms (MIMIC), ± 58 ms (LUDB) and ± 51 ms (PTB), comparable with the LUDB P-onset error SD of 48.01 ms; this per-beat analysis was added after the criterion was fixed and is descriptive.

Against the LUDB expert boundaries, inverse-Dower input changed the mean error by at most 1.3 ms and the mean absolute error by at most 0.4 ms at all five boundaries. Without any VCG input,

the P-onset mean absolute error rose from 31.9 to 39.7 ms and the P-offset error from 14.8 to 19.3 ms, while more P waves were set (1,388 versus 1,250 matched references); only the P onset met the error-relevance criterion (bias change ≥ 0.25 scale or mean absolute error change $\geq 10\%$ of the value in Table S3b-1). Measured Frank leads as delineator input (PTB) shifted QRS duration and QT by LoA of ± 0.5 and ± 3.0 ms and PR interval by -24.6 to 22.4 ms; no expert boundaries exist in PTB, so no statement on the quality of this input follows. Limits: one delineator configuration (weights 0.40/0.35/0.25) was tested; the representative beat can differ between variants, and the markers include this selection; LUDB was used in developing the delineator, so this arm is no independent validation; PTB has no expert boundaries; removing the VCG input is a technical variant, not a delineator tuned for that case.

Segmentation is also not invariant to a uniform gain. The multilead stage uses fixed millivolt floors (noise floor 0.002 mV; prominence floors 0.012 mV for P and 0.025 mV for T candidates; 0.015 mV for Q and S), and the NeuroKit wavelet stage scores T- and P-peak candidates by adding signal amplitude to a time term. When these constants were scaled with the gain in memory, the delineation of a doubled signal was identical to the baseline (checked in 12 ECGs, 134 beats). In 385 development ECGs, scaling all twelve leads by 1.05 or 1.10 changed the area QRS-T angle by root-mean-square 12.6° and 16.6° and the normalized Fréchet distance by 0.056 and 0.059, mainly through large changes in a minority of ECGs, coinciding with a change of the representative beat and of the isoelectric origin. In 40 development ECGs, factors of 2 and 0.5 gave angle changes of 20.8° and 28.6° (root-mean-square). Both matrix arms share one set of fiducials, so the gain sensitivity described here acts on both arms; the matrix contrast was not recomputed under uniform gain changes and is not shown to be gain-invariant. The gain variation within the clinical pairs was not measured, so the share of the angle repeat differences attributable to gain is not estimated; only the observed perturbation effects above are reported.

S2i. Circular markers: periods, angular repeat variation and catalog sensitivity

Markers that are angles on a circle cannot be compared by subtraction near the coordinate cut at $\pm 180^\circ$. The catalog-wide repeat and matrix analyses used raw differences, so for circular markers they mix genuine disagreement with jumps at the cut. A first attempt to correct this (wrapped second measurements and a linear ICC computed from them) was withdrawn, because a constructed second value depends on the first and creates spurious agreement. The post hoc analysis below replaces it. It uses development pairs only. In the main results the 29 circular markers are not classified; the values including them are the historical set, reported here as a sensitivity.

Periods. Periods were read from the code definition of each marker, not from its value range or its catalog label, and the eleven source files defining these markers had identical content in the locked release source used for the main analyses and in the current source. Twenty-nine markers have a verified circular scale: 26 directed angles with a period of 360° (azimuths of the P, QRS, ST and T area vectors, of the peak, maximum and spatial-gradient vectors, of septal activation and of

the ST injury vector, initial and terminal QRS force azimuths at 10-40 ms, ST azimuths at J+20 to J+80 ms, early and late T-trajectory azimuths, and the frontal axes of the secondary morphology and of the delta wave), one undirected axis with a period of 180° (loop ellipse orientation) and two classical frontal-axis variables with a period of 360° that had not been flagged in the catalog. One flagged marker (peak_area_qrs_azimuth_difference_deg) is an unsigned distance in $[0^\circ, 180^\circ]$ and is not periodic; angle-valued holonomy and angle-difference markers are not periodic either.

Method. The difference is the shortest angular distance with the period of the marker. The angular repeat distance D95 (not comparable to the SD-based RC of other markers) is the empirical 95th percentile of this distance (95% intervals from the same 1,000 person resamples as the main analysis, seed 77010); bias is the circular mean of the signed difference. As a reference, first and second values within the population were paired at random (20 permutations). The coverage of the rule $1.96 \times \text{SD}$ is reported for comparison. A linear ICC is not defined for circular markers and is not reported; the unwrapped linear values remain in the catalog files only so that catalog medians can be reproduced. Tests on synthetic data (wrapping, antipodal pairs, seam distributions, interval coverage) were passed before the run.

Table S2i-1. Circular markers, summary of D95 and related quantities over the 26 directed angles with a period of 360° (minimum to maximum, median).

Quantity	All pairs	Stability proxy (25 estimable)
D95, 95th percentile of angular distance ($^\circ$)	91.9 to 166.4 (153.2)	63.7 to 167.6 (143.0)
D95 under random pairing ($^\circ$)	143.1 to 171.6 (167.0)	128.5 to 173.7 (164.9)
Median angular distance ($^\circ$)	5.6 to 60.7 (28.4)	4.9 to 49.7 (24.2)
Median under random pairing ($^\circ$)	38.6 to 89.1 (71.0)	31.8 to 88.2 (65.0)
Circular mean difference ($^\circ$)	-3.0 to +1.0	-1.8 to +1.9
Pairs covered by the $1.96 \times \text{SD}$ rule (%)	88.3 to 97.7 (24 of 26 below 95)	87.7 to 94.4 (25 of 25 below 95)
Pairs with distance $\geq 90^\circ$ (%)	5.1 to 35.3	3.0 to 28.6

A D95 close to its random-pairing value does not mean that typical pairs agree poorly: the median distance is much smaller. It means that a minority of recordings, probably those in which the vector is short or unstable (not tested here), differ by more than 90°. D95 should therefore be read together with the median distance and the share beyond 90°.

Table S2i-2. Circular markers, all pairs. Period in degrees; pairs / persons; D95 = 95th percentile of the shortest angular distance [95% interval], degrees; D95 under random pairing; median distance; circular mean difference; share of pairs covered by $1.96 \times \text{SD}$ (%); D95 in the stability proxy [interval]. In the CSV files, D95 is held in the columns `circular_*_rc_p95_distance`.

Marker	Period	Pairs / persons	D95 [95% interval]	Random pairing	Median distance	Circular mean	Coverage of 1.96 SD rule	Proxy D95 [interval]
classical_left_axis_deviation	360	13,490 / 9,040	40.0 [38.0, 43.0]	132	5.0	-0.5	95.6	28 [26, 30]
classical_right_axis_deviation	360	13,490 / 9,040	40.0 [38.0, 43.0]	131	5.0	-0.5	95.6	28 [26, 30]
delta_wave_frontal_axis_deg	360	500 / 430	160.8 [147.9, 165.1]	171	28.8	0.1	89.9	not estimable
p_area_vector_azimuth_deg	360	3,360 / 2,700	153.8 [149.2, 157.3]	161	34.7	-1.5	91.5	149 [138, 154]
peak_svg_azimuth_deg	360	13,030 / 8,970	95.9 [89.5, 100.5]	143	7.2	-0.3	93.0	71 [62, 85]
qrs_area_vector_azimuth_deg	360	14,250 / 9,600	91.9 [86.1, 95.5]	157	10.7	-0.4	93.1	64 [58, 70]
qrs_initial_10ms_force_azimuth_deg	360	14,250 / 9,600	166.4 [165.4, 167.2]	168	60.7	1.0	97.7	161 [158, 164]
qrs_initial_20ms_force_azimuth_deg	360	14,250 / 9,600	163.7 [162.5, 164.9]	169	54.2	-0.2	95.6	158 [155, 161]
qrs_initial_30ms_force_azimuth_deg	360	14,250 / 9,600	156.5 [155.0, 158.0]	168	38.6	-0.5	91.9	148 [144, 152]
qrs_initial_40ms_force_azimuth_deg	360	14,250 / 9,600	140.1 [137.0, 143.0]	161	20.5	-0.9	90.9	118 [110, 125]
qrs_max_vector_azimuth	360	14,250 / 9,600	97.2 [90.9, 102.4]	144	5.6	-0.2	92.8	72 [60, 85]
qrs_terminal_10ms_force_azimuth_deg	360	14,250 / 9,600	157.8 [156.5, 159.3]	169	36.0	0.4	91.3	155 [152, 157]

Marker	Period	Pairs / persons	D95 [95% interval]	Random pairing	Median distance	Circular mean	Coverage of 1.96 SD rule	Proxy D95 [interval]
qrs_terminal_20ms_force_azimuth_deg	360	14,250 / 9,600	153.8 [152.2, 155.3]	169	34.4	-0.3	91.4	152 [147, 155]
qrs_terminal_30ms_force_azimuth_deg	360	14,250 / 9,600	144.5 [142.5, 146.7]	165	27.0	-0.9	91.1	135 [130, 140]
qrs_terminal_40ms_force_azimuth_deg	360	14,250 / 9,600	126.0 [122.3, 130.0]	159	18.7	-1.1	91.7	106 [100, 113]
secondary_morphology_frontal_axis_deg	360	410 / 360	161.9 [152.3, 168.5]	172	21.0	-0.9	88.3	168 [121, 174]
septal_activation_azimuth_deg	360	14,920 / 9,880	162.3 [161.3, 163.6]	166	40.4	-3.0	92.5	158 [155, 161]
st_area_vector_azimuth_deg	360	about 13,900 / about 9,400	153.5 [151.4, 155.0]	167	33.4	0.7	91.3	145 [140, 149]
st_injury_vector_azimuth_deg	360	14,660 / 9,780	154.3 [152.5, 156.0]	167	33.8	0.7	91.3	145 [142, 150]
st_j_plus_20ms_azimuth_deg	360	13,940 / 9,440	154.1 [152.2, 156.1]	167	33.6	0.5	91.4	146 [142, 151]
st_j_plus_40ms_azimuth_deg	360	13,940 / 9,440	152.8 [151.3, 154.9]	167	32.4	0.6	91.2	143 [138, 147]
st_j_plus_60ms_azimuth_deg	360	13,940 / 9,440	152.6 [150.1, 154.1]	168	30.5	-0.2	91.0	141 [137, 147]
st_j_plus_80ms_azimuth_deg	360	13,940 / 9,440	149.7 [147.4, 152.2]	168	28.0	-0.3	90.9	139 [135, 143]
svg_azimuth	360	13,510 / 9,210	148.7 [146.3, 150.8]	166	24.7	-0.7	90.7	135 [130, 141]
t_area_vector_azimuth_deg	360	13,340 / 9,120	140.3 [137.1, 143.3]	165	19.1	0.4	91.1	124 [115, 133]
t_early_trajectory_azimuth_deg	360	13,340 / 9,120	141.5 [138.5, 144.5]	166	21.3	0.3	90.9	124 [119, 132]
t_late_trajectory_azimuth_deg	360	13,340 / 9,120	133.7 [130.3, 137.5]	164	17.4	-0.0	91.2	109 [102, 117]
t_max_vector_azimuth	360	13,340 / 9,120	156.6 [154.9, 158.5]	167	14.1	0.4	88.9	144 [135, 150]
loop_ellipse_orientation_deg	180	14,920 / 9,880	42.5 [40.2, 45.1]	75	3.1	0.1	93.4	35 [30, 38]

Pair and person counts in this table are rounded to the nearest 10, as in Supplementary Data S2 (cells below 10 are suppressed; fixed study denominators are printed exactly).

Table S2i-3. Catalog summaries without the 29 circular markers (main results; point estimates, intervals not recomputed) and with them (historical set; sensitivity).

Quantity	Main: without the 29 circular markers	Historical set with them
Estimable markers, all pairs / proxy	1,958 / 1,946	1,987 / 1,974
Median ICC, all pairs	0.4678	0.4665 [0.4591, 0.4778]
Median ICC, proxy	0.5259	0.5242 [0.5142, 0.5457]
ICC ≥ 0.75 , all pairs	311 (15.88%)	313 (15.75%)
ICC ≥ 0.75 , proxy	482 (24.77%)	484 (24.52%)
Matrix class dependent / conditional / stable	1,045 / 684 / 0	1,071 / 684 / 0
Identical nonconstant outputs	214	217
Non-identical estimable outputs	1,729	1,755
Share dependent / conditional	60.4% / 39.6%	61.0% / 39.0%

Of the 29 circular markers, 26 (25 directed angles and the ellipse axis) are in the catalog class dependent; the delta-wave axis and the two classical axes are in the class identical at shared fiducials. Matrix classes of circular markers were not re-derived, and no new classification rule for circular quantities is introduced; in the main results they are not classified (periodic).

Figure S1 shows the historical composition of the catalog by matrix agreement class.

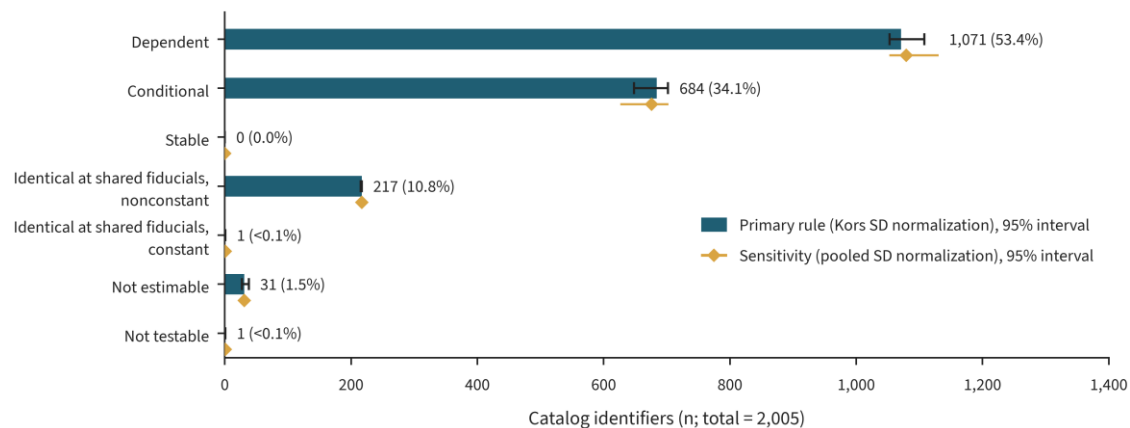


Figure S1. Historical composition of the 2,005-identifier catalog by same-ECG matrix agreement class (inverse Dower versus Kors, 5,648 development ECGs, one per person), including the 29 circular markers, whose classes derive from raw angle differences and are not valid circular classifications (main Table 4 excludes them: 1,045 dependent, 684 conditional). “Identical at shared fiducials” means that the output is the same under both matrices because delineation and fiducials are shared and partly Kors-assisted; it does not mean independence from the matrix. Bars: primary classification (Kors-SD normalization); diamonds: pooled-SD sensitivity. Whiskers: 95% percentile intervals of the class count from 1,000 person-bootstrap draws (seeds 77010/77011 by fold); they describe classification uncertainty, not the probability of clinical interchangeability. Percentages refer to all 2,005 identifiers. The classes are technical rules, not clinical tolerances; zero stable entries is not an equivalence test.

Flags. For 55 binary markers, Cohen’s κ equalled the ICC to within 0.005 in all 50 estimable markers (all pairs; computed from unrounded values, whereas the CSV shows estimates for binary markers to two significant digits); prevalence-adjusted agreement (PABAK) is inflated for rare flags and is not used. Of the 55 binary markers, 44 were identical under both matrices, 9 were not estimable, one was constant and identical, and one (multifocal_atrial_tachycardia_pattern_flag)

was not identical, with fewer than 10 discordant pairs and κ 0.43; its catalog class dependent follows from the quintile rule on ties.

S3. Short-interval reproducibility, denominators and sensitivity

Current repeatability tables use the positive normalized denominator rule and seed 77010. Superseded confidence intervals are omitted; earlier source versions remain archived.

Basis	Catalog	evaluable status	Finite ICC	Meaning
Historical export	2,005	1,989	1,984	status and finite coefficient are different
Re-scaled moment audit / all	2,005	formal_estimable based on finite ICC	1,987	T2 denominator
Re-scaled moment audit / proxy	2,005	formal_estimable based on finite ICC	1,974	T2 denominator

Four outputs became finite after rescaling (`beat_smoothness_index`, `global_vcg_smoothness_index`, `qrst_smoothness_index` and `st_t_smoothness_index`), while `secondary_morphology_qt_beat_to_beat_variability_ms` no longer met the revised criteria: the net increase is three, not three newly finite identifiers.

The historical nonfinite evaluable rows are `beat_smoothness_index`, `global_vcg_smoothness_index`, `precordial_rs_absent_flag`, `qrst_smoothness_index` and `st_t_smoothness_index`. Historical `reliable_for_individual_change` has 313 true rows (ICC convention); no native-unit acceptance criterion is encoded by that flag. Re-scaled point estimability requires finite ICC after normalization, $n_pairs > 1$, $n_persons \geq 30$ and $denominator > 1e-14$. Shared person draws preserve pair overlap and marker dependence. Point pair weighting and cluster resampling are separate operations.

T2b. Identity, selection, native-unit and paired contrasts

Waveform identity was checked for every equal-time pair using original file paths, data and header hashes and decoded physical signals with channel order and sampling rate. Excluding equal-time pairs was a sensitivity analysis, regardless of identity. The supplementary repeat audit used ICC(A,1), equal pair weights, at least 30 persons with finite paired values and a positive normalized ANOVA denominator; this positive-denominator rule is reported separately from the earlier $> 1e-14$ criterion. Shared person weights in 1,000 bootstrap draws (seed 77010) preserved proxy and full covariance. Contrasts used 1,974 jointly estimable point markers and the same jointly finite marker set within each draw (1,953-1,972; median 1,966). Restricting full pairs to proxy persons holds persons, but not recording times, constant. Between-person SD is the SD of person-level means of pair means, with one vote per person; $RC = 1.96 \text{ SD}(\text{centered paired differences})$, a descriptive spread of repeat differences that includes clinical change, selection and possibly correlated measurement errors; it is not interpreted as a smallest detectable change or standard error of measurement. The column $\text{SD}(\text{differences})/\sqrt{2}$ is a purely arithmetic quantity without measurement-error interpretation. This normal-span convention does not guarantee empirical 95%

coverage. Repeated pairs of the same person require within-person clustering (Bland and Altman 2007; published correspondence identifies issues in its numerical examples, which were not used here); our estimates are pair-weighted with person-bootstrap uncertainty. The $ICC \geq 0.75$ line is a reporting convention after Koo and Li (2016) applied to point estimates. Absolute heart-rate changes came from the measured context field.

No decoded waveform, data-file, header-file or path identities were found among 360 equal-time pairs from 343 persons; all pairs were resolved. Exclusion left 15,333 pairs/10,014 persons.

T2b. Population	Pairs / persons	Estimable / catalog	Median ICC [95% interval]	ICC ≥ 0.75 / estimable; % [95% interval]
All	15,693 / 10,187	1,987 / 2,005	0.4665 [0.4591, 0.4778]	313/1,987; 15.75 [14.66, 17.43]
No equal-time pairs	15,333 / 10,014	1,987 / 2,005	0.4650 [0.4578, 0.4765]	308/1,987; 15.50 [14.56, 17.35]
Proxy	4,596 / 3,560	1,974 / 2,005	0.5242 [0.5142, 0.5457]	484/1,974; 24.52 [22.38, 26.42]
Full pairs of proxy persons	6,121 / 3,560	1,977 / 2,005	0.4999 [0.4919, 0.5203]	426/1,977; 21.55 [19.49, 23.12]

T2b and main-text Table 2 and the catalog medians use the supplementary rule set (seed 77010, positive normalized denominator). On 1,974 jointly estimable markers, the proxy-minus-all difference of median ICCs was 0.05773 [0.04592, 0.07644], whereas the median of markerwise differences was 0.03560 [0.02721, 0.04575]. Holding persons fixed (full pair set: 6,121/3,560) reduced these contrasts to 0.02429 [0.01245, 0.03397] and 0.00735 [0.00393, 0.01203]. Bootstrap common-marker denominators varied as specified in section 2.3. Median/P95 $|\Delta HR|$ was 5.970/59.735 bpm in all 15,693 pairs and 3.086/15.284 bpm in 4,596 proxy pairs. For area angle, RC/between-person SD was 82.405°/42.233° overall and 71.057°/42.373° in the proxy; for QTcF, 61.783/37.794 ms and 47.547/35.194 ms. Supplement S3 provides native-unit intervals and all five fixed marker contrasts. Among those five markers, only proxy QRS duration had RC below between-person SD (1/5 versus 0/5 overall); this is not an individual-change certification.

Difference of medians, median of marker differences and fraction difference are separate estimands (fraction difference in proportion units). The proxy remains selected even when persons are held fixed.

Key dimensions: Comparison / metric.

Comparison	Metric	Point common markers	Bootstrap common min / max / median	Contrast [95% interval]	Finite draws
proxy minus all pairs	difference_of_medians	1,974	1,953/1,972/1,966	0.05773 [0.04592, 0.07644]	1,000
proxy minus all pairs	median_of_marker_differences	1,974	1,953/1,972/1,966	0.0356 [0.0272, 0.0457]	1,000
proxy minus all pairs	difference_reliable_fraction	1,974	1,953/1,972/1,966	0.0876 [0.0640, 0.1049]	1,000
proxy minus all pairs in proxy persons	difference_of_medians	1,974	1,953/1,972/1,966	0.02429 [0.01245, 0.03397]	1,000
proxy minus all pairs in proxy persons	median_of_marker_differences	1,974	1,953/1,972/1,966	0.0074 [0.0039, 0.0120]	1,000
proxy minus all pairs in proxy persons	difference_reliable_fraction	1,974	1,953/1,972/1,966	0.0294 [0.0178, 0.0432]	1,000

Native-unit coefficients under the supplementary repeat definition

The T2a table above retains historical audit intervals for chronology only; the main-text key-measure table (Table 2) uses the supplementary definition below. The supplementary table below uses seed 77010 and its positive normalized denominator criterion. Pointwise percentile intervals are estimator uncertainty; RC is a centered difference span, including true clinical variation, and does not guarantee 95% coverage. Between-person SD is computed from person means; it is not an ICC denominator or clinical reference norm. Missing marker pairs stay excluded with explicit denominators.

Supplementary table 026, part 1.

Row	Population / marker	Unit	Finite pairs / persons	ICC [95% interval]	Bias [95% interval]	RC [95% interval]
1	All/spatial_qrs_t_angle_deg	°	13,310/9,120	0.6170 [0.6031, 0.6321]	0.13 [−0.6254, 0.7903]	82.41 [80.85, 83.91]
2	All/qtc_fridericia_ms	ms	12,450/8,630	0.7151 [0.6969, 0.7343]	1.98 [1.453, 2.473]	61.78 [59.48, 63.99]
3	No equal-time pairs/spatial_qrs_t_angle_deg	°	13,020/8,960	0.6165 [0.6026, 0.6316]	0.18 [−0.5636, 0.8412]	82.43 [80.85, 83.97]
4	No equal-time pairs/qtc_fridericia_ms	ms	12,180/8,470	0.7164 [0.6970, 0.7353]	1.992 [1.484, 2.494]	61.38 [59.04, 63.68]
5	Proxy/spatial_qrs_t_angle_deg	°	4,220/3,310	0.6934 [0.6710, 0.7152]	0.18 [−0.8709, 1.220]	71.06 [68.44, 73.66]
6	Proxy/qtc_fridericia_ms	ms	4,140/3,250	0.7894 [0.7645, 0.8140]	2.13 [1.404, 2.803]	47.55 [44.30, 50.64]
7	Full pairs of proxy persons/spatial_qrs_t_angle_deg	°	5,500/3,360	0.6694 [0.6486, 0.6893]	0.2588 [−0.7152, 1.139]	74.70 [72.41, 76.95]
8	Full pairs of proxy persons/qtc_fridericia_ms	ms	5,320/3,310	0.7612 [0.7377, 0.7855]	1.865 [1.163, 2.513]	52.05 [49.01, 55.05]
9	All/qtc_bazett_ms	ms	12,450/8,630	0.6298 [0.6092, 0.6512]	−1.32 [−1.995, −0.6509]	78.56 [75.77, 81.07]
10	No equal-time pairs/qtc_bazett_ms	ms	12,180/8,470	0.6355 [0.6152, 0.6566]	−1.440 [−2.090, −0.7703]	77.58 [74.79, 80.04]
11	Proxy/qtc_bazett_ms	ms	4,140/3,250	0.7697 [0.7403, 0.7995]	1.49 [0.6583, 2.272]	54.40 [50.63, 58.13]
12	Full pairs of proxy persons/qtc_bazett_ms	ms	5,320/3,310	0.7178 [0.6897, 0.75]	0.5423 [−0.3239, 1.403]	62.33 [58.54, 65.96]
13	All/p_duration_ms [historical multilead fusion]	ms	3,400/2,730	0.4915 [0.4431, 0.5382]	0.29 [−0.4751, 1.069]	47.84 [44.71, 50.97]
14	No equal-time pairs/p_duration_ms [historical multilead fusion]	ms	3,340/2,690	0.4894 [0.4400, 0.5372]	0.2601 [−0.5242, 1.058]	48.07 [44.96, 51.23]
15	Proxy/p_duration_ms [historical multilead fusion]	ms	1,470/1,250	0.4539 [0.3766, 0.5325]	−0.27 [−1.622, 1.053]	50.94 [45.80, 56.30]
16	Full pairs of proxy persons/p_duration_ms [historical multilead fusion]	ms	1,800/1,350	0.4619 [0.3912, 0.5319]	−0.1375 [−1.288, 1.002]	50.28 [45.74, 54.83]

Row	Population / marker	Unit	Finite pairs / persons	ICC [95% interval]	Bias [95% interval]	RC [95% interval]
17	All/qrs_duration_ms	ms	15,130/9,960	0.8665 [0.8523, 0.8794]	0.22 [0.025, 0.4215]	27.27 [25.86, 28.77]
18	No equal-time pairs/qrs_duration_ms	ms	14,780/9,790	0.8660 [0.8513, 0.8790]	0.1986 [-0.0006, 0.3949]	27.19 [25.76, 28.70]
19	Proxy/qrs_duration_ms	ms	4,550/3,530	0.9169 [0.9031, 0.9293]	0.07 [-0.1785, 0.28]	15.99 [14.76, 17.21]
20	Full pairs of proxy persons/qrs_duration_ms	ms	6,020/>3,500	0.8923 [0.8651, 0.9142]	0.0834 [-0.1353, 0.2972]	19.96 [17.79, 22.45]

Pair and person counts in this table are rounded to the nearest 10, as in Supplementary Data S2 (cells below 10 are suppressed; fixed study denominators are printed exactly).

Supplementary table 026, part 2.

Row	Between-person SD	SD(differences)/ $\sqrt{2}$ (arithmetic)
1	42.23	29.73
2	37.79	22.29
3	42.21	29.74
4	37.71	22.15
5	42.37	25.64
6	35.19	17.15
7	41.62	26.95
8	34.55	18.78
9	41.03	28.34
10	40.97	27.99
11	38.37	19.63
12	37.69	22.49
13	20.63	17.26
14	20.68	17.34
15	21.46	18.38
16	20.81	18.14
17	25.33	9.838
18	25.17	9.808
19	19.37	5.770
20	19.61	7.202

Heart-rate change on the same pair populations

Population	Finite / candidate pairs	Median / P95 / max absolute Δ HR, bpm	Fraction >5 / >10 / >20 bpm
All	15,693/15,693	5.971/59.74/188.4	0.5466/0.3665/0.2273
No equal-time pairs	15,333/15,333	5.990/59.62/188.4	0.5483/0.3669/0.2268
Proxy	4,596/4,596	3.086/15.28/64.78	0.3357/0.1240/0.0248
Full pairs of proxy persons	6,121/6,121	3.679/32.07/188.4	0.4030/0.2032/0.0918
All, one pair/person	10,187/10,187	5.707/57.88/188.4	0.5349/0.3507/0.2114
Proxy, one pair/person	3,560/3,560	3.153/15.94/64.78	0.3396/0.1295/0.0284

All context-heart-rate pair values were available; no QTc-derived back-calculation was used. No heart-rate adjustment or intervention-free attribution is claimed.

T2 contains quality and one-pair sensitivities. Full source files provide bias and RC, marker availability and subgroup intervals. Main-text Figure 1 compares overall and proxy results for four key measures (QTcB is reported in the native-unit table above); unavailable markers remain separate-

ly disclosed in the tables. Small subgroups remain descriptive; device and era interpretation is restricted. Group-effect versus RC evidence is measurement context only, without prognostic performance tables.

S3c. Variation strata

The original pair set was unchanged. Sinus and header-normal are report-defined states. Absolute heart-rate strata use the measured context field; gaps are [0, 15], (15,60] and (60,120] min. New groups use 1,000 person-bootstrap draws (seed 149,010), keeping all selected-person pairs. Equal-time recordings were distinct, but their timestamps do not prove constant physiology or identify a pure noise component.

Table S3c-1. Candidate pair/person denominators.

Population	Candidate pairs	Candidate persons
all	15,693	10,187
proxy	4,596	3,560
Equal recorded time	360	343
Sinus reports in both recordings	5,051	3,864
other_rhythm	10,642	7,134
Heart-rate difference < 5 bpm	7,115	5,530
HR_5to15	4,181	3,561
HR_gt15	4,397	3,341
gap_0to15min	6,077	4,658
gap_15to60min	4,894	4,046
gap_60to120min	4,722	3,988
Header-normal	>300	>250
sinus_HR_le5	3,374	2,733
normal_sinus_HR_le5	>200	>150

Table S3c-2. Unsigned area-angle finite denominators and person-bootstrap intervals.

Population	Finite pairs	Persons	ICC [95% CI]	RC ° [95% CI]
all	13,310	9,120	0.6170 [0.6031, 0.6321]	82.41 [80.85, 83.91]
proxy	4,220	3,310	0.6934 [0.6710, 0.7152]	71.06 [68.44, 73.66]
Equal recorded time	294	282	0.6358 [0.5477, 0.7162]	81.46 [71.86, 89.72]
Sinus reports in both recordings	4,627	3,584	0.6892 [0.6678, 0.7083]	71.58 [69.36, 74.15]
other_rhythm	8,685	6,217	0.5803 [0.5618, 0.5985]	87.63 [85.83, 89.40]
Heart-rate difference < 5 bpm	6,295	4,991	0.6983 [0.6813, 0.7154]	72.68 [70.62, 74.57]
HR_5to15	3,612	3,132	0.6300 [0.6061, 0.6536]	80.45 [77.86, 82.94]
HR_gt15	3,405	2,727	0.4598 [0.4260, 0.4928]	99.52 [96.51, 102.64]
gap_0to15min	4,953	3,971	0.5996 [0.5775, 0.6201]	84.90 [82.70, 87.36]
gap_15to60min	4,201	3,555	0.6255 [0.6009, 0.6490]	81.54 [79.03, 84.11]
gap_60to120min	4,158	3,563	0.6291 [0.6049, 0.6530]	80.17 [77.61, 82.72]
Header-normal	322	277	0.6780 [0.5840, 0.7533]	46.64 [40.30, 52.74]
sinus_HR_le5	3,089	2,527	0.7129 [0.6905, 0.7365]	69.07 [66.08, 71.99]
normal_sinus_HR_le5	210	187	0.6334 [0.5080, 0.7321]	49.81 [41.46, 58.63]

Pair and person counts in the rows all and proxy of this table are rounded to the nearest 10, as in Supplementary Data S2.

S3d. Family distributions and empirical redundancy

Families follow a deterministic unit/name hierarchy independent of ICC/RC: counters/flags, angles, durations, ratios, amplitudes/areas and remaining shape measures. The angle family has 261 estimable markers in Table S3d-1, which includes the 29 circular markers; without them it has 232 markers (median ICC 0.445; main Figure 2). Operational types do not replace registry families. RC distributions retain a common native unit; marker quantiles are not person-confidence intervals.

Table S3d-1. Family composition and ICC distributions.

Population	Family	Catalog markers	Estimable markers	Median	25th percentile	75th percentile
all	amplitudes_areas	719	716	0.377	0.1871	0.7003
all	durations	61	58	0.6777	0.5732	0.7484
all	shape	419	418	0.4884	0.2775	0.6853
all	ratios	362	360	0.4975	0.3193	0.666
all	angles	264	261	0.437	0.3158	0.6052
all	counters_flags	180	174	0.5177	0.4197	0.6187
proxy	amplitudes_areas	719	716	0.4294	0.2021	0.7864
proxy	durations	61	56	0.7396	0.6322	0.7979
proxy	shape	419	418	0.5602	0.2965	0.7573
proxy	ratios	362	357	0.5655	0.3536	0.7516
proxy	angles	264	259	0.5124	0.3423	0.6705
proxy	counters_flags	180	168	0.5434	0.4303	0.6452

Training-only screening used 2,824 persons, all 2,005 markers, at least 100 common finite persons and $|\text{Spearman}| > 0.999$. It produced 134 edges, 1,883 components and 111 nontrivial components. One lexicographic representative per component was selected without reliability selection; constants/non-estimable markers remained singleton representatives. Transitivity does not guarantee complete linkage or algebraic identity.

Table S3d-2. Training-defined representative sensitivity.

Population	Representatives	Finite estimates	Median ICC
all	1,883	1,865	0.4591
proxy	1,883	1,852	0.5148

The catalog is an inventory of 2,005 marker outputs (Supplementary Data S2); related identifiers differ in formula, segment or normalization (S1), and its families differ in size. Table S3d-3 gives the matrix class of the non-circular markers by family; the counts are aggregated from the public marker file and reproduce main Table 4.

Table S3d-3. Technical same-ECG matrix class by family for the 1,976 non-circular catalog markers (inverse Dower versus Kors; classes as in main Table 4). The last column is the share of dependent among the dependent and conditional outputs.

Family	Catalog markers	Dependent	Conditional	Identical at shared fiducials	Not estimable, not testable or constant	Dependent, %
Amplitudes and areas	719	275	400	39	5	40.7
Angles	235	150	47	32	6	76.1
Counters and flags	180	98	8	64	10	92.5
Durations	61	9	4	43	5	69.2
Ratios	362	206	127	23	6	61.9
Shape descriptors	419	307	98	13	1	75.8
All non-circular markers	1,976	1,045	684	214	33	60.4

S3e. Bounded-angle LoA and recorded-sex/age strata

Unsigned-angle differences are unwrapped within $[-180^\circ, 180^\circ]$. Empirical percentiles are spread limits, not confidence intervals; absolute-difference P95 includes bias, whereas RC is centered.

Table S3e-1. Normal-theory and empirical area-angle LoA, degrees.

Population	Finite pairs	Persons	Normal-theory LoA lower	Normal-theory LoA upper	Empirical 2.5th percentile	Empirical 97.5th percentile	Absolute-difference P95
all	13,310	9,120	-82.28	82.54	-91.5	95.24	93.24
proxy	4,220	3,310	-70.88	71.23	-79.63	81.86	80.27
Equal recorded time	294	282	-83.39	79.54	-90.72	86.59	88.02
Header-normal	322	277	-49.85	43.42	-62.14	44.79	52.14

Pair and person counts in the rows all and proxy of this table are rounded to the nearest 10, as in Supplementary Data S2.

Recorded sex is F/M; age strata are <65/ ≥ 65 years at the earliest selected first ECG per person. Missing metadata are excluded. Subgroups are descriptive, without adjusted interaction inference; RC retains native units.

Table S3e-2. Family ICC distributions by recorded sex and age.

Population	Family	Candidate pairs	Candidate persons	Estimable markers	Median	25th percentile	75th percentile
age_ge65	amplitudes_areas	>9,700	>6,200	716	0.3549	0.1677	0.6699
age_ge65	durations	>9,700	>6,200	57	0.6636	0.552	0.7323
age_ge65	shape	>9,700	>6,200	418	0.4814	0.2661	0.6694
age_ge65	ratios	>9,700	>6,200	360	0.4786	0.3141	0.6495
age_ge65	angles	>9,700	>6,200	260	0.4225	0.3127	0.5754
age_ge65	counters_flags	>9,700	>6,200	172	0.5056	0.4175	0.6076
age_lt65	amplitudes_areas	>5,900	>3,900	716	0.4389	0.238	0.7635
age_lt65	durations	>5,900	>3,900	57	0.688	0.5776	0.7712
age_lt65	shape	>5,900	>3,900	418	0.5259	0.296	0.7097
age_lt65	ratios	>5,900	>3,900	360	0.5447	0.3381	0.7143
age_lt65	angles	>5,900	>3,900	260	0.4604	0.3227	0.6231
age_lt65	counters_flags	>5,900	>3,900	172	0.5276	0.419	0.626
sex_F	amplitudes_areas	>6,800	>4,500	716	0.3991	0.203	0.736
sex_F	durations	>6,800	>4,500	57	0.657	0.5512	0.7528
sex_F	shape	>6,800	>4,500	418	0.4876	0.2674	0.6748
sex_F	ratios	>6,800	>4,500	360	0.4852	0.3254	0.6817
sex_F	angles	>6,800	>4,500	260	0.4231	0.3005	0.5837
sex_F	counters_flags	>6,800	>4,500	174	0.5	0.4079	0.6031
sex_M	amplitudes_areas	>8,700	>5,600	716	0.3735	0.1909	0.6928
sex_M	durations	>8,700	>5,600	57	0.6753	0.5829	0.7543
sex_M	shape	>8,700	>5,600	418	0.4973	0.282	0.6878
sex_M	ratios	>8,700	>5,600	360	0.5067	0.3245	0.6567
sex_M	angles	>8,700	>5,600	260	0.4531	0.3255	0.5997
sex_M	counters_flags	>8,700	>5,600	172	0.5275	0.4291	0.624

S3f. Equal-time repeats under the unchanged matrix rule

The first recording is the reference. Each fold requires ≥ 100 finite nonconstant pairs; the smaller validation group limits estimability. Pooling is descriptive, not a replacement for the two-fold criterion. Distinct signals make this a repeat comparison rather than an identity control.

Table S3f-1. Complete counts under the nominal rule.

universe	fold	Catalog markers	Estimable	stable	conditional	dependent	Not estimable
catalog	pool	2,005	1,721	0	167	1,554	284
catalog	train	2,005	1,715	0	162	1,553	290
catalog	validation	2,005	205	0	28	177	1,800
catalog	worse_fold	2,005	205	0	10	195	1,800
origi- nal_1755_matr ix_estimable	pool	1,755	1,560	0	139	1,421	195
origi- nal_1755_matr ix_estimable	train	1,755	1,558	0	135	1,423	197
origi- nal_1755_matr ix_estimable	validation	1,755	165	0	25	140	1,590
origi- nal_1755_matr ix_estimable	worse_fold	1,755	165	0	8	157	1,590

S3g. Post hoc sensitivities of the stability proxy

Because the proxy selects pairs by a QRS-duration class condition and by rhythm, pacing and interval criteria, three post hoc sensitivities were run on the development pairs (15,693 pairs, 10,187 persons): (i) the equal-QRS-class condition was removed (all other criteria unchanged); (ii) every person received equal weight (pair weight $1/n$ for n pairs of the person, and 200 random draws of one pair per person); (iii) the proxy was compared with all pairs of the same persons. Estimators, normalization and the 1,000 shared person resamples (seed 77010) were unchanged. The proxy rule was reconstructed exactly from stored pair attributes (all 15,693 stored flags reproduced) and the main medians and contrasts were reproduced before the sensitivities were read.

Table S3g-1. Catalog median ICC over estimable markers.

Population	Pairs	Estimable markers	Median ICC [95% interval]	ICC ≥ 0.75 , %
All pairs	15,693	1,987	0.4665 [0.4591, 0.4778]	15.75
All pairs, equal person weights	15,693	1,987	0.4700 [0.4630, 0.4817]	16.51
Proxy	4,596	1,974	0.5242 [0.5142, 0.5457]	24.52
Proxy, equal person weights	4,596	1,974	0.5207 [0.5123, 0.5451]	24.32
Proxy without QRS-class condition	4,768	1,974	0.5237 [0.5126, 0.5440]	23.81
Same, equal person weights	4,768	1,974	0.5226 [0.5157, 0.5445]	24.01
Only the 172 pairs excluded by the QRS-class condition	172	1,924	0.4743 [0.4248, 0.5339]	13.05
All pairs of the proxy persons	6,121	1,977	0.4999 [0.4919, 0.5203]	21.55
All pairs of the persons of the proxy without QRS condition	6,314	1,977	0.4994 [0.4915, 0.5195]	20.99

Table S3g-2. Contrasts of median ICC (difference of medians over jointly estimable markers; 1,000 draws, all valid).

Contrast	Value [95% interval]
Proxy minus all pairs	0.0577 [0.0465, 0.0774]
Proxy without QRS condition minus all pairs	0.0572 [0.0452, 0.0752]
Proxy without QRS condition minus proxy (effect of the QRS condition)	0.0005 [-0.0020, 0.0058]
Proxy minus all pairs of the proxy persons (persons held fixed)	0.0243 [0.0128, 0.0349]
Same without QRS condition	0.0240 [0.0118, 0.0334]
Equal person weights: proxy minus all pairs	0.0509 [0.0406, 0.0725]
Equal person weights and persons held fixed: proxy	0.0099 [0.0023, 0.0214]
Equal person weights and persons held fixed: without QRS condition	0.0131 [0.0061, 0.0224]
All pairs: equal person weights minus pair weights	0.0035 [-0.0016, 0.0087]
Proxy: equal person weights minus pair weights	-0.0035 [-0.0086, 0.0044]

With one randomly drawn pair per person (200 repetitions), the catalog median ICC was 0.4705 (all pairs), 0.5218 (proxy) and 0.5229 (proxy without QRS condition); the ranges of the repetitions (0.465-0.475, 0.516-0.527, 0.515-0.530) reflect the choice of pair only, not sampling uncertainty.

Table S3g-3. Key measures in the proxy with and without the QRS-class condition, and in all pairs with equal person weights (ICC; RC).

Measure	Proxy	Proxy without QRS condition [RC interval]	All pairs, equal person weights
QRS duration (ms)	0.917; 15.99 [14.76, 17.21]	0.904; 17.36 [16.11, 18.61]	0.871; 26.17
QTcF (ms)	0.789; 47.55 [44.30, 50.64]	0.787; 48.33 [45.16, 51.42]	0.727; 59.86
Area QRS-T angle (°)	0.693; 71.06 [68.44, 73.66]	0.687; 71.98 [69.40, 74.43]	0.624; 81.61
P duration (ms)	0.454; 50.94 [45.80, 56.30]	0.453; 51.29 [46.22, 56.45]	0.490; 47.20

Interpretation. The equal-QRS-class condition removed 3.6% of the otherwise eligible pairs and did not change the catalog median; it did raise the QRS-duration RC by about 1.4 ms when removed (the 172 excluded pairs have QRS ICC 0.41 and RC 39 ms). The proxy advantage over all pairs was attenuated under the examined analyses: it fell from 0.058 to 0.024 with persons held fixed and to 0.010 with equal person weights as well. What remains (rhythm, pacing report, gap) is small. Equal person weights changed the medians by less than 0.004 with intervals including zero, so frequent repeaters do not dominate the catalog medians. Proxy values are therefore not an isolated stability result. The quality criterion (score ≥ 0.6 on both recordings) was applied when pairs were formed; only 0.15% of development ECGs had a score below 0.6, so it cannot have removed more than about 0.3% of the candidate pairs, and its omission was not run.

S3h. Machine-reported measurements on the same pairs (post hoc)

Question. How large are the ICC and the repeat variation (RC) of the measurements that the recording devices stored with MIMIC-IV-ECG (the machine measurements) on the same development pairs, estimated in the same way as the LoopLens values? Both measurement chains analyze the same pair of recordings, so the comparison does not separate measurement noise from clinical change; it shows whether the repeat variation reported in the main text is specific to LoopLens or also present in another measurement chain.

Design. This comparison was added after the first complete draft and is post hoc. Its rule (derived quantities, validity limits, estimators, populations, comparison and checks) was written to a file with a time stamp and the hash of the analysis script on 16 October 2026 before the analysis was run, and it was not changed afterwards. A first run was discarded because a programming error in the assignment of derived values became apparent from the check against the stored QRS duration; the rule was unchanged and the analysis was repeated with a corrected script. Only the development pairs were used (15,693 pairs, 10,187 persons); no test-partition data were opened. All 28,867 recordings of these pairs had a stored machine record.

Quantities. From the stored time fields, QRS duration is QRS end minus QRS onset, QT is T end minus QRS onset, P duration is P end minus P onset and the PR interval is QRS onset minus P on-

set. The record does not contain a corrected QT, so QTcF ($QT/RR^{(1/3)}$) and QTcB ($QT/RR^{(1/2)}$) were derived from the stored RR interval (RR in s). The frontal QRS-T angle is the shortest angular distance between the stored QRS axis and T axis ($0-180^\circ$). The P, QRS and T axes (degrees, period 360°) are circular; their repeat variation is described by D95 and the median of the shortest angular distance, with weights and resampling as for the other quantities. Time fields outside 1-2,999 ms (including the sentinel values 29,999, 32,767, 61,440, 65,534 and 65,535), RR outside 200-3,000 ms, axes outside -180 to 360° and derived durations of zero or less were treated as missing; no other plausibility filter was applied. The device P onset equals 40 ms in 50.0% of these recordings, which limits P duration and PR interval as measurements of the P onset.

Estimators were those of the main analysis: ICC(A,1) (at least 30 persons), RC as 1.96 SD of the centered paired differences, and 1,000 person-level resamples with seed 77010 and the same person weights as the LoopLens estimates. The comparison used the pairs in which the device and LoopLens values were finite on both recordings, so that both tools are evaluated on exactly the same pairs; the RC ratio is the device RC divided by the LoopLens RC (below 1: the device values varied less). The LoopLens estimates on all pairs were reproduced before the comparison was run (QRS duration and QTcF: ICC, RC and pair counts equal to the main analysis), and the QRS duration derived here equalled the stored value in the pair table in all 15,357 first and 15,346 second recordings in which both were available.

Table S3h-1. Device-reported and LoopLens values on identical pairs, all pairs. Intervals are 95% person-bootstrap percentile intervals.

Quantity	Pairs / persons	Device: ICC; RC [95% interval]	LoopLens: ICC; RC [95% interval]	RC ratio, device / LoopLens [95% interval]	ICC difference, device minus LoopLens [95% interval]
QRS duration (ms)	15,079 / 9,944	0.8527; 26.17 [24.88, 27.37]	0.8677; 26.98 [25.48, 28.43]	0.970 [0.909, 1.031]	-0.0150 [-0.0322, 0.0018]
QT interval (ms)	14,196 / 9,496	0.7484; 81.22 [78.57, 83.78]	0.7810; 76.74 [74.68, 78.66]	1.058 [1.028, 1.091]	-0.0326 [-0.0447, -0.0212]
QTcF (ms)	12,424 / 8,613	0.7304; 49.79 [48.2, 51.4]	0.7166; 61.49 [59.21, 63.67]	0.810 [0.776, 0.851]	0.0138 [-0.0088, 0.0338]
QTcB (ms)	12,424 / 8,613	0.6470; 59.13 [57.5, 60.83]	0.6309; 78.26 [75.52, 80.79]	0.756 [0.727, 0.786]	0.0160 [-0.0085, 0.0386]
P duration (ms)	2,171 / 1,793	0.6355; 28.4 [26.68, 30.08]	0.4667; 48.89 [45.04, 52.66]	0.581 [0.527, 0.640]	0.1688 [0.0940, 0.2420]
PR interval (ms)	4,437 / 3,461	0.8147; 31.38 [29.03, 33.8]	0.5677; 65.05 [62.31, 67.91]	0.482 [0.442, 0.524]	0.2470 [0.2074, 0.2839]
Frontal QRS-T angle ($^\circ$)	12,785 / 8,846	0.8045; 69.12 [67.18, 70.98]	0.6203; 103.5 [101.6, 105.3]	0.668 [0.649, 0.687]	0.1842 [0.1689, 0.1993]

Table S3h-2. The same comparison in the stability proxy.

Quantity	Pairs / persons	Device: ICC; RC [95% interval]	LoopLens: ICC; RC [95% interval]	RC ratio, device / LoopLens [95% interval]	ICC difference, device minus LoopLens [95% interval]
QRS duration (ms)	4,550 / 3,530	0.9561; 11.7 [11.08, 12.28]	0.9169; 15.99 [14.76, 17.21]	0.732 [0.675, 0.801]	0.0392 [0.0262, 0.0524]
QT interval (ms)	4,303 / 3,356	0.8003; 44.91 [42.7, 47.33]	0.8067; 47.98 [45.17, 50.88]	0.936 [0.878, 1.001]	-0.0064 [-0.0306, 0.0166]
QTcF (ms)	4,140 / 3,250	0.7984; 38.2 [35.59, 40.89]	0.7894; 47.55 [44.3, 50.64]	0.803 [0.735, 0.891]	0.0090 [-0.0264, 0.0411]
QTcB (ms)	4,140 / 3,250	0.7892; 40.67 [37.94, 43.59]	0.7697; 54.4 [50.63, 58.13]	0.748 [0.684, 0.827]	0.0196 [-0.0202, 0.0559]
P duration (ms)	974 / 841	0.6807; 25.35 [22.76, 27.72]	0.4312; 53.08 [46.49, 59.59]	0.478 [0.408, 0.557]	0.2495 [0.1331, 0.3626]
PR interval (ms)	2,214 / 1,819	0.8640; 25.52 [23.51, 27.6]	0.5070; 73.26 [69.08, 77.26]	0.348 [0.318, 0.385]	0.3570 [0.3112, 0.4022]
Frontal QRS-T angle (°)	4,095 / 3,221	0.8890; 46.8 [44.26, 49.54]	0.7041; 88.33 [85.07, 91.48]	0.530 [0.500, 0.563]	0.1849 [0.1614, 0.2070]

Pair and person counts in the rows QRS duration, QTcF and QTcB of this table are rounded to the nearest 10, as in Supplementary Data S2.

Results. The device-reported QRS duration varied about as much as the LoopLens QRS duration (RC 26.17 versus 26.98 ms; ratio 0.970 [0.909, 1.031]) and the QT interval slightly more (ratio 1.058 [1.028, 1.091]). The derived corrected QT varied less (QTcF ratio 0.810 [0.776, 0.851]; QTcB 0.756 [0.727, 0.786]), and so did P duration (0.581), the PR interval (0.482) and the frontal QRS-T angle (0.668). The ICC of the device values was within 0.04 of the LoopLens ICC for QRS duration, QT, QTcF and QTcB, and higher for P duration, PR interval and the frontal angle. In the stability proxy the device values varied less than the LoopLens values for QRS duration, QTcF, QTcB, P duration, PR interval and the frontal angle (Table S3h-2).

Table S3h-3. Device-reported quantities on all pairs in which the device value was finite on both recordings (not restricted to pairs with a LoopLens value). Bias is the mean difference, second minus first recording.

Population	Quantity	Pairs / persons	ICC [95% inter-val]	RC [95% interval]	Bias
All pairs	QRS duration (ms)	15,637 / 10,164	0.8404 [0.8274, 0.8536]	28.71 [27.33, 29.99]	-0.6373
All pairs	QT interval (ms)	15,642 / 10,167	0.7375 [0.7232, 0.7507]	86.11 [83.4, 88.78]	8.146
All pairs	QTcF (ms)	>15,500 / >10,100	0.6865 [0.6698, 0.7024]	57.43 [55.77, 59.35]	2.157
All pairs	QTcB (ms)	>15,500 / >10,100	0.6003 [0.5818, 0.6190]	66.49 [64.6, 68.35]	-1.613
All pairs	P duration (ms)	6,288 / 4,752	0.3736 [0.2329, 0.5040]	49.44 [38.22, 71.45]	-0.08206
All pairs	PR interval (ms)	10,342 / 7,343	0.5513 [0.4608, 0.6236]	78.75 [68, 94.51]	1.597
All pairs	Frontal QRS-T angle (°)	15,319 / 10,038	0.7784 [0.7668, 0.7884]	74.42 [72.74, 76.29]	-3.567
Stability proxy	QRS duration (ms)	4,596 / 3,560	0.9570 [0.9514, 0.9620]	11.85 [11.13, 12.47]	-0.4517
Stability proxy	QT interval (ms)	4,596 / 3,560	0.7929 [0.7716, 0.8119]	47.07 [44.59, 49.53]	2.954
Stability proxy	QTcF (ms)	4,596 / 3,560	0.7826 [0.7558, 0.8056]	41.35 [38.8, 43.95]	1.702
Stability proxy	QTcB (ms)	4,596 / 3,560	0.7719 [0.7448, 0.7961]	43.82 [41.26, 46.59]	0.9851
Stability proxy	P duration (ms)	3,123 / 2,479	0.5616 [0.5204, 0.6024]	32.86 [31.11, 34.63]	-0.1089
Stability proxy	PR interval (ms)	4,596 / 3,560	0.8289 [0.8047, 0.8514]	37.46 [34.81, 40.1]	0.183
Stability proxy	Frontal QRS-T angle (°)	4,538 / 3,522	0.8789 [0.8652, 0.8916]	49.19 [46.6, 51.95]	-1.633

Table S3h-4. Repeat variation of the device-reported axes.

Population	Axis	Pairs / persons	D95 (°) [95% interval]	Median angular distance (°) [95% interval]
All pairs	P axis	9,718 / 6,965	74 [68, 79]	8 [8, 9]
All pairs	QRS axis	15,477 / 10,104	51 [48, 54]	5 [5, 5]
All pairs	T axis	15,389 / 10,072	122 [118, 125]	10 [10, 11]
Stability proxy	P axis	>4,500 / >3,500	41 [39, 43]	7 [7, 7]
Stability proxy	QRS axis	4,568 / 3,541	28 [26, 31]	4 [4, 5]
Stability proxy	T axis	4,563 / 3,540	62 [55, 67]	7 [7, 8]

Interpretation and limits. The device measurements showed similar repeat variation for QRS duration and QT, so this variation is not specific to LoopLens (a descriptive observation, not an identified shared cause); for QTcF and the frontal angle the device values varied less, so a tool-specific component cannot be excluded (P duration and PR interval are limited by the device P-onset value, below). The data do not allow the tool-specific component to be quantified. Four limits apply. First, the algorithms and versions that produced the device measurements are not documented in the fields used here and probably differ between manufacturers, so the device values are a comparator and not a reference standard. Second, the QTc values and the angle are derived quantities: the frontal QRS-T angle between two device axes is not the spatial area angle of the main text, and the P-onset value of 40 ms that the device returns in half of the recordings probably lowers the apparent variation of P duration and PR interval. Third, the pairs are the same for both tools but the pair populations differ from the main analysis in that both values must be finite. Fourth, a repeat within one recording (first against second half of the same 10-s recording) would separate processing noise from change between recordings better, but it needs two runs of the measurement core on the raw signals and was not performed. The comparison is exploratory and its ratios are not tolerances.

Supplementary Data S2

[supplementary_data_S2_marker_reliability_public_v8.csv](#) contains one aggregate row per catalog identifier, family, empirical component, availability and native-unit reliability; version 4 adds the columns circular_marker, circular_period_degrees and the angular repeat-variation columns of S2i, and the former smallest-detectable-change columns are renamed because they duplicate RC. [supplementary_data_S2_marker_matrix_public_v8.csv](#) shares those identifiers and contains fold classes, native-unit LoA, cross-fitted conversion, RC ratios and selected perturbation panels. Blank estimates denote non-estimability. Counts of 1-9 recordings, pairs or persons, and counts or fractions from which such a count could be recovered, are blank, with the reason suppressed_lt10 in an adjacent _status column; quintile-switch fractions are rounded so that their denominators do not allow a count of 1-9 to be recovered (rule in the dictionary). Neither file contains patient records. The accompanying [data dictionary](#) defines every public column, measurement unit, denominator and observed categorical value list. The [marker descriptions](#) provide compact catalog definitions where available, with unavailable definitions explicitly marked. The

new short-description table preserves all 2,005 marker identifiers and the operational family/unit used in S2. A blank definition explicitly indicates that no exact catalog identifier or declared alias was available in the inspected metadata; it does not license inference of a formula from the marker name. Formula equivalence remains unestablished. All person, pair and recording counts in the CSV files are rounded to the nearest 10, cells below 10 are suppressed, and the status column reads `rounded_to_10` where a status column exists (fixed study denominators such as 2,824, 5,648, 15,693 and 10,187 are printed exactly); the availability fractions are rounded so that fraction times denominator does not give a unique count. Numerical CSV values other than these counts, these fractions and the quintile-switch fractions remain unrounded, use a decimal point and ASCII minus, and preserve blank estimates and suppressed cells; estimates for binary and integer-valued markers are shown to two significant digits (rule in the dictionary).

Family distributions, recorded-sex/age summaries, representative-marker medians, variation strata and bounded-angle limits are reported in S3c-S3e. Component membership and marker-level intervals are included in the public reliability file; detailed redundancy edges are available from the author.

S3a. P availability and author-rated coarse-error screen

P availability is the fraction of ECGs for which the stored output of the release (the release cache) contains a finite P duration; “fresh” values are those of a recomputation of the same records (main text, section 2.2). Cache-available and cache-missing cases were characterized across the full 1,500-person report-selected reference. Cached and freshly computed durations were compared on identically available persons, separately from the additional fresh values; percentile intervals were obtained by person bootstrap. Availability, confirmed audit-error bounds and incompletely adjudicated onset bounds have distinct denominators.

T4c. Reference characteristics	Cache available	Cache missing
Persons	932	568
Median age, years	52	55.50
Women / persons	506/932	330/568
Report sinus / persons	932/932	568/568
Median machine QRS, ms	86	88
Median signal quality	0.9703	0.9653
Age / QRS missing	0 / 0	0 / 0
Signal failures	0/932	13/568

Cached and fresh representative multilead-fusion P durations were exactly identical on all 932 jointly available persons (P97.5 180.9 ms [160, 197.45]). Fresh values were also available in 422 of 568 cache-missing persons: P97.5 240 ms [230, 246], compared with 224 ms [218, 228] among all 1,354 fresh-available persons. The additional durations and availability differences are consistent with informative missingness; they do not establish its cause. No within-person correction was observed on the 932 jointly available cases. Available-case screen results do not transfer to cache-missing persons; durations are not clinical normal limits.

Key dimensions: Group / measure.

Group	Measure	Available persons	Median, ms [95% interval]	P97.5, ms [95% interval]
cache available	p_duration_ms [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
cache available	p_duration_new [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
cache missing	p_duration_new [historical multilead fusion]	422	135.0 [126.0, 146.0]	240.0 [230.0, 246.0]
cache available, fresh available	p_duration_ms [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
cache available, fresh available	p_duration_new [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
cache missing, fresh available	p_duration_new [historical multilead fusion]	422	135.0 [126.0, 146.0]	240.0 [230.0, 246.0]
all fresh-available	p_duration_ms [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
all fresh-available	p_duration_new [historical multilead fusion]	1,354	108.0 [106, 108.0]	224 [218, 228]
full reference	p_duration_ms [historical multilead fusion]	932	104 [102.0, 104]	180.9 [160, 197.5]
full reference	p_duration_new [historical multilead fusion]	1,354	108.0 [106, 108.0]	224 [218, 228]

Fresh-only 422 persons are a subset of the 568 cache-missing persons; 146 remain without fresh duration. Age and machine-QRS values were complete in both cache groups; signal failed in 13 cache-missing persons. These reported characteristics do not remove verification bias. The later screen has its own reconstruction, rater and post-hoc calibration limits.

S3a-1. Protocol, counts and scope

The author rated 154 original displays (60 short, 60 medium, all 34 long), 16 repeats and 30 LUDB calibration displays in randomized order. Source labels, strata, durations, prior labels and identifiers were hidden. The visible boundary lines permit inferred duration; signal characteristics can suggest source. Twelve leads and a rhythm strip were displayed. MIMIC lines were release reconstructions matching cache duration, without documented historical absolute coordinate identity. A single author-rater is neither independent nor a specialist reference.

The original protocol specified ± 20 -ms visual judgments against global boundaries. The 200 displays were rated in 27 min (median 4.9 s/display); the author reported accepting borderline deviations as correct. Intra-rater agreement was 16/16 at each boundary (point $\kappa = 1$), measuring within-session consistency rather than delayed reliability or accuracy. Offset κ confidence limits were unavailable under the defined finite-draw rule.

Table S3a-1. Original ratings, conditional on assessability. CP intervals describe hypothetical binomial uncertainty; long cases are a census of the fixed tail. Counts of 1-9 persons are shown as <10 and their exact intervals are suppressed, because the intervals would reveal the counts; long-stratum error shares are given as bounds because the error-free and the unassessable long cases each number fewer than 10.

Cache stratum	Boundary	Errors / assessable	Unassessable	Exact 95% CP interval, %
short	onset	0/60	0	[0.000, 5.963]
medium	onset	$<10/60$	0	suppressed (<10 persons)
long	onset	$>90\%$ of assessable	<10	suppressed (<10 persons)
short	offset	0/60	0	[0.000, 5.963]
medium	offset	$<10/60$	0	suppressed (<10 persons)
long	offset	<10 of assessable	<10	suppressed (<10 persons)
short	any	0/60	0	[0.000, 5.963]
medium	any	$<10/60$	0	suppressed (<10 persons)
long	any	$>90\%$ of assessable	<10	suppressed (<10 persons)

Weights were 767/932, 131/932 and 34/932 with long census fixed. Weighted by these stratum weights, the frequency of onset-error judgments was approximately 4% (both bounds), with conservative simultaneous envelopes from approximately 3% to approximately 12%; for any-error judgments it was approximately 5%, with envelopes from approximately 4% to approximately 13%. These values are rounded because, with the stratum weights, more precise bounds would reveal counts below 10. They are frequencies of the author's own judgments under the stated conditions (visible proposed boundary lines, one rater, short viewing times, a later change of reference and tolerance). They are not error prevalence, exclude systematic rater error, and support no accuracy claim. A blinded second marking, including P waves currently missing from the available cases, would be required for an accuracy statement. Complete-case standardization is a separate conditional estimand; cache-missing persons remain outside the target.

S3a-2. All four post-hoc calibration variants

The same 30 LUDB cases, clusters, predictions and ratings were evaluated against extreme and lead-median boundaries at ± 20 and ± 40 ms after the weak original calibration. Extreme boundaries use earliest onset/latest offset; lead medians are unweighted. The κ acceptance rule was fixed

before recalculation, after original calibration inspection. The accepted use is a coarse-error screen at ± 40 ms against lead medians, not a precision reference.

Table S3a-2. Nominal record-bootstrap intervals from 2,000 draws; all variants and both boundaries.

Variant	Reference / tolerance	Boundary	Agreement count	Agreement % [CI]	κ [CI]	Defined κ draws
a	extreme / ± 20 ms	onset	15/30	50.0 [33.3, 66.7]	0.198 [0.000, 0.396]	2000/2000
a	extreme / ± 20 ms	offset	24/30	80.0 [63.3, 93.3]	0.204 [-0.061, 0.630]	1999/2000
b	median / ± 20 ms	onset	27/30	90.0 [76.7, 100.0]	0.620 [0.000, 1.000]	1999/2000
b	median / ± 20 ms	offset	26/30	86.7 [73.3, 96.7]	0.444 [0.000, 0.839]	1999/2000
c	extreme / ± 40 ms	onset	24/30	80.0 [63.3, 93.3]	0.439 [0.000, 0.769]	2000/2000
c	extreme / ± 40 ms	offset	26/30	86.7 [73.3, 96.7]	-0.034 [-0.067, 0.000]	1977/2000
d	median / ± 40 ms	onset	28/30	93.3 [83.3, 100.0]	0.714 [0.000, 1.000]	1992/2000
d	median / ± 40 ms	offset	29/30	96.7 [90.0, 100.0]	0.651; CI unavailable	1748/2000

Variant d onset $\kappa = 0.714$ has CI [0, 1]; two onset judgments marked correct exceeded 40 ms early against the median reference. Offset $\kappa = 0.651$ lacked reportable confidence limits because too few draws defined κ . High percent agreement in this imbalanced sample does not prove population $\kappa \geq 0.6$ or discriminating boundary accuracy. No specialist precision claim follows.

S3a-3. Historical label reconciliation

The original labels document onset errors in more than 24 of 34 selected long-duration cases (fewer than 10 had none): most had a primary onset-error category, and fewer than 10 cases primarily categorized as an end error had both onset and end error labels. Thus more than 24 distinct cases had confirmed boundary errors, fewer than 10 of them at both boundaries.

This label-level reconciliation involved no new signal review. Historical and later screens have unequal definitions and tolerances; their comparison is not a formal improvement test.

S3b. Expert-annotated LUDB technical reaudit

LUDB (Kalyakulina *et al* 2020, 2021), distributed through PhysioNet (Pollard *et al* 2026), is an externally annotated developmental benchmark rather than an independent confirmation cohort. All 200 recordings were included in reference reconstruction. The original expert boundaries were annotated per lead; the global reference here additionally imposes earliest-onset/latest-offset aggregation. The production path uses supported boundary clusters and detector fusion, which are not identical to that aggregation. Expert QRS groups were formed from at least three distinct leads with anchored peak spread no greater than 80 ms. For a matched QRS, the last expert P peak less than 400 ms earlier and first expert T peak less than 700 ms later supplied the

corresponding wave reference. These operational associations may not identify the physiologically corresponding wave in every rhythm.

Amplitude scaling: the record headers of LUDB 1.0.1 give each lead its own gain factor, so that every lead of all 200 recordings (12 leads each) spans exactly 1.000 mV, whereas the dataset documentation reports amplitudes in mV and does not mention the scaling (Kalyakulina *et al* 2021). Because the specified segmentation is not invariant to gain (S2h) and a Kors regression of per-lead normalized signals is distorted, the boundary errors in this section apply to this operating point; they do not necessarily hold for physical amplitudes as in MIMIC-IV-ECG. LUDB amplitudes, vector magnitudes and angles were not interpreted, and a rescaling to typical amplitudes was not performed as a sensitivity analysis.

Across all expert QRS groups, 1,418 had an eligible P reference and 1,681 an eligible T reference. Among QRS matches, the corresponding reference counts were 1,402 and 1,644, and finite production boundaries numbered 1,250 and 1,642. The P error population covered 174 recordings. No unannotated wave was treated as proven physiological absence. All timing errors below retain extreme values; the literature detection tolerance was not applied to truncate them.

The initial conditional timing-error audit independently rebuilt the expert references and recomputed the stored errors. A subsequent bound-release rerun reproduced all 14,631 final landmark rows exactly and retained complete prediction positions for independent 150-ms assignment (S3b-10/11). This ties the rerun to the archived output coordinates; the exact historical runtime copy remains inaccessible, so it is not a universal runtime-identity documentation.

All intervals below are nominal 95% percentile intervals from 1,000 recording-cluster resamples (seed 14,020,261,012). Entire recordings were resampled, and pooled means, sample SDs, medians and MAEs were recomputed within each draw. This differs from the bootstrap of recording medians in the earlier audit. The intervals describe uncertainty conditional on this database and implementation; they provide neither simultaneous inference nor independent validation.

Figure S3 shows the error distributions underlying Table S3b-1.

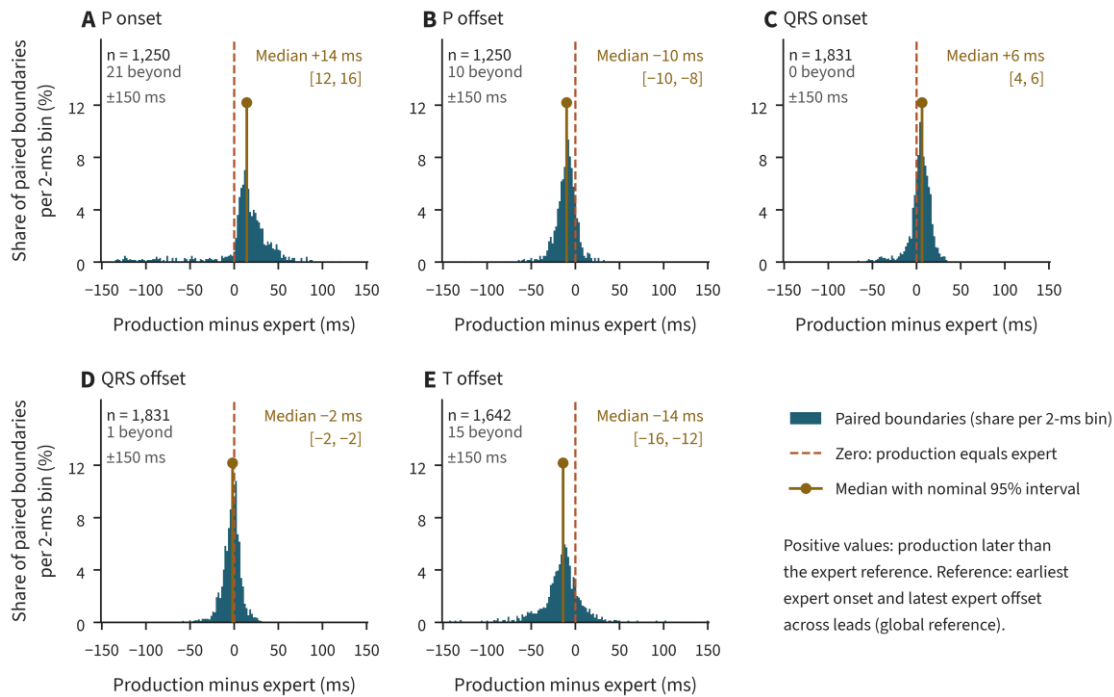


Figure S3. Distribution of boundary errors (production minus expert annotation) in the LUBD technical reaudit, by boundary: (A) P onset, (B) P offset, (C) QRS onset, (D) QRS offset, (E) T offset. Bars show the share of paired boundaries per 2-ms bin (pairs conditional on matched QRS groups; n as printed in each panel; errors lie on the 2-ms sampling grid). The dashed line marks zero error. The solid line and dot mark the median with its nominal 95% recording-cluster bootstrap interval (1,000 resamples; Table 5 and Table S3b-1). Errors beyond ± 150 ms are not drawn; their number is given in each panel. Positive values mean that the production boundary is later than the reference. The reference uses the earliest expert onset and the latest expert offset across leads; the lead-median timing-error reference is in Table S3b-2, with complete-output matching in S3b-10/11. LUBD had informed delineation development, so this is a technical reaudit without independent or clinical validation. T onset is not shown; its errors are in Table 5.

S3b-1. All final global boundaries and peaks. Reference rows refer to matched-QRS expert waves, with missing predictions retained in the reference count.

Land-mark / marker	Refer-ence rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
P offset	1,402	1,250	174	-12.24 $\pm$ 22.82	-10.00	14.75	[-13.97, -10.53]	[18.00, 27.20]	[-10.00, -8.00]	[13.21, 16.34]
P onset	1,402	1,250	174	6.32 $\pm$ 48.01	14.00	31.88	[2.57, 9.89]	[42.45, 53.47]	[12.00, 16.00]	[29.14, 34.76]
P peak	1,402	1,250	174	0.63 $\pm$ 24.70	3.00	8.66	[-1.08, 2.33]	[18.20, 30.70]	[2.00, 3.00]	[7.19, 10.29]
QRS offset	1,831	1,831	200	-2.84 $\pm$ 11.59	-2.00	8.07	[-3.92, -1.82]	[10.18, 13.26]	[-2.00, -2.00]	[7.36, 8.81]
QRS onset	1,831	1,831	200	4.25 $\pm$ 13.52	6.00	10.27	[2.84, 5.63]	[11.53, 15.49]	[4.00, 6.00]	[9.37, 11.28]
R peak	1,831	1,831	200	4.64 $\pm$ 10.08	3.00	6.28	[3.56, 5.74]	[7.73, 12.17]	[3.00, 4.00]	[5.23, 7.54]
T offset	1,644	1,642	200	-14.65 $\pm$ 32.80	-14.00	23.55	[-17.42, -11.68]	[26.98, 38.39]	[-16.00, -12.00]	[20.93, 26.23]
T onset	1,644	1,642	200	6.06 $\pm$ 29.74	6.00	21.52	[3.13, 8.93]	[26.49, 33.16]	[4.00, 10.00]	[19.66, 23.73]
T peak	1,644	1,642	200	0.20 $\pm$ 18.96	1.00	7.24	[-1.36, 1.72]	[14.06, 23.37]	[0.00, 1.00]	[5.72, 9.04]

S3b-2. The same pairs and predictions against lead-median references. This changes the reference only; it is not a calibration or an optimized alternative production method.

Land-mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
P offset	1,402	1,250	174	3.69 $\pm$ 22.40	4.00	10.98	[1.92, 5.34]	[17.13, 26.89]	[3.00, 5.00]	[9.65, 12.31]
P onset	1,402	1,250	174	-11.43 $\pm$ 46.74	1.00	23.70	[-15.00, -8.19]	[41.06, 52.60]	[0.00, 2.00]	[20.66, 27.29]
P peak	1,402	1,250	174	0.63 $\pm$ 24.70	3.00	8.66	[-1.08, 2.33]	[18.20, 30.70]	[2.00, 3.00]	[7.19, 10.29]
QRS offset	1,831	1,831	200	13.17 $\pm$ 8.93	12.00	13.33	[12.38, 13.94]	[7.58, 10.54]	[11.00, 12.00]	[12.56, 14.08]
QRS onset	1,831	1,831	200	-8.01 $\pm$ 12.52	-5.00	9.01	[-9.52, -6.66]	[10.01, 14.85]	[-6.00, -4.00]	[7.77, 10.46]
R peak	1,831	1,831	200	4.64 $\pm$ 10.08	3.00	6.28	[3.56, 5.74]	[7.73, 12.17]	[3.00, 4.00]	[5.23, 7.54]
T offset	1,644	1,642	200	9.89 $\pm$ 30.78	4.00	16.92	[7.21, 12.93]	[24.36, 36.96]	[3.00, 6.00]	[14.59, 19.61]
T onset	1,644	1,642	200	-29.33 $\pm$ 32.24	-26.00	33.95	[-32.65, -25.85]	[28.70, 35.94]	[-29.00, -23.00]	[31.00, 37.05]
T peak	1,644	1,642	200	0.20 $\pm$ 18.96	1.00	7.24	[-1.36, 1.72]	[14.06, 23.37]	[0.00, 1.00]	[5.72, 9.04]

S3b-3. Stored record-level production markers versus independently reconstructed recording-median expert intervals. These populations and markers differ from the pooled beat-boundary errors.

Land-mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
P duration	200	144	144	-27.57 $\pm$ 12.32	-26.00	27.57	[-29.57, -25.54]	[10.42, 14.26]	[-28.00, -24.00]	[25.54, 29.57]
PR interval	200	155	155	-8.14 $\pm$ 16.14	-8.00	12.28	[-10.39, -5.33]	[10.49, 23.39]	[-9.00, -6.00]	[10.39, 14.60]
Tpeak-Tend	200	192	192	-15.12 $\pm$ 16.04	-14.00	16.86	[-17.35, -12.92]	[11.87, 20.90]	[-15.50, -12.50]	[15.00, 18.94]

S3b-4. Detection metrics that are exactly reconstructible at the export's 80-ms peak-matching tolerance. N denotes QRS. Raw P/T entries concern observed internal per-lead candidates, not final waveform detections. Predictions in scope are determined by candidate peaks; outside-span and referenceless wave segments are not assumed negative. NA indicates an unidentifiable PPV with no in-scope predictions.

Scope	Lead	Wave	Ref	Predictions in scope	TP80	Un-matched refs	Un-matched candidates	Se80 (%) [95% CI]	PPV80 (%) [95% CI]
QRS, global	global	N	1,869	1,847	1,831	38	16	97.97 [96.11, 99.40]	99.13 [98.07, 100.00]
raw lead candidate	all	p	16,796	8,280	5,584	11,212	2,696	33.25 [32.21, 34.20]	67.44 [64.76, 69.87]
raw lead candidate	all	t	19,650	12,940	11,054	8,596	1,886	56.25 [55.51, 56.88]	85.43 [83.35, 87.50]
raw lead candidate	I	p	1,401	1,869	1,260	141	609	89.94 [87.37, 92.21]	67.42 [63.79, 71.07]
raw lead candidate	I	t	1,642	1,900	1,591	51	309	96.89 [94.90, 98.39]	83.74 [80.92, 86.82]
raw lead candidate	II	p	1,401	1,594	1,206	195	388	86.08 [82.93, 89.16]	75.66 [72.15, 79.09]
raw lead candidate	II	t	1,642	1,917	1,583	59	334	96.41 [94.23, 98.07]	82.58 [78.97, 86.06]
raw lead candidate	III	p	1,403	0	0	1,403	0	not evaluated	not evaluated
raw lead candidate	III	t	1,637	0	0	1,637	0	not evaluated	not evaluated
raw lead candidate	aVR	p	1,401	0	0	1,401	0	not evaluated	not evaluated
raw lead candidate	aVR	t	1,643	0	0	1,643	0	not evaluated	not evaluated
raw lead candidate	aVL	p	1,403	2,098	1,148	255	950	81.82 [78.14, 85.01]	54.72 [51.58, 57.78]
raw lead candidate	aVL	t	1,644	0	0	1,644	0	not evaluated	not evaluated
raw lead candidate	aVF	p	1,401	1,604	1,150	251	454	82.08 [78.81, 85.32]	71.70 [68.32, 74.90]
raw lead candidate	aVF	t	1,643	0	0	1,643	0	not evaluated	not evaluated
raw lead candidate	V1	p	1,398	0	0	1,398	0	not evaluated	not evaluated
raw lead candidate	V1	t	1,614	0	0	1,614	0	not evaluated	not evaluated
raw lead candidate	V2	p	1,396	1,115	820	576	295	58.74 [53.66, 63.64]	73.54 [69.23, 77.47]
raw lead candidate	V2	t	1,616	1,852	1,553	63	299	96.10 [93.94, 97.80]	83.86 [81.13, 86.72]
raw lead candidate	V3	p	1,400	0	0	1,400	0	not evaluated	not evaluated
raw lead candidate	V3	t	1,642	1,884	1,595	47	289	97.14 [95.25, 98.59]	84.66 [82.01, 87.62]

Scope	Lead	Wave	Ref	Predictions in scope	TP80	Un-matched refs	Un-matched candidates	Se80 (%) [95% CI]	PPV80 (%) [95% CI]
raw lead candidate	V4	p	1,395	0	0	1,395	0	not evaluated	not evaluated
raw lead candidate	V4	t	1,641	1,780	1,582	59	198	96.40 [93.84, 98.32]	88.88 [86.13, 91.68]
raw lead candidate	V5	p	1,399	0	0	1,399	0	not evaluated	not evaluated
raw lead candidate	V5	t	1,643	1,788	1,586	57	202	96.53 [94.75, 98.13]	88.70 [86.12, 91.31]
raw lead candidate	V6	p	1,398	0	0	1,398	0	not evaluated	not evaluated
raw lead candidate	V6	t	1,643	1,819	1,564	79	255	95.19 [92.87, 97.19]	85.98 [82.91, 88.96]

The native candidate observer receives only the production algorithm's preferred leads, so its twelve-lead pooled recall includes leads that the native candidate routine does not evaluate. This table documents the candidate observation path. It must not be used as the final delineator's P-wave and T-wave sensitivity. Its PPV is likewise conditional on annotated wave spans, with uncertain negative regions excluded.

S3b-6. Descriptive relation of observed error SD to the 2σ _CSE values reproduced by Kalyakulina *et al* (2020, Table 6 of the IEEE Access version). The original recommendations (CSE Working Party 1985) were bibliographically verified, but their numerical full-text table was not retrieved; these are not independently verified original CSE thresholds. Global-reference aggregation and pair selection differ from the published applications. No pass/fail certification is made.

Boundary	Observed SD (ms) [95% CI]	Reproduced 2σ _CSE (ms)	Descriptive relation
P onset	48.01 [42.45, 53.47]	10.20	above
P offset	22.82 [18.00, 27.20]	12.70	above
QRS onset	13.52 [11.53, 15.49]	6.50	above
QRS offset	11.59 [10.18, 13.26]	11.60	below
T offset	32.80 [26.98, 38.39]	30.60	above (point estimate; interval includes the reproduced limit)

The comparison uses σ_{error} versus $2\sigma_{\text{CSE}}$, not $2\sigma_{\text{error}}$ versus $2\sigma_{\text{CSE}}$. No reproduced CSE limit is available for the peaks or T onset. The QRS-offset point SD is close to the reproduced limit and its interval overlaps it. Because definitions differ and the sample is selected, no claim of conformity or clinical acceptability can be made.

S3b-7. Tpeak-Tend definition sensitivity on identical expert T groups including lead II; each recording contributes its within-record median. Differences are alternative minus baseline.

Baseline	Alternative	Paired records	Mean difference $\pm$ SD (ms)	Median difference [95% CI] (ms)	MAE (ms)
lead II	median of lead intervals	200	0.27 ± 7.31	0.00 [−0.50, 1.50]	5.16
lead II	latest multilead T offset minus median T peak	200	22.98 ± 14.21	19.50 [18.00, 21.75]	22.98
median of lead intervals	latest multilead T offset minus median T peak	200	22.71 ± 13.93	19.75 [17.50, 21.00]	22.71

These reference-definition differences are not algorithm errors or validated physiological dispersion. The comparison supports stating a Tpeak-Tend definition before the measure is transported or interpreted.

S3b-8. Complete per-source and raw per-lead timing inventory. **detector_global** rows are internal proposals, including temporally inadmissible candidates where present, not accepted final marker outputs. **raw_lead_candidate** rows are native observed candidates matched in that lead at 80 ms. Do not pool these with final fusion errors.

Scope	Lead	Source	Land mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
detector, global	global	multilead fusion	P offset	1,225	1,225	176	-14.13 $\pm$ 27.73	-10.00	16.62	[-16.2, 8, -11.97]	[22.25, 32.55]	[-12.0, 0, -10.00]	[14.72, 18.59]
detector, global	global	NeuroKit	P offset	1,402	1,402	176	-31.05 $\pm$ 41.39	-16.00	33.51	[-35.5, 4, -26.77]	[37.10, 46.04]	[-22.0, 0, -12.00]	[29.55, 37.94]
detector, global	global	VCG	P offset	1,397	1,397	176	14.51 $\pm$ 54.20	24.00	36.21	[7.89, 20.39]	[37.87, 68.34]	[20.00, 26.00]	[31.17, 41.81]
detector, global	global	multilead fusion	P onset	1,225	1,225	176	-7.85 $\pm$ 59.50	14.00	41.05	[-13.1, 0, -3.10]	[54.84, 64.05]	[12.00, 16.00]	[38.00, 44.65]
detector, global	global	NeuroKit	P onset	1,402	1,402	176	22.26 $\pm$ 35.19	18.00	30.68	[18.61, 25.59]	[30.56, 40.21]	[14.00, 22.00]	[28.31, 33.34]
detector, global	global	VCG	P onset	1,397	1,397	176	-10.55 $\pm$ 56.72	6.00	40.10	[-15.4, 2, -5.78]	[52.39, 61.66]	[4.00, 8.00]	[36.84, 44.08]
detector, global	global	multilead fusion	P peak	1,225	1,225	176	-1.07 $\pm$ 30.31	3.00	11.07	[-3.31, 1.13]	[24.05, 35.83]	[2.00, 3.00]	[9.23, 13.04]
detector, global	global	NeuroKit	P peak	1,402	1,402	176	-7.59 $\pm$ 30.51	1.00	13.55	[-10.7, 4, -4.52]	[25.60, 35.74]	[0.00, 1.00]	[11.10, 16.59]
detector, global	global	VCG	P peak	1,397	1,397	176	12.50 $\pm$ 53.25	5.00	27.88	[6.38, 17.61]	[42.27, 63.35]	[4.00, 5.00]	[22.50, 33.36]
detector, global	global	multilead fusion	QRS offset	1,830	1,830	200	-2.84 $\pm$ 11.59	-2.00	8.07	[-3.91, -1.82]	[10.18, 13.26]	[-2.00, -2.00]	[7.36, 8.81]
detector, global	global	NeuroKit	QRS offset	1,781	1,781	199	-18.43 $\pm$ 29.74	-18.00	24.66	[-21.8, 7, -15.32]	[23.15, 35.75]	[-18.0, 2, -16.00]	[21.87, 27.63]
detector, global	global	VCG	QRS offset	1,831	1,831	200	-14.55 $\pm$ 10.56	-12.00	14.87	[-15.6, 2, -13.50]	[9.65, 11.50]	[-14.0, 0, -12.00]	[13.88, 15.88]
detector, global	global	multilead fusion	QRS onset	1,830	1,830	200	4.24 $\pm$ 13.53	6.00	10.27	[2.84, 5.62]	[11.54, 15.49]	[4.00, 6.00]	[9.37, 11.29]
detector, global	global	NeuroKit	QRS onset	1,772	1,772	199	-7.32 $\pm$ 35.47	6.00	23.58	[-10.8, 6, -4.00]	[32.53, 38.25]	[4.00, 6.00]	[21.21, 26.27]
detector, global	global	VCG	QRS onset	1,831	1,831	200	11.82 $\pm$ 11.86	12.00	14.02	[10.48, 13.03]	[9.90, 13.76]	[12.00, 12.00]	[13.13, 14.93]
detector, global	global	multilead fusion	R peak	1,831	1,831	200	4.64 $\pm$ 10.08	3.00	6.28	[3.56, 5.74]	[7.73, 12.17]	[3.00, 4.00]	[5.23, 7.54]

Scope	Lead	Source	Land mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
detector, global	global	NeuroKit	R peak	1,831	1,831	200	4.64 $\pm$ 10.08	3.00	6.28	[3.56, 5.74]	[7.73, 12.17]	[3.00, 4.00]	[5.23, 7.54]
detector, global	global	VCG	R peak	1,831	1,831	200	4.64 $\pm$ 10.08	3.00	6.28	[3.56, 5.74]	[7.73, 12.17]	[3.00, 4.00]	[5.23, 7.54]
detector, global	global	multilead fusion	T offset	1,641	1,641	200	-12.63 $\pm$ 33.75	-14.00	23.29	[-15.65, -9.63]	[27.43, 39.81]	[-14.00, -12.00]	[20.70, 26.15]
detector, global	global	NeuroKit	T offset	1,611	1,611	199	-77.18 $\pm$ 90.81	-34.00	78.18	[-87.23, -67.17]	[82.58, 98.05]	[-38.00, -32.00]	[68.25, 88.20]
detector, global	global	VCG	T offset	1,641	1,641	200	-17.60 $\pm$ 54.62	-20.00	39.93	[-22.76, -11.96]	[46.96, 62.32]	[-22.00, -18.00]	[35.64, 44.63]
detector, global	global	multilead fusion	T onset	1,641	1,641	200	5.03 $\pm$ 28.54	6.00	20.65	[2.09, 8.13]	[25.31, 32.23]	[4.00, 10.00]	[18.87, 22.78]
detector, global	global	NeuroKit	T onset	1,611	1,611	199	54.26 $\pm$ 64.42	68.00	75.63	[48.03, 60.60]	[58.74, 69.59]	[65.97, 72.00]	[72.42, 79.12]
detector, global	global	VCG	T onset	1,641	1,641	200	-3.65 $\pm$ 74.73	-22.00	50.77	[-12.68, 6.69]	[57.16, 91.74]	[-26.00, -16.00]	[43.94, 59.22]
detector, global	global	multilead fusion	T peak	1,641	1,641	200	-1.18 $\pm$ 16.42	-1.00	6.91	[-2.73, 0.29]	[12.26, 20.61]	[-2.00, 0.00]	[5.65, 8.42]
detector, global	global	NeuroKit	T peak	1,611	1,611	199	-27.98 $\pm$ 71.65	1.00	40.74	[-35.37, -20.77]	[64.83, 77.55]	[1.00, 2.00]	[33.97, 47.91]
detector, global	global	VCG	T peak	1,641	1,641	200	-3.31 $\pm$ 61.81	2.00	23.94	[-10.54, 4.52]	[47.37, 74.38]	[1.00, 2.00]	[16.98, 31.27]
raw lead candidate	aVF	raw multilead candidate	P offset	1,150	1,150	176	-2.61 $\pm$ 14.90	-4.00	10.17	[-3.99, -1.19]	[12.91, 17.05]	[-4.00, -2.00]	[9.26, 11.12]
raw lead candidate	aVF	raw multilead candidate	P onset	1,150	1,150	176	-2.48 $\pm$ 44.40	10.00	28.55	[-5.93, 0.82]	[40.41, 47.87]	[10.00, 12.00]	[25.92, 31.01]
raw lead candidate	aVF	raw multilead candidate	P peak	1,150	1,150	176	1.75 $\pm$ 8.36	2.00	3.97	[1.03, 2.43]	[6.38, 10.25]	[2.00, 2.00]	[3.42, 4.62]
raw lead candidate	aVL	raw multilead candidate	P offset	1,148	1,148	173	-6.46 $\pm$ 18.76	-6.00	13.27	[-8.14, -4.84]	[16.94, 20.67]	[-6.00, -4.00]	[12.02, 14.62]
raw lead candidate	aVL	raw multilead candidate	P onset	1,148	1,148	173	-19.92 $\pm$ 57.58	4.00	39.06	[-24.63, -15.23]	[53.39, 61.41]	[0.00, 6.00]	[35.53, 42.62]

Scope	Lead	Source	Land mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
raw lead candidate	aVL	raw multilead candidate	P peak	1,148	1,148	173	-2.05 $\pm$ 15.29	2.00	7.29	[-3.53, -0.74]	[13.01, 17.57]	[2.00, 2.00]	[5.99, 8.71]
raw lead candidate	I	raw multilead candidate	P offset	1,260	1,260	176	-4.71 $\pm$ 14.09	-4.00	9.08	[-5.84, -3.55]	[11.54, 16.71]	[-4.00, -2.00]	[8.14, 10.18]
raw lead candidate	I	raw multilead candidate	P onset	1,260	1,260	176	-1.72 $\pm$ 41.60	10.00	26.79	[-5.40, 1.94]	[37.00, 45.67]	[8.00, 10.00]	[24.13, 29.53]
raw lead candidate	I	raw multilead candidate	P peak	1,260	1,260	176	1.31 $\pm$ 10.21	2.00	4.63	[0.51, 2.14]	[8.15, 12.25]	[2.00, 2.00]	[3.92, 5.49]
raw lead candidate	I	raw multilead candidate	T offset	1,591	1,591	199	-2.91 $\pm$ 27.45	-6.00	15.30	[-5.02, -0.72]	[22.38, 32.69]	[-6.00, -4.00]	[13.52, 17.42]
raw lead candidate	I	raw multilead candidate	T onset	1,591	1,591	199	-10.75 $\pm$ 30.25	-6.00	22.47	[-13.78, -7.87]	[27.15, 33.21]	[-8.00, -4.00]	[20.44, 24.61]
raw lead candidate	I	raw multilead candidate	T peak	1,591	1,591	199	0.21 $\pm$ 8.32	0.00	4.11	[-0.25, 0.74]	[6.14, 10.54]	[0.00, 0.00]	[3.53, 4.80]
raw lead candidate	II	raw multilead candidate	P offset	1,206	1,206	174	-4.35 $\pm$ 14.08	-6.00	9.69	[-5.64, -2.79]	[10.57, 18.58]	[-6.00, -4.00]	[8.82, 10.71]
raw lead candidate	II	raw multilead candidate	P onset	1,206	1,206	174	3.90 $\pm$ 37.65	12.00	24.82	[1.41, 6.47]	[34.10, 41.22]	[12.00, 14.00]	[22.93, 26.81]
raw lead candidate	II	raw multilead candidate	P peak	1,206	1,206	174	2.43 $\pm$ 6.70	2.00	3.55	[1.94, 2.95]	[4.67, 8.67]	[2.00, 2.00]	[3.12, 4.05]
raw lead candidate	II	raw multilead candidate	T offset	1,583	1,583	198	-1.79 $\pm$ 31.70	-6.00	17.56	[-4.44, 1.04]	[25.22, 37.94]	[-8.00, -4.00]	[15.35, 20.15]
raw lead candidate	II	raw multilead candidate	T onset	1,583	1,583	198	-8.77 $\pm$ 33.50	-2.00	23.88	[-12.36, -5.58]	[29.92, 37.33]	[-6.00, 0.00]	[21.60, 26.46]
raw lead candidate	II	raw multilead candidate	T peak	1,583	1,583	198	0.77 $\pm$ 8.55	0.00	3.86	[0.16, 1.43]	[6.53, 10.38]	[0.00, 0.00]	[3.29, 4.50]

Scope	Lead	Source	Land mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
raw lead candidate	V2	raw multilead candidate	P offset	820	820	159	3.53 $\pm$ 19.86	0.00	13.53	[1.53, 5.57]	[17.31, 22.51]	[-2.00, 2.00]	[11.82, 15.43]
raw lead candidate	V2	raw multilead candidate	P onset	820	820	159	-9.61 $\pm$ 61.43	14.00	45.16	[-15.49, -3.88]	[56.99, 66.19]	[10.00, 18.00]	[41.72, 49.03]
raw lead candidate	V2	raw multilead candidate	P peak	820	820	159	1.59 $\pm$ 12.30	2.00	5.11	[0.47, 2.58]	[9.72, 14.85]	[2.00, 2.00]	[4.06, 6.42]
raw lead candidate	V2	raw multilead candidate	T offset	1,553	1,553	198	-3.59 $\pm$ 26.31	-8.00	16.58	[-5.77, -1.22]	[21.90, 30.73]	[-10.00, -6.00]	[14.89, 18.28]
raw lead candidate	V2	raw multilead candidate	T onset	1,553	1,553	198	-4.28 $\pm$ 28.27	0.00	20.13	[-7.45, -1.36]	[25.00, 31.40]	[-2.00, 4.00]	[18.06, 22.31]
raw lead candidate	V2	raw multilead candidate	T peak	1,553	1,553	198	0.66 $\pm$ 5.28	0.00	2.86	[0.28, 1.05]	[4.15, 6.45]	[0.00, 0.00]	[2.54, 3.22]
raw lead candidate	V3	raw multilead candidate	T offset	1,595	1,595	199	-5.53 $\pm$ 25.73	-10.00	16.88	[-8.22, -3.06]	[21.19, 30.22]	[-10.00, -8.00]	[15.23, 18.66]
raw lead candidate	V3	raw multilead candidate	T onset	1,595	1,595	199	0.01 $\pm$ 27.23	4.00	19.31	[-2.79, 2.84]	[24.21, 30.06]	[2.00, 8.00]	[17.57, 21.15]
raw lead candidate	V3	raw multilead candidate	T peak	1,595	1,595	199	-0.09 $\pm$ 6.96	0.00	3.03	[-0.59, 0.45]	[4.85, 8.99]	[0.00, 0.00]	[2.59, 3.57]
raw lead candidate	V4	raw multilead candidate	T offset	1,582	1,582	198	-5.72 $\pm$ 24.84	-10.00	16.16	[-8.10, -2.82]	[18.48, 31.71]	[-10.00, -8.00]	[14.35, 18.44]
raw lead candidate	V4	raw multilead candidate	T onset	1,582	1,582	198	-0.30 $\pm$ 28.96	5.00	20.38	[-3.92, 2.99]	[24.39, 33.59]	[2.00, 8.00]	[18.25, 22.91]
raw lead candidate	V4	raw multilead candidate	T peak	1,582	1,582	198	0.10 $\pm$ 4.77	0.00	2.58	[-0.25, 0.47]	[3.71, 5.84]	[0.00, 0.00]	[2.29, 2.90]
raw lead candidate	V5	raw multilead candidate	T offset	1,586	1,586	199	-3.87 $\pm$ 28.08	-8.00	15.89	[-6.66, -0.72]	[20.65, 35.33]	[-8.00, -6.00]	[13.72, 18.42]

Scope	Lead	Source	Land mark / marker	Reference rows	Paired	Paired records	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)	Mean 95% CI	SD 95% CI	Median 95% CI	MAE 95% CI
raw lead candidate	V5	raw multilead candidate	T onset	1,586	1,586	199	-4.17 $\pm$ 30.53	2.00	20.94	[-7.48, -1.05]	[26.23, 34.86]	[-1.00, 4.00]	[18.67, 23.59]
raw lead candidate	V5	raw multilead candidate	T peak	1,586	1,586	199	-0.51 $\pm$ 7.54	0.00	3.02	[-1.27, 0.15]	[4.92, 10.09]	[0.00, 0.00]	[2.41, 3.73]
raw lead candidate	V6	raw multilead candidate	T offset	1,564	1,564	200	-1.62 $\pm$ 29.39	-6.00	16.22	[-4.21, 1.01]	[23.31, 35.37]	[-8.00, -6.00]	[14.09, 18.67]
raw lead candidate	V6	raw multilead candidate	T onset	1,564	1,564	200	-7.64 $\pm$ 31.44	0.00	21.29	[-10.64, -4.76]	[27.19, 35.52]	[-4.00, 0.00]	[18.88, 23.97]
raw lead candidate	V6	raw multilead candidate	T peak	1,564	1,564	200	-0.05 $\pm$ 6.82	0.00	3.00	[-0.54, 0.44]	[4.89, 8.54]	[0.00, 0.00]	[2.53, 3.54]

Temporally admissible and inadmissible detector rows remain distinguishable. We make no detector-specific performance claim here. The full aggregate CSV preserves error counts, minima, maxima and the P95 absolute error. For space, the main manuscript table is restricted to five clinically recognizable boundaries; all nine final landmark groups are reported above.

S3b-9. Detector proposals by their stored temporal-admissibility flag. This descriptive inventory is separate from final production boundaries; no new subgroup inference is asserted.

Landmark	Source	Temporal admissibility	Rows	Mean $\pm$ SD (ms)	Median (ms)	MAE (ms)
P offset	multilead fusion	admissible	1,225	-14.13 ± 27.73	-10.00	16.62
P offset	NeuroKit	admissible	1,402	-31.05 ± 41.39	-16.00	33.51
P offset	VCG	admissible	1,397	14.51 ± 54.20	24.00	36.21
P onset	multilead fusion	admissible	1,225	-7.85 ± 59.50	14.00	41.05
P onset	NeuroKit	admissible	1,402	22.26 ± 35.19	18.00	30.68
P onset	VCG	admissible	1,397	-10.55 ± 56.72	6.00	40.10
P peak	multilead fusion	admissible	1,225	-1.07 ± 30.31	3.00	11.07
P peak	NeuroKit	admissible	1,402	-7.59 ± 30.51	1.00	13.55
P peak	VCG	admissible	1,397	12.50 ± 53.25	5.00	27.88
R offset	multilead fusion	admissible	1,830	-2.84 ± 11.59	-2.00	8.07
R offset	NeuroKit	admissible	1,781	-18.43 ± 29.74	-18.00	24.66
R offset	VCG	admissible	1,831	-14.55 ± 10.56	-12.00	14.87
R onset	multilead fusion	admissible	1,830	4.24 ± 13.53	6.00	10.27
R onset	NeuroKit	admissible	1,771	-7.22 ± 35.22	6.00	23.49
R onset	NeuroKit	inadmissible	1	$-188.00 \pm \text{NA}$	-188.00	188.00
R onset	VCG	admissible	1,831	11.82 ± 11.86	12.00	14.02
R peak	multilead fusion	admissible	1,831	4.64 ± 10.08	3.00	6.28
R peak	NeuroKit	admissible	1,831	4.64 ± 10.08	3.00	6.28
R peak	VCG	admissible	1,831	4.64 ± 10.08	3.00	6.28
T offset	multilead fusion	admissible	1,641	-12.63 ± 33.75	-14.00	23.29
T offset	NeuroKit	admissible	1,611	-77.18 ± 90.81	-34.00	78.18
T offset	VCG	admissible	1,641	-17.60 ± 54.62	-20.00	39.93
T onset	multilead fusion	admissible	1,641	5.03 ± 28.54	6.00	20.65
T onset	NeuroKit	admissible	1,607	54.66 ± 63.99	70.00	75.56
T onset	NeuroKit	inadmissible	4	-106.00 ± 26.88	-97.00	106.00
T onset	VCG	admissible	1,641	-3.65 ± 74.73	-22.00	50.77
T peak	multilead fusion	admissible	1,641	-1.18 ± 16.42	-1.00	6.91
T peak	NeuroKit	admissible	1,611	-27.98 ± 71.65	1.00	40.74
T peak	VCG	admissible	1,641	-3.31 ± 61.81	2.00	23.94

Source and reproducibility. All S3b values were recomputed from the stored production outputs and the public LUDB annotations; publisher checksums of all 2,600 header and annotation files matched. The analysis scripts are public (Code availability in the main text), the aggregate output tables are in this Supplement and in Supplementary Data S2; a number-by-number provenance table is available from the author on request.

S3b-10. Complete-output 150-ms point matching

All final P, QRS and T onset, peak and offset positions were retained. Missing positions were recorded explicitly. References were reconstructed from valid manual onset-peak-offset triplets and anchored peak groups spanning at most 80 ms across at least three distinct leads. Each landmark was matched separately using one-to-one assignment within ± 150 ms; P/T matching was not conditioned on a preceding QRS match. True positives were matched points, false negatives unmatched reference points, and false positives unmatched prediction points within the specified

evaluation domain. Wave detection was operationally summarized by its corresponding peak; no waveform-overlap or morphology accuracy is implied.

The annotated-envelope domain retained predictions between the first and last reference landmark of the same type, expanded by 150 ms at each end. A record without a reference for a wave supplied no evaluable annotated envelope for that wave. The full-record domain retained all final predictions, including those outside the annotated envelope. Its PPV treats unmatched predictions as markup false positives and cannot distinguish erroneous predictions from genuine unannotated waves. Reference counts were unchanged between domains. Median-reference sensitivity analysis used unchanged production outputs and the same matching rule; envelope endpoints followed the respective reference definition. Both domains and all landmarks are reported, without selecting the more favorable result. Confidence intervals resample all 200 recordings jointly and recompute pooled count ratios in every draw; they are nominal and conditional on the fixed implementation and reference definition.

Table S3b-10. Global landmark detection using 150-ms point matching within annotated envelopes. Peak rows operationally represent wave detection. Values are not directly comparable to pooled per-lead algorithm benchmarks. Counts are TP/reference/prediction; intervals are nominal 95% recording-bootstrap intervals.

Reference	Landmark	TP / references / predictions	Se % [95% CI]	PPV % [95% CI]
extreme	p_offset	1240/1418/1252	87.45 [84.23, 90.07]	99.04 [98.45, 99.52]
extreme	p_onset	1230/1418/1253	86.74 [83.54, 89.52]	98.16 [97.21, 98.93]
extreme	p_peak	1242/1418/1253	87.59 [84.47, 90.14]	99.12 [98.57, 99.58]
extreme	r_offset	1830/1869/1846	97.91 [96.11, 99.36]	99.13 [98.00, 100.00]
extreme	r_onset	1831/1869/1847	97.97 [96.22, 99.40]	99.13 [98.00, 100.00]
extreme	r_peak	1831/1869/1847	97.97 [96.22, 99.40]	99.13 [98.00, 100.00]
extreme	t_offset	1628/1772/1650	91.87 [89.46, 94.35]	98.67 [97.65, 99.57]
extreme	t_onset	1641/1772/1651	92.61 [90.24, 95.02]	99.39 [98.67, 99.94]
extreme	t_peak	1637/1772/1651	92.38 [90.06, 94.74]	99.15 [98.40, 99.77]
Median	p_offset	1244/1418/1254	87.73 [84.60, 90.31]	99.20 [98.67, 99.66]
Median	p_onset	1222/1418/1252	86.18 [82.91, 88.99]	97.60 [96.55, 98.48]
Median	p_peak	1242/1418/1253	87.59 [84.47, 90.14]	99.12 [98.57, 99.58]
Median	r_offset	1830/1869/1846	97.91 [96.11, 99.36]	99.13 [98.00, 100.00]
Median	r_onset	1831/1869/1847	97.97 [96.22, 99.40]	99.13 [98.00, 100.00]
Median	r_peak	1831/1869/1847	97.97 [96.22, 99.40]	99.13 [98.00, 100.00]
Median	t_offset	1630/1772/1649	91.99 [89.59, 94.49]	98.85 [97.78, 99.76]
Median	t_onset	1639/1772/1651	92.49 [90.15, 94.88]	99.27 [98.52, 99.88]
Median	t_peak	1637/1772/1651	92.38 [90.06, 94.74]	99.15 [98.40, 99.77]

Table S3b-11. The same point-counting rule over complete recordings. PPV assumes all unmatched predictions are markup false positives, including predictions in unannotated portions; it does not estimate adjudicated clinical false-alarm performance.

Reference	Landmark	TP / references / predictions	Se % [95% CI]	PPV % [95% CI]
extreme	p_offset	1240/1418/1689	87.45 [84.23, 90.07]	73.42 [70.54, 75.82]
extreme	p_onset	1230/1418/1689	86.74 [83.54, 89.52]	72.82 [69.90, 75.16]
extreme	p_peak	1242/1418/1689	87.59 [84.47, 90.14]	73.53 [70.65, 75.88]
extreme	r_offset	1830/1869/2158	97.91 [96.11, 99.36]	84.80 [83.44, 85.89]
extreme	r_onset	1831/1869/2158	97.97 [96.22, 99.40]	84.85 [83.51, 85.96]
extreme	r_peak	1831/1869/2159	97.97 [96.22, 99.40]	84.81 [83.47, 85.96]
extreme	t_offset	1628/1772/2144	91.87 [89.46, 94.35]	75.93 [74.64, 77.11]
extreme	t_onset	1641/1772/2144	92.61 [90.24, 95.02]	76.54 [75.41, 77.61]
extreme	t_peak	1637/1772/2144	92.38 [90.06, 94.74]	76.35 [75.22, 77.45]
Median	p_offset	1244/1418/1689	87.73 [84.60, 90.31]	73.65 [70.79, 75.96]
Median	p_onset	1222/1418/1689	86.18 [82.91, 88.99]	72.35 [69.43, 74.79]
Median	p_peak	1242/1418/1689	87.59 [84.47, 90.14]	73.53 [70.65, 75.88]
Median	r_offset	1830/1869/2158	97.91 [96.11, 99.36]	84.80 [83.44, 85.89]
Median	r_onset	1831/1869/2158	97.97 [96.22, 99.40]	84.85 [83.51, 85.96]
Median	r_peak	1831/1869/2159	97.97 [96.22, 99.40]	84.81 [83.47, 85.96]
Median	t_offset	1630/1772/2144	91.99 [89.59, 94.49]	76.03 [74.73, 77.23]
Median	t_onset	1639/1772/2144	92.49 [90.15, 94.88]	76.45 [75.30, 77.55]
Median	t_peak	1637/1772/2144	92.38 [90.06, 94.74]	76.35 [75.22, 77.45]

QTDB was excluded as an independent benchmark because it had already been used for delineation release testing. Its two-channel recordings and selectively annotated beats would also require a different signal and evaluation protocol.

S4. All variants, aliases and hypothesis ledger

Controlled identical-recording sampling comparisons are reported in S2g; they do not establish general sampling invariance.

T6. Repair	Original marker	Persons (+/-)	Original / repair AUC	Δ AUC [uncorrected interval]
Repair 01	qrs_t_normalized_disc rete_frechet	2,615 (628/1,987)	0.8054 / 0.7893	-0.0161 [-0.0234, -0.0086]
Repair 02	qrs_t_loop_mirror_symmetry	2,655 (642/2,013)	0.7936 / 0.7658	-0.0277 [-0.0365, -0.0190]
Repair 03	qrs_t_normalized_disc rete_frechet	2,615 (628/1,987)	0.8054 / 0.8085	0.0031 [-0.0020, 0.0082]
Repair 04	qrs_t_normalized_disc rete_frechet	2,615 minus <10 (628 minus <10 / 1,987 minus <10)	0.8051 / 0.7873	-0.0178 [-0.0258, -0.0097]
Repair 05	qrs_t_normalized_disc rete_frechet	2,615 minus <10 (628 minus <10 / 1,987 minus <10)	0.8051 / 0.7363	-0.0688 [-0.0877, -0.0501]
Repair 06	qrs_t_normalized_disc rete_frechet	2,615 (628/1,987)	0.8054 / 0.8063	0.0009 [0.0004, 0.0013]
Repair 07	qrs_t_normalized_disc rete_frechet	2,615 minus <10 (628 minus <10 / 1,987 minus <10)	0.8051 / 0.5589	-0.2462 [-0.2768, -0.2153]
Repair 08	qrs_t_normalized_disc rete_frechet	2,615 (628/1,987)	0.8054 / 0.6662	-0.1392 [-0.1580, -0.1212]
Repair 09	loop_near_self_approach_count	2,759 (679/2,080)	0.7307 / 0.5754	-0.1553 [-0.1916, -0.1189]
Repair 10	loop_graph_cycle_count_proxy	2,759 (679/2,080)	0.741 / 0.5719	-0.1690 [-0.1964, -0.1413]
Repair 11	loop_graph_cycle_count_proxy	2,759 (679/2,080)	0.741 / 0.5441	-0.1969 [-0.2308, -0.1632]
Repair 12	loop_near_self_approach_count	2,759 (679/2,080)	0.7307 / 0.5831	-0.1476 [-0.1799, -0.1149]
Repair 13	loop_near_self_approach_count	2,759 (679/2,080)	0.7307 / 0.5854	-0.1453 [-0.1811, -0.1094]
Repair 14	loop_near_self_approach_count	2,759 (679/2,080)	0.7307 / 0.5272	-0.2035 [-0.2414, -0.1664]
Repair 15	loop_graph_cycle_count_proxy	2,759 (679/2,080)	0.741 / 0.4841	-0.2569 [-0.2948, -0.2202]
Repair 16	loop_near_self_approach_count	2,680 (653/2,027)	0.7295 / 0.5501	-0.1794 [-0.2167, -0.1422]

T6 retains every comparison between original and repair, available uncorrected intervals and differing complete-case denominators. S4 also links the original discarded proxy conclusions and decisions to the dated prior dispositions, rather than removing them from history. Figure S4 shows all comparisons without selecting a winner. The corresponding aggregate and source ledger and the key inventories preserve the alias and adjusted-coverage limitations. The original dated dispositions have not yet been exported as a final public release; existing audit paths alone do not form the final journal supplement.

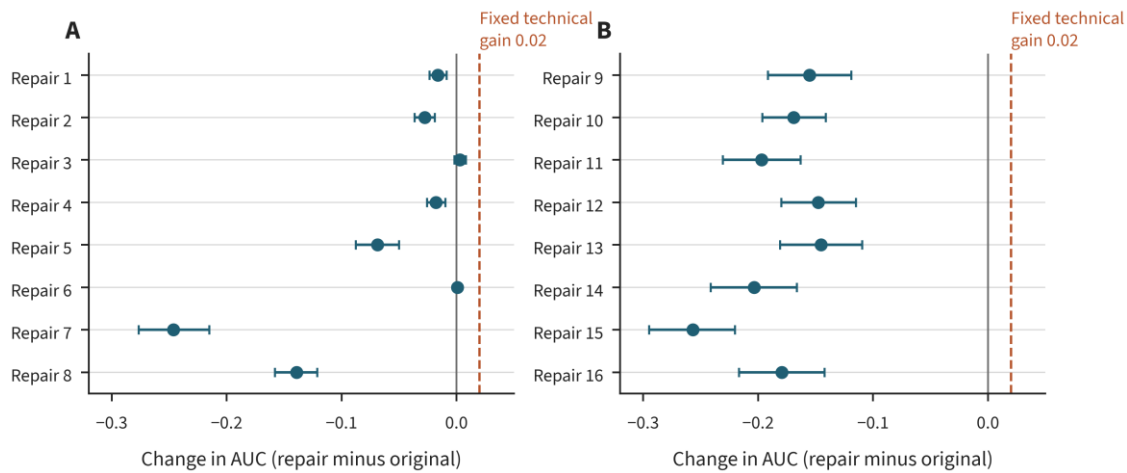


Figure S4. Change in AUC (repair minus original marker) for all 16 post-result repairs in the internal validation partition. (A) Repairs 1-8; (B) Repairs 9-16. Original markers, case counts and AUCs are given in Table T6. Bars are uncorrected descriptive 95% patient-bootstrap intervals; the planned simultaneous family was not estimable, case sets differ between repairs, and the figure does not constitute an independent test. The dashed line is the fixed technical gain of 0.02.

S4a. Supplementary search and repair details

Supplement S4/T6 retains all 16 post-result repairs and their original comparators. Repair15 changed AUC 0.740962 to 0.484093 in 2,759 internal-validation persons (679 positive / 2,080 negative); $\Delta -0.256868[-0.294820, -0.220157]$. No variant achieved the fixed technical 0.02 point gain; intervals are uncorrected and give no independent efficacy confirmation.

Eight raw candidate statements were discarded post-result; S4 retains their disposition as selection history, not as eight biological null tests.

Alias-reviewed generalist suspicion affected 43/94 dossiers (43/61 cross-sectional). Adjusted coverage reached at most two domains, which precludes a specificity conclusion. The observed search had 160,916 keys, 1,988 markers, 81 endpoints and four panels; 321,832 screening fold rows and 160,916 combined single-marker rows share that union. This is bookkeeping, not an independent-test count or FDR pass. S4 retains details.

S5. Cohort, linkage, timing and flags

T1a/S5. Local development	Master ECGs / persons	Selected ECGs / persons	Successful ECGs / persons
Train	477,493 / 96,738	477,363 / 96,680	471,654 / 96,443
Validation	162,883 / 32,597	162,841 / 32,579	160,876 / 32,504
Total	640,376 / 129,335	640,204 / 129,259	632,530 / 128,947

Original short-interval reproducibility includes 360 equal-time pairs. Ordered proxy losses were 360 zero gaps, 10,367 pairs without sinus annotation on both recordings, and 370 pairs that failed the QRS-class condition or, if they met it, had a pacing report (fewer than 10 of the latter), leaving 4,596. Each pair is counted at its first failing step, so pairs that failed both the QRS-class condition and the pacing condition are counted under the QRS-class condition. Of the 4,966 pairs entering this step, removing the QRS-class condition alone restores 172 (4,768 pairs, S3g); the other 198 of the 370 fail a further proxy condition, which in this list can only be the pacing report. This is or-

dered bookkeeping, not causal ranking. The higher-quality proxy lost 331 further pairs. Historical transform selection contained 15,000 rows in 60 train partitions, 12,185 person indices and 12,035 successful extractions. The new normal-report branch selected 1,500 from 43,630 eligible persons/90,760 ECGs; 1,487 passed signal processing. PTB's 549 records/290 persons led to 286 accepted primary persons and 282 integral-angle pairs; four primary technical losses and four missing paired angles are distinct. These branches overlap and cannot be summed.

S5a. Reconstructed development repeat flow

Neighbors were formed in the complete time-ordered development master before extraction/quality filters, preserving original adjacency. Documented procedure/input starts strictly between ECGs were excluded, not every clinical intervention. Final pair/person keys exactly matched the original artifact. Historical public-to-local import losses precede this start and remain unquantified. Overlapping branches must not be summed. Person counts that would reveal a difference of fewer than 10 persons between adjacent steps are given as bounds.

Table S5a-1. Ordered flow; candidate pairs precede final analysis pairs.

Step	Persons	Pairs	Rule
successful extracted persons	128,947	n/a	≥ 1 successful ECG
≥ 2 ECGs in same admission	45,750	n/a	nonmissing admission
adjacent same-admission	>45,740	170,948	neighbors in complete master
gap 0-2 h	11,394	18,445	including zero
same setting	11,233	17,978	equal ED-stay category
no procedure start between	10,875	17,211	documented starts only
no input start between	10,589	16,584	documented starts only
distinct stored signal	10,553	16,526	equal nonmissing hashes excluded
both extraction successful	10,187	15,693	failed/missing excluded
both quality ≥ 0.6	10,187	15,693	missing quality excluded

Table S5a-2. Selection characteristics; common age index is earliest successful development ECG. Age for the repeat group under the analyzed-pair index is given only in S5b; these are distinct indices.

Population	Persons	Median age [IQR], years	Recorded female n (%)	Missing age / sex
With repeats	10,187	67 [56, 78] (earliest-successful index)	4,519 (44.360%)	<10 / <10
Without repeats	118,760	57 [42, 71]	63,043 (53.084%)	14 / 14

The article-input audit independently reproduced core estimates, confirmed person-disjoint development partitions and checked current bindings. Supplementary populations without saved indices were traced through inspected sources and archived specifications; exact historical masks were not independently rebuilt. This does not certify pipeline delivery or clinical validity.

Flow S5a. Reconstructed development repeat flow, ECGs or pairs and persons at each step (counts as in Table S5a-1).

1. Development master: 640,376 ECGs / 129,335 persons

2. Selected: 640,204 ECGs / 129,259 persons
3. Successful extraction: 632,530 ECGs / 128,947 persons
4. At least two same-admission ECGs: 45,750 persons
5. Adjacent same-admission pairs: 170,948 pairs / more than 45,740 persons
6. Gap 0-2 h: 18,445 pairs / 11,394 persons
7. Same setting, no documented procedure or input start between, distinct signal (intermediate counts in Table S5a-1)
8. Successful extraction and quality ≥ 0.6 : 15,693 pairs / 10,187 persons

The control-flow label validation at an early selection step denotes more than 30 candidate dofetilide pairs, while more than 10 are final supported QTc pairs. They are different selection steps, not relabeled training results; the support denominator in T8 is final.

S5b. Characteristics of the analyzed populations

Population	Partition	Persons	Pairs or recordings	Age, years, median [IQR]	Female, n (%)	Missing age	Missing sex
Clinical repeats, all	Training and validation	10,187	15,693	69.0 [58.0, 80.0]	4,519 (44.4%)	<10	<10
Clinical repeats, all	Training	7,571	11,609	69.5 [58.0, 81.0]	3,362 (44.4%)	<10	<10
Clinical repeats, all	Validation	2,616	4,084	68.0 [57.0, 80.0]	1,157 (44.2%)	<10	<10
Stability proxy	Training and validation	3,560	4,596	66.0 [54.0, 77.0]	1,646 (46.2%)	<10	<10
Stability proxy	Training	2,654	3,392	66.0 [55.0, 77.0]	1,245 (46.9%)	<10	<10
Stability proxy	Validation	906	1,204	64.0 [53.0, 76.0]	401 (44.3%)	<10	<10
Catalog matrix comparison	Training and validation	5,648	5,648	68.0 [56.0, 79.0]	2,609 (46.2%)	<10	<10
Catalog matrix comparison	Training	2,824	2,824	68.0 [56.0, 79.0]	1,306 (46.2%)	<10	<10
Catalog matrix comparison	Validation	2,824	2,824	68.0 [57.0, 79.0]	1,303 (46.1%)	<10	<10
Normal-report reference	Training and validation	1,500	1,500	53.0 [41.0, 64.0]	836 (55.7%)	<10	<10
Normal-report reference	Training	1,131	1,131	54.0 [41.0, 64.0]	622 (55.0%)	<10	<10
Normal-report reference	Validation	369	369	52.0 [41.0, 64.0]	214 (58.0%)	<10	<10
Dofetilide, exposed	Training	31	(31+<10)	70.0 [63.0, 78.0]	10 (32.3%)	<10	<10
Dofetilide, exposed	Validation	12	(12+<10)	70.0 [59.8, 75.5]	<10	<10	<10
Dofetilide, untreated control	Training	16,400	35,024	67.0 [56.0, 79.0]	7,533 (45.9%)	<10	<10
Dofetilide, untreated control	Validation	1,449	2,097	70.0 [60.0, 81.0]	666 (46.0%)	<10	<10
Sotalol, exposed	Training	35	(35+<10)	69.0 [62.5, 74.0]	14 (40.0%)	<10	<10
Sotalol, exposed	Validation	10	10	73.5 [63.8, 81.8]	<10	<10	<10
Sotalol, untreated control	Training	15,124	29,937	67.0 [56.0, 78.0]	6,681 (44.2%)	<10	<10
Sotalol, untreated control	Validation	4,776	8,797	67.0 [55.0, 78.0]	2,103 (44.0%)	<10	<10
Total calcium, complete models	Training	1,026	1,026	69.0 [56.0, 79.0]	458 (44.6%)	<10	<10
Total calcium, complete models	Validation	1,019	1,019	67.0 [56.0, 79.0]	445 (43.7%)	<10	<10

Population	Partition	Persons	Pairs or recordings	Age, years, median [IQR]	Female, n (%)	Missing age	Missing sex
PTB Frank comparison, paired	External technical sample	282	282	58.0 [48.0, 67.0]	78 (27.7%)	14	<10
PTB Frank comparison, header-normal	External technical sample	51	51	37.0 [30.0, 54.0]	13 (25.5%)	<10	<10
PTB-XL LAFB teaching sample	External technical sample	92	92	70.0 [62.0, 81.0]	35 (38.0%)	<10	<10
Clinical repeats, all	Test partition	2,549	3,897 pairs	not reported	not reported	not reported	not reported
Stability proxy	Test partition	931	1,174 pairs	not reported	not reported	not reported	not reported
Catalog matrix comparison	Test partition	5,206	5,206 recordings	not reported	not reported	not reported	not reported
Normal-report reference	Test partition	1,500	1,500 recordings	not reported	not reported	not reported	not reported

The test rows report existing selection aggregates only. Age, recorded sex, gap distribution, $|\Delta\text{HR}|$, rhythm proportions and between-person SD of the five key markers were not reported in the input aggregate reports. No test data were opened and no additional test demographics were calculated. Test repeat flow was 4,098 candidate pairs/2,647 persons, minus 201 pairs removed for identical decoded signals (fewer than 10 pairs) or later QC failures, leaving 3,897 pairs/2,549 persons; the proxy retained 1,174/931. The fixed matrix halves contained 2,587/2,619 persons and positive pools 469/501 rather than the intended 706 per half, without replenishment (S13).

Age and sex are person-level characteristics. For repeated-recording analyses, age refers to the earliest eligible first recording for each person. For the other populations, it refers to the selected recording. MIMIC age was calculated as anchor_age plus recording year minus anchor_year; ages at the oldest end of the distribution are affected by deidentification. PTB ages and sex values were taken from the source records. IQR gives the 25th and 75th percentiles among persons with available age. Female percentages use all persons in each row as the denominator. Counts below 10, including zero counts, are shown as <10; percentages for these cells are withheld. Further suppression prevents reconstruction of small sex cells. Counts from which a value between 1 and 9 could be derived by subtraction or summation across tables were also coarsened. QT rows refer to QTcF with shared control support; the calcium rows describe the identical complete-case populations for QT, Q-oT, Q-aT and QTcF within 6 h. External populations are technical samples. Training and validation contain different persons; validation was inspected during development and is not an independent confirmation. Substudy populations may overlap across analyses. The full demographic CSV provides marker-specific secondary populations and the original PTB-XL folds.

S6. Complete controls, support and failures

S6-0. Exploratory routine-care exposure methods and results

QT controls required documented eMAR administration, compatible admission and ECG timing, passing of both quality thresholds and the same nonmissing rhythm-context category. Dispensing is not administration; eMAR does not independently confirm ingestion. Prespecified windows before and after exposure, documentation-free start criteria, gap strata and training-fixed baseline strata limited post-hoc selection. The estimand was mean exposed change minus standardized untreated change, restricted to control support. Shared patient weights were used where persons contributed to both groups, with weights re-estimated in each bootstrap draw. Time-varying electrolytes, renal function, heart rate, rhythm, dose and concomitant drugs remained incompletely adjusted. QTcF was primary; QTcB provided parallel evidence on frequency correction. QT measurement recommendations provide standards context (Rautaharju *et al* 2009) but do not validate our implementation. Dofetilide initiation is linked to monitored admission, renal-dose assessment and potassium management in its prescribing information (Pfizer n.d.). The start setting and electrolyte trajectories of individual pairs were not established; they may confound the contrast. No transferable expected effect-size threshold was fixed for these routine-care pairs. The magnitude-curvature check used the specified source functions on fixed synthetic curves, not on invented patient ECGs.

Supplement S6/T8 shows support-restricted control-adjusted contrasts. The inference criterion requires ≥ 30 exposed and ≥ 30 control persons; small validation intervals are descriptive. Prewindows were insufficient; among the two QT drugs only training Sotalol passed the QRS negative-control rule. Dofetilide QTcF contrasts were +37.57 ms [23.45, 51.62] in training (31 exposed persons, with fewer than 10 further pairs) and +41.41 ms [22.89, 62.81] in validation (12 exposed persons, with fewer than 10 further pairs; descriptive only); QTcB was also positive. Initiation monitoring differs from untreated routine care and may contribute to the contrast; effects of electrolytes, renal function or start setting were not quantified and no transferable expected drug-effect magnitude was established. Sotalol validation is unresolved for QTcF and reverses sign for QTcB (-1.82 ms [-15.86, 11.03]); Digoxin QTc is unresolved in both partitions. QT recovery does not certify the full VCG chain or complete the main-run control audit. The rationale for a positive control follows prior work (Chiang *et al* 2010); it is not a validated effect-size requirement for these routine-care pairs.

Within-person drug contrasts require state-stable pairs from different recordings with comparable time gaps as the recording-change null distribution. Existing untreated time controls do not by themselves establish this requirement; a within-recording rest-versus-rest comparison is insufficient. Statements of clinical change remain exploratory until this criterion is documented.

Table T8 dimensions: Drug / partition / measure. **Supplementary table 033, part 1.**

Row	Drug	Partition	Measure	Exposed pairs/persons	Untreated pairs/persons	Exposed change
1	dofetilide	train	QTcF, ms	(31+<10)/31	35,024/16,400	32.78
2	dofetilide	validation	QTcF, ms	(12+<10)/12	2,097/1,449	25.76
3	dofetilide	train	QTcB, ms	(31+<10)/31	33,568/17,390	24.64
4	dofetilide	validation	QTcB, ms	(12+<10)/12	3,685/2,330	14.5
5	sotalol	train	QTcF, ms	(35+<10)/35	29,937/15,124	12.84
6	sotalol	validation	QTcF, ms	10/10	8,797/4,776	4.660
7	sotalol	train	QTcB, ms	(35+<10)/35	29,937/15,124	8.770
8	sotalol	validation	QTcB, ms	10/10	8,418/4,536	-6.890
9	digoxin	train	QTcF, ms	117/104	39,804/19,171	-5.040
10	digoxin	validation	QTcF, ms	(39+<10)/39	10,368/5,195	10.20
11	digoxin	train	QTcB, ms	117/104	35,522/16,857	-9.790
12	digoxin	validation	QTcB, ms	(39+<10)/39	10,368/5,195	1.49
13	digoxin	train	magnitude curvature, μV	149/134	37,166/17,683	2.500
14	digoxin	validation	magnitude curvature, μV	(45+<10)/45	9,769/5,045	-25.19

Supplementary table 033, part 2.

Row	Control change	Contrast [95% interval]	Status
1	-4.790	+37.57 [23.45, 51.62]	positive direction in training
2	-15.66	+41.41 [22.89, 62.81]	descriptive only; fewer than 30 exposed persons
3	-5.850	30.49 [15.83, 45.94]	positive direction in training
4	-12.82	27.32 [4.660, 47.40]	descriptive only; fewer than 30 exposed persons
5	-4.790	17.63 [8.910, 27.95]	positive direction in training
6	-2.990	7.640 [-8.930, 23.62]	descriptive only; fewer than 30 exposed persons; QTcF effect unresolved
7	-2.670	11.44 [1.400, 22.16]	positive direction in training
8	-5.070	-1.82 [-15.86, 11.03]	descriptive only; fewer than 30 exposed persons; QTcB contrast reverses direction
9	-5.860	0.8200 [-6.780, 8.740]	effect unresolved
10	-1.290	11.50 [-0.6000, 22.42]	effect unresolved
11	-7.870	-1.930 [-10.57, 7.080]	effect unresolved
12	-3.460	4.950 [-10.31, 18.24]	effect unresolved
13	-3.710	6.210 [-8.910, 18.43]	signed operationalization failed
14	0.4400	-25.63 [-89.66, 14.92]	signed operationalization failed

All secondary contrasts (including pooled exploratory results) are reported below from the same control specification. Units are native; QT/T-related quantities need their own expected direction and do not inherit QTc success.

Key dimensions: Drug / partition / marker. **Supplementary table 034, part 1.**

Row	Drug	Partition	Marker	Role / unit	Exposed fi-nite→supported pairs/persons	Control fi-nite→supported pairs/persons
1	dofetilide	train	qtc_fridericia_ms	primary/ms	(31+<10)→(31+<10)/31	49,708→35,024/16,400
2	dofetilide	validation	qtc_fridericia_ms	primary/ms	(12+<10)→(12+<10)/12	17,226→2,097/1,449
3	dofetilide	development_pooled	qtc_fridericia_ms	primary/ms	(43+<10)→(43+<10)/43	66,934→47,168/22,018
4	dofetilide	train	qtc_bazett_ms	secondary/ms	(31+<10)→(31+<10)/31	49,708→33,568/17,390
5	dofetilide	validation	qtc_bazett_ms	secondary/ms	(12+<10)→(12+<10)/12	17,226→3,685/2,330
6	dofetilide	development_pooled	qtc_bazett_ms	secondary/ms	(43+<10)→(43+<10)/43	66,934→50,925/24,748
7	dofetilide	train	jt_interval_ms	secondary/ms	(32+<10)→(32+<10)/32	51,933→38,919/18,672
8	dofetilide	validation	jt_interval_ms	secondary/ms	(13+<10)→(13+<10)/13	17,951→7,882/4,365
9	dofetilide	development_pooled	jt_interval_ms	secondary/ms	(45+<10)→(45+<10)/45	69,884→59,335/26,700
10	dofetilide	train	tpeak_tend_ms	secondary/ms	(32+<10)→(32+<10)/32	51,926→42,896/19,227
11	dofetilide	validation	tpeak_tend_ms	secondary/ms	(13+<10)→(13+<10)/13	17,951→7,702/4,329
12	dofetilide	development_pooled	tpeak_tend_ms	secondary/ms	(45+<10)→(45+<10)/45	69,877→57,765/25,829
13	dofetilide	train	spatial_qrs_t_angle_deg	secondary/degree	(32+<10)→(32+<10)/32	50,281→41,622/19,406
14	dofetilide	validation	spatial_qrs_t_angle_deg	secondary/degree	(13+<10)→(13+<10)/13	17,353→5,945/3,459
15	dofetilide	development_pooled	spatial_qrs_t_angle_deg	secondary/degree	(45+<10)→(45+<10)/45	67,634→55,958/26,090
16	dofetilide	train	svg_magnitude	secondary/uV*ms	(32+<10)→(32+<10)/32	50,658→40,799/19,563
17	dofetilide	validation	svg_magnitude	secondary/uV*ms	(13+<10)→(13+<10)/13	17,499→6,213/3,758
18	dofetilide	development_pooled	svg_magnitude	secondary/uV*ms	(45+<10)→(45+<10)/45	68,157→60,680/27,516
19	dofetilide	train	qrs_duration_ms	negative_marker/ms	(33+<10)→(33+<10)/33	54,276→41,438/18,708
20	dofetilide	validation	qrs_duration_ms	negative_marker/ms	(14+<10)→(14+<10)/14	18,784→6,740/3,474
21	dofetilide	development_pooled	qrs_duration_ms	negative_marker/ms	(47+<10)→(47+<10)/47	73,060→55,730/25,068
22	sotalol	train	qtc_fridericia_ms	primary/ms	(35+<10)→(35+<10)/35	49,708→29,937/15,124
23	sotalol	validation	qtc_fridericia_ms	primary/ms	10→10/10	17,226→8,797/4,776
24	sotalol	development_pooled	qtc_fridericia_ms	primary/ms	(45+<10)→(45+<10)/45	66,934→40,305/20,319
25	sotalol	train	qtc_bazett_ms	secondary/ms	(35+<10)→(35+<10)/35	49,708→29,937/15,124
26	sotalol	validation	qtc_bazett_ms	secondary/ms	10→10/10	17,226→8,418/4,536

Row	Drug	Partition	Marker	Role / unit	Exposed fi-nite→supported pairs/persons	Control fi-nite→supported pairs/persons
27	sotalol	development_pooled	qtc_bazett_ms	secondary/ms	(45+<10)→(45+<10)/45	66,934→40,305/20,319
28	sotalol	train	jt_interval_ms	secondary/ms	(38+<10)→(38+<10)/38	51,933→31,331/15,619
29	sotalol	validation	jt_interval_ms	secondary/ms	10→10/10	17,951→7,179/4,062
30	sotalol	development_pooled	jt_interval_ms	secondary/ms	(48+<10)→(48+<10)/48	69,884→42,144/20,977
31	sotalol	train	tpeak_tend_ms	secondary/ms	(38+<10)→(38+<10)/38	51,926→31,324/15,616
32	sotalol	validation	tpeak_tend_ms	secondary/ms	10→10/10	17,951→6,099/3,747
33	sotalol	development_pooled	tpeak_tend_ms	secondary/ms	(48+<10)→(48+<10)/48	69,877→42,137/20,974
34	sotalol	train	spatial_qrs_t_angle_deg	secondary/degree	(36+<10)→(36+<10)/36	50,281→26,243/13,707
35	sotalol	validation	spatial_qrs_t_angle_deg	secondary/degree	10→10/10	17,353→7,267/4,230
36	sotalol	development_pooled	spatial_qrs_t_angle_deg	secondary/degree	(46+<10)→(46+<10)/46	67,634→40,745/20,603
37	sotalol	train	svg_magnitude	secondary/uV*ms	(37+<10)→(37+<10)/37	50,658→30,537/15,397
38	sotalol	validation	svg_magnitude	secondary/uV*ms	10→10/10	17,499→5,949/3,683
39	sotalol	development_pooled	svg_magnitude	secondary/uV*ms	(47+<10)→(47+<10)/47	68,157→41,075/20,689
40	sotalol	train	qrs_duration_ms	negative_marker/ms	(41+<10)→(41+<10)/41	54,276→32,839/16,073
41	sotalol	validation	qrs_duration_ms	negative_marker/ms	10→10/10	18,784→7,469/3,978
42	sotalol	development_pooled	qrs_duration_ms	negative_marker/ms	(51+<10)→(51+<10)/51	73,060→44,151/21,563
43	digoxin	train	qtc_fridericia_ms	secondary/ms	117→117/104	49,708→39,804/19,171
44	digoxin	validation	qtc_fridericia_ms	secondary/ms	(39+<10)→(39+<10)/39	17,226→10,368/5,195
45	digoxin	development_pooled	qtc_fridericia_ms	secondary/ms	>140→>140/143	66,934→53,575/25,770
46	digoxin	train	qtc_bazett_ms	secondary/ms	117→117/104	49,708→35,522/16,857
47	digoxin	validation	qtc_bazett_ms	secondary/ms	(39+<10)→(39+<10)/39	17,226→10,368/5,195
48	digoxin	development_pooled	qtc_bazett_ms	secondary/ms	>140→>140/143	66,934→47,866/22,654
49	digoxin	train	jt_interval_ms	secondary/ms	141→141/124	51,933→34,081/16,466
50	digoxin	validation	jt_interval_ms	secondary/ms	(44+<10)→(44+<10)/44	17,951→7,925/4,383
51	digoxin	development_pooled	jt_interval_ms	secondary/ms	>160→>160/168	69,884→45,872/22,154
52	digoxin	train	tpeak_tend_ms	secondary/ms	141→141/124	51,926→39,339/18,724
53	digoxin	validation	tpeak_tend_ms	secondary/ms	(44+<10)→(44+<10)/44	17,951→10,813/5,358
54	digoxin	development_pooled	tpeak_tend_ms	secondary/ms	>160→>160/168	69,877→52,860/25,155
55	digoxin	train	spatial_qrs_t_angle_deg	secondary/degree	128→128/114	50,281→43,502/20,401

Row	Drug	Partition	Marker	Role / unit	Exposed finite→supported pairs/persons	Control finite→supported pairs/persons
56	digoxin	validation	spatial_qrs_t_angle_deg	secondary/degree	(40+<10)→(40+<10)/40	17,353→9,484/5,005
57	digoxin	development_pooled	spatial_qrs_t_angle_deg	secondary/degree	>150→>150/154	67,634→58,417/27,417
58	digoxin	train	svg_magnitude	secondary/uV*ms	133→133/118	50,658→41,567/19,435
59	digoxin	validation	svg_magnitude	secondary/uV*ms	(41+<10)→(41+<10)/41	17,499→10,538/5,292
60	digoxin	development_pooled	svg_magnitude	secondary/uV*ms	>150→>150/159	68,157→55,834/26,117
61	digoxin	train	qrs_duration_ms	negative_marker/ms	147→147/131	54,276→43,841/20,160
62	digoxin	validation	qrs_duration_ms	negative_marker/ms	(46+<10)→(46+<10)/46	18,784→11,312/5,490
63	digoxin	development_pooled	qrs_duration_ms	negative_marker/ms	>170→>170/177	73,060→58,980/27,080
64	digoxin	train	magnitude_curvature	morphology/uV	149→149/134	52,662→37,166/17,683
65	digoxin	validation	magnitude_curvature	morphology/uV	(45+<10)→(45+<10)/45	18,204→9,769/5,045
66	digoxin	development_pooled	magnitude_curvature	morphology/uV	>170→>170/179	70,866→49,979/23,740

Supplementary table 034, part 2.

Row	Union persons	Exposed change [interval]	Control change	Contrast [interval]	Inference criterion / status
1	16,410	32.78 [17.06, 49.01]	-4.790	+37.57 [23.45, 51.62]	True/positive direction in training
2	suppressed (overlap <10 persons)	25.76 [6.870, 48.35]	-15.66	+41.41 [22.89, 62.81]	False/descriptive only; fewer than 30 exposed persons
3	about 22,000	30.84 [19.38, 44.75]	-7.740	38.58 [27.65, 49.76]	True/positive direction in training
4	17,401	24.64 [6.840, 42.44]	-5.850	30.49 [15.83, 45.94]	True/positive direction in training
5	suppressed (overlap <10 persons)	14.5 [-6.690, 36.24]	-12.82	27.32 [4.660, 47.40]	False/descriptive only; fewer than 30 exposed persons
6	about 24,800	21.84 [8.500, 34.97]	-7.790	29.63 [17.77, +41.41]	True/positive direction in training
7	suppressed (small cell <10 persons)	43.14 [24.22, 62.38]	-6.720	49.86 [33.48, 66.30]	True/positive direction in training
8	suppressed (overlap <10 persons)	32.80 [-0.9300, 68.41]	-6.590	39.39 [6.180, 74.85]	False/descriptive only; fewer than 30 exposed persons
9	about 26,700	40.04 [22.85, 59.17]	-6.740	46.78 [31.68, 63.58]	True/positive direction in training
10	suppressed (small cell <10 persons)	9.430 [3.170, 16.13]	0.29	9.130 [3.740, 14.96]	True/effect unresolved
11	suppressed (overlap <10 persons)	7.730 [-10.25, 29.21]	-3.2	10.93 [-4.790, 29.29]	False/descriptive only; fewer than 30 exposed persons
12	about 25,800	8.920 [2.500, 15.91]	-0.7800	9.700 [4.090, 16.00]	True/effect unresolved
13	suppressed (small cell <10 persons)	-7.110 [-19.28, 4.960]	-2.080	-5.020 [-16.04, 6.180]	True/effect unresolved
14	suppressed (overlap <10 persons)	-9.220 [-30.78, 11.71]	-9.700	0.4900 [-20.07, 20.24]	False/descriptive only; fewer than 30 exposed persons
15	about 26,100	-7.720 [-17.45, 2.420]	-4.220	-3.500 [-13.33, 5.580]	True/effect unresolved
16	19,573	9,440 [-5,329; 27,220]	2,220	7,220 [-5,984; 25,198]	True/effect unresolved
17	suppressed (overlap <10 persons)	805.4 [-7,893; 10,808]	1,369	-563.6 [-8,964; 7,593]	False/descriptive only; fewer than 30 exposed persons
18	about 27,500	6,922 [-3,472; 20,218]	1,917	5,004 [-4,542; 18,631]	True/effect unresolved
19	suppressed (small cell <10 persons)	3.000 [-1.000, 7.750]	-0.2200	3.220 [-0.7800, 7.890]	True/negative_control_not_passed
20	suppressed (overlap <10 persons)	0.1200 [-8.250, 12.38]	-1.370	1.49 [-7.050, 13.77]	False/descriptive only; fewer than 30 exposed persons
21	about 25,100	2.080 [-2.260, 7.100]	-0.5800	2.660 [-1.620, 7.400]	True/negative_control_not_passed

Row	Union persons	Exposed change [interval]	Control change	Contrast [interval]	Inference criterion / status
22	15,147	12.84 [4.290, 22.32]	-4.790	17.63 [8.910, 27.95]	True/positive direction in training
23	suppressed (overlap <10 persons)	4.660 [-17.56, 25.95]	-2.990	7.640 [-8.930, 23.62]	False/descriptive only; fewer than 30 exposed persons
24	about 20,300	11.10 [3.220, 19.12]	-4.410	+15.51 [8.510, 23.38]	True/positive direction in training
25	15,147	8.770 [-1.290, 19.77]	-2.670	11.44 [1.400, 22.16]	True/positive direction in training
26	suppressed (overlap <10 persons)	-6.890 [-23.98, 11.36]	-5.070	-1.82 [-15.86, 11.03]	False/descriptive only; fewer than 30 exposed persons
27	about 20,300	5.440 [-2.720, 14.40]	-3.190	8.620 [0.6200, 17.20]	True/positive direction in training
28	15,642	13.30 [0.7100, 25.71]	-11.07	24.37 [11.83, 37.95]	True/positive direction in training
29	suppressed (overlap <10 persons)	21.80 [-16.67, 61.28]	-8.000	29.80 [-1.680, 59.63]	False/descriptive only; fewer than 30 exposed persons
30	about 21,000	15.00 [1.740, 26.62]	-10.37	25.37 [12.95, 37.09]	True/positive direction in training
31	15,639	5.950 [-2.060, 14.68]	-1.300	7.250 [-1.190, 16.91]	True/effect unresolved
32	suppressed (overlap <10 persons)	10.80 [1.170, 21.17]	2.360	8.440 [0.2400, 18.65]	False/descriptive only; fewer than 30 exposed persons
33	about 21,000	6.920 [0.1600, 14.04]	-0.5600	7.480 [0.80, 15.00]	True/effect unresolved
34	13,732	1.210 [-10.63, 11.80]	0.9800	0.2300 [-11.97, 11.38]	True/effect unresolved
35	suppressed (overlap <10 persons)	-2.290 [-27.83, 25.93]	2.320	-4.600 [-30.45, 22.37]	False/descriptive only; fewer than 30 exposed persons
36	about 20,600	0.4800 [-11.11, 10.27]	1.100	-0.6300 [-10.91, 9.260]	True/effect unresolved
37	15,422	7,781 [-4,463; 22,250]	-1,642	9,423 [-3,009; 24,076]	True/effect unresolved
38	suppressed (overlap <10 persons)	-1,653 [-19,566; 16,750]	-9,234	7,581 [-7,854; 22,912]	False/descriptive only; fewer than 30 exposed persons
39	about 20,700	5,856 [-3,928; 17,164]	-3,086	8,942 [-341.3; 20,896]	True/effect unresolved
40	16,098	-0.7900 [-3.950, 2.570]	-0.5500	-0.2400 [-3.300, 2.910]	True/operational equivalence
41	suppressed (overlap <10 persons)	1.600 [-5.330, 9.510]	-0.9600	2.560 [-4.300, 10.73]	False/descriptive only; fewer than 30 exposed persons
42	about 21,600	-0.3400 [-3.420, 2.560]	-0.6300	0.29 [-2.650, 3.020]	True/operational equivalence
43	19,224	-5.040 [-11.90, 1.870]	-5.860	0.8200 [-6.780, 8.740]	True/effect unresolved

Row	Union persons	Exposed change [interval]	Control change	Contrast [interval]	Inference criterion / status
44	5,220	10.20 [0.5100, 18.79]	-1.290	11.50 [-0.6000, 22.42]	True/effect unresolved
45	about 25,800	-0.9400 [-6.830, 5.060]	-4.660	3.720 [-3.150, 10.00]	True/effect unresolved
46	16,909	-9.790 [-18.73, -0.6000]	-7.870	-1.930 [-10.57, 7.080]	True/effect unresolved
47	5,220	1.49 [-11.56, 13.67]	-3.460	4.950 [-10.31, 18.24]	True/effect unresolved
48	about 22,700	-6.760 [-14.25, 0.7200]	-6.700	-0.06 [-7.790, 7.640]	True/effect unresolved
49	16,534	3.960 [-3.600, 11.55]	6.920	-2.960 [-9.660, 4.050]	True/effect unresolved
50	4,415	19.92 [8.350, 31.74]	14.12	5.800 [-6.330, 17.81]	True/effect unresolved
51	about 22,200	8.07 [1.840, 14.44]	8.790	-0.7100 [-6.530, 5.110]	True/effect unresolved
52	18,791	3.110 [-0.27, 6.860]	-1.010	4.120 [0.7200, 7.840]	True/effect unresolved
53	5,386	10.78 [3.960, 18.43]	2.850	7.920 [1.870, 14.85]	True/effect unresolved
54	about 25,200	5.080 [1.990, 8.360]	-0.03	5.110 [2.170, 8.150]	True/effect unresolved
55	20,466	-1.730 [-8.690, 5.450]	-9.050	7.320 [0.4100, 14.38]	True/effect unresolved
56	5,033	-3.170 [-19.51, 12.7]	-1.780	-1.400 [-15.78, 13.27]	True/effect unresolved
57	about 27,500	-2.100 [-9.100, 4.570]	-7.160	5.060 [-1.850, 11.50]	True/effect unresolved
58	19,500	5,869 [-1,307; 12,742]	4,281	1,588 [-5,122; 8,300]	True/effect unresolved
59	5,320	22,775 [-11,319; 91,242]	-1,443	24,218 [-9,443; 95,213]	True/effect unresolved
60	about 26,200	10,143 [-1,047; 28,205]	2,838	7,305 [-3,669; 25,257]	True/effect unresolved
61	20,235	-1.200 [-6.020, 2.450]	-0.9300	-0.27 [-4.960, 3.340]	True/operational_equivalence
62	5,518	0.3100 [-3.320, 3.770]	-1.250	1.560 [-2.310, 5.220]	True/negative_control_not_passed
63	about 27,200	-0.8100 [-4.160, 1.990]	-1.020	0.22 [-3.040, 2.910]	True/operational_equivalence
64	17,752	2.500 [-12.83, 16.56]	-3.710	6.210 [-8.910, 18.43]	True/signed operationalization failed
65	5,076	-25.19 [-90.10, 17.85]	0.4400	-25.63 [-89.66, 14.92]	True/signed operationalization failed
66	about 23,800	-4.460 [-23.67, 11.87]	-2.640	-1.82 [-20.33, 13.61]	True/signed operationalization failed

In Supplementary table 034, union persons are suppressed where fewer than 10 persons belong to both the exposed and the control branch or to only one of the two branches, because the exposed and control person counts would otherwise reveal that count. The pooled union column is rounded to the nearest 100. Exposed pair counts that exceed the person count by fewer than 10 are shown as the person count plus <10.

Negative controls and pre-exposure windows

Control	Fold	Persons	QRS difference, ms	95% CI	Status
dofetilide	train	33	3.22	-0.78 to 7.89	negative_control_not_passed
dofetilide	validation	14	1.49	-7.05 to 13.77	descriptive only; fewer than 30 exposed persons
sotalol	train	41	-0.24	-3.30 to 2.91	operational_equivalence
sotalol	validation	10	2.56	-4.30 to 10.73	descriptive only; fewer than 30 exposed persons
digoxin	train	131	-0.27	-4.96 to 3.34	operational_equivalence
digoxin	validation	46	1.56	-2.31 to 5.22	negative_control_not_passed

Pre-exposure windows required two ECGs in the same admission during the 48 hours before start, separated by at least 2 hours, with the same quality and rhythm criteria. No standardized control contrast was available for these windows; <30 persons leaves the inference criterion open. Rows with fewer than 10 persons are suppressed.

Supplementary table 035, part 1.

Row	Drug	Fold	Post-start candidate pairs	Prewindow available	QTcF pairs	Persons
1	digoxin	train	>150	58	(39+<10)	39
2	digoxin	validation	>50	10-19	14	14
3	dofetilide	train	>30	11	<10	<10
4	dofetilide	validation	>10	<10	<10	<10
5	sotalol	train	>40	15	<10	<10
6	sotalol	validation	10	<10	<10	<10

Supplementary table 035, part 2.

Row	Δ QTcF, ms	95% interval	Cluster criterion
1	1.0	[-9.520, 12.31]	True
2	-9.030	[-25.72, 4.880]	False
3	suppressed (<10 persons)	suppressed (<10 persons)	suppressed (<10 persons)
4	suppressed (<10 persons)	suppressed (<10 persons)	suppressed (<10 persons)
5	suppressed (<10 persons)	suppressed (<10 persons)	suppressed (<10 persons)
6	suppressed (<10 persons)	suppressed (<10 persons)	suppressed (<10 persons)

Folds, controlled and exposed-only changes, untreated support, pair and person counts, secondary measures, negative controls and prewindow availability require separate interpretation.

Table S6a dimensions: QTcF support, drug/fold.

Drug	Fold	Exposed matched pairs/persons	Untreated supported pairs/persons	Union persons
Dofetilide	train	(31+<10)/31	35,024/16,400	16,410
Dofetilide	validation	(12+<10)/12	2,097/1,449	suppressed (overlap <10 persons)
Sotalol	train	(35+<10)/35	29,937/15,124	15,147
Sotalol	validation	10/10	8,797/4,776	suppressed (overlap <10 persons)

Person counts overlap across exposure and control branches; a union is not their sum. Unions are suppressed where fewer than 10 persons belong to both branches or to only one branch. Exposed pair counts that exceed the person count by fewer than 10 are shown as the person count plus <10. A complete demographic control table is unavailable in the audited reporting package. Secondary-control numerical aggregates are fully reported above. Validation intervals are descriptive and training success is partial. The synthetic Digitalis shapes are test curves, not patient examples. No failed or unsupported control is recoded as a biological null. An optional state-switch control is specified, not executed.

S6-1. Routine-care control panel and flags

Global flags were true in 321,832 rows across 81 endpoints, while specific verification criteria had passing rows for only six endpoints, without universal endpoint approval. Computation is not clinical verification. In the main-run control panel (validation partition, ROC-AUC with 0.5 as no effect), a positive control counted as recovered when it showed the expected direction with $p \leq 0.01$, and a negative control counted as a false positive when its AUC differed from 0.5 by at least 0.05. Three of six declared positive controls were recovered (hypokalemia and Tpeak-Tend, hypocalcemia and QT, digoxin and ST depression). Two showed only the expected direction with AUCs of 0.522 and 0.504 (hyperkalemia with T-wave peaking and with QRS widening), and one had an AUC of 0.500, nominally in the opposite direction (QT-prolonging drugs and QT). One of four negative controls was labeled a false positive (hypocalcemia and P width, AUC 0.591); as the largest negative-control effect, it also sets the panel's confounding noise floor of 0.091. The panel's reliability flag is set when at least half of the positive controls are recovered and does not take negative-control false positives into account; we therefore report the panel descriptively and not as a global reliability certificate. The panel classifies single ECGs by an exposure label, whereas the routine-care contrasts in S6-0 compare recordings before and after documented administration; randomized public controls are reported separately in S6b.

S6a. Calcium control under an explicit measurement definition

ECG-EHR clock alignment remains empirically unconfirmed at the individual level. The release's conservative ineligibility flag is not a measured clock offset. Hour-scale calcium pairing therefore

remains provisional. In a fixed technical heart-rate matching audit of ICU ECGs against charted heart rate (shifts of -12 to $+12$ h), population-level agreement peaked at a zero offset in both partitions, indicating no systematic clock shift; however, an individual offset was identifiable in only 392/17,067 (development) and 145/5,846 (validation) persons, of whom 67.1% and 70.3% lay within ± 60 min, below the fixed technical 90% criterion. Hour-scale pairing is therefore treated as nominal: random misalignment may attenuate calcium-interval associations, whereas informative timing could bias them in either direction, and the calcium analysis is reported with this limitation.

Total and ionized calcium were audited separately. The table below contains all four total-calcium interval coefficients for the 6-h/all model in each internal partition; it does not select a favorable interval. Nearest laboratory IDs were joined back by person and laboratory group to original laboratory timestamps. Pairing is symmetric within 6 h, not evidence of blood sampling before ECG or therapy. Numeric uncensored laboratory values, unit checks, actual time availability and complete covariate cases were required. Missing values were not imputed. QT ends at T end, Q-oT at T onset, Q-aT at T peak; QTcF uses Fridericia correction.

OLS included a centered natural heart-rate spline ($df = 4$; eligible HR 30-180), age, sex, QRS duration, potassium and magnesium. Intervals are 95% person-cluster-robust, small-sample-corrected t intervals. The fixed sample contributes one ECG per person and laboratory type; no extra independent information comes from repeated ECGs. Folds have separate intervals, without asserting a pooled covariance. Candidate window rows and complete model persons are different denominators.

S6a-Ca. Partition	Interval	Complete ECGs/persons / window rows	β ms per mmol/L [95% interval]
Training	QT	1,026/1,975	-19.39 [-27.42, -11.37]
Training	Q-oT	1,026/1,975	-9.030 [-14.64, -3.420]
Training	Q-aT	1,026/1,975	-15.71 [-22.76, -8.660]
Training	QTcF	1,026/1,975	-21.09 [-29.86, -12.32]
Internal validation	QT	1,019/1,920	-20.49 [-31.27, -9.710]
Internal validation	Q-oT	1,019/1,920	-10.20 [-17.53, -2.860]
Internal validation	Q-aT	1,019/1,920	-16.74 [-25.36, -8.120]
Internal validation	QTcF	1,019/1,920	-21.95 [-33.60, -10.30]

All eight adjusted coefficients are negative. The earlier unadjusted release-documentation reversal is a confounding example, especially concerning frequency, rather than evidence of an opposite calcium effect. This does not quantify the fraction attributable to heart rate alone. The internal second partition was previously inspected and is not independent confirmation.

The two calcium types, 2-h/6-h windows, QRS/K/Mg strata and additional pH fits remain separate sensitivities in the full source CSV. A nearby pH value need not come from the same calcium specimen; identical timestamps do not prove specimen identity. Medication and administration-time adjustment was not performed. Residual treatment, renal and sampling confounding remains possible. This is not an untreated or causal positive control, clinical specificity, or an

equivalence test; no smallest-effect or absence conclusion is drawn. A qualitative textbook state description does not predict one linear coefficient across the entire clinical calcium range and is not declared validated here.

Source and reproducibility. The archived aggregate output of the calcium measurement-definition audit supplies training and internal-validation results for total calcium, QT, Q-oT, Q-aT and QTcF, the 6-h window and all eligible strata, with calcium coefficients in ms per mmol/L and complete-model and person counts. Source run and fixed inputs are as in S1b. The original source record identifies the private laboratory pairs, laboratory query and origin-corrected signal aggregates; the archived analysis and laboratory-definition scripts produced these results. The audit used only the aggregate CSV and report, without opening these patient-level files.

S6b. Randomized public exposure controls (ECGRDVQ, ECGCIPA unit audit)

ECGRDVQ is a randomized, double-blind, five-period crossover study of four drugs and placebo in 22 participants, with seven-day washout (Johannesen *et al* 2014; Vicente *et al* 2015; ECGRDVQ 2016; Pollard *et al* 2026). Single fasting morning doses were dofetilide 500 µg, quinidine sulfate 400 mg, ranolazine 1,500 mg and verapamil 120 mg (Vicente *et al* 2015). One participant withdrew before the final quinidine period; the available quinidine contrast contains 21 participants. ECGCIPA was used only for a waveform-unit audit, not effect replication (ECGCIPA 2018; Vicente *et al* 2019; Pollard *et al* 2026); both datasets use the Open Data Commons Attribution License v1.0.

Methods and measurement routes

We examined the publicly available ECGRDVQ randomized crossover recordings using the specified measurement software. The fixed primary assessment was the baseline- and placebo-corrected change in Fridericia-corrected QT at 2 h. Expectations were fixed before this calculation: prolongation with dofetilide and quinidine, a smaller increase with ranolazine, and no relevant increase with verapamil. This was a technical recalculation with disclosed prior result awareness, rather than a prospectively registered independent validation. The prior awareness was the following: the first seven rows of an earlier parallel 2-h table were displayed during the extraction by the author, earlier than the protocol foresaw, and the adapter for the source route (QT from the original boundaries with the RR of the clinical source table; angles with the release integration function and a fixed median origin) was defined after early single outputs of the production route had been seen; no marker, time point or test was changed because of this. Raw recordings were resampled to 500 Hz and processed with the release signal paths, 60-Hz notch, multilead R detection, fusion delineation and Kors regression reconstruction. Source-annotation measurements were reported separately. For these median beats, QTcF combined annotated QT with the source-recording RR; source area metrics used the release integration formula and a fixed pre-P baseline. The source annotations lacked T onset and could not support the release-defined normalized Fréchet measure.

Triplicates were averaged within participant, period and nominal time. Changes from each treatment-period baseline were corrected by the same participant's time-matched placebo change. Confidence intervals used 10,000 participant bootstrap samples. Four primary tests were Holm-adjusted. The secondary family comprised four drugs by area angle, Tpeak-Tend, QRS duration and normalized Fréchet coupling, with Benjamini-Hochberg correction over all 16 contrasts separately for each measurement route. Unavailable contrasts remained in the family with $p = 1$. Participant and period effects, with participant-clustered small-sample intervals, were examined separately; prior-treatment sensitivity used periods 2-5. All other scheduled time points were reported descriptively.

QTcF contrasts and prior-treatment sensitivity

Table S6b-1. Primary QTcF contrasts at 2 h, corresponding to main Table 6.

Production delineation recovered 3 of the three expected positive QTcF directions at the fixed 2-h assessment after multiplicity correction. Source-reference effects and production effects were reported separately (Table). These paired measurements use the same trial recordings and are not independent replications. Numerical source-reference QTcF agreed with the clinical source table to a maximum absolute difference of 0.000000 ms across 5,217 available recordings. The production quinidine effect was 11.51 ms smaller than the source-reference effect (participant-bootstrap 95% CI for the difference, -16.55 to -6.54 ms; the post hoc route-difference analysis of S6b-4 used a separate seed family and gave -11.51 ms, -16.63 to -6.47). Recovery of direction therefore did not establish numerical agreement. Differences concern the complete measurement chain, including boundary placement and beatwise RR pairing. Verapamil met the exploratory ± 10 -ms equivalence margin at 2 h; this technical margin does not establish clinical safety. Normalized Fréchet was unavailable from the source annotations because T onset was not provided.

Drug	Participants, production/source	Production $\Delta\Delta\text{QTcF}$, ms [95% CI]	Source-reference $\Delta\Delta\text{QTcF}$, ms [95% CI]	Production Holm-adjusted p
Dofetilide	22/22	61.96 [55.05, 69.33]	62.28 [53.64, 72.44]	4.42×10^{-13}
Quinidine	21/21	66.86 [60.60, 73.52]	78.37 [70.41, 86.34]	4.08×10^{-14}
Ranolazine	22/22	5.78 [2.35, 9.20]	7.39 [3.73, 11.20]	0.0078
Verapamil	22/22	-0.48 [-5.12 , 4.26]	3.42 [-0.50 , 7.15]	0.846

Table note: Participant-level mean double differences; percentile 95% bootstrap intervals. Source-reference QTcF uses annotated QT and the corresponding recording RR. Source-reference and production participant sets may differ. Published concentration-response or peak-effect estimates are different estimands and are not treated as exact 2-h numerical targets. In the production prior-treatment sensitivity restricted to periods 2-5, the ranolazine estimate was 5.79 ms (cluster-robust 95% CI, -0.42 to 12.00 ms); recovery was therefore not uniform across all design sensitivities.

Secondary family and boundary-definition sensitivity

Table S6b-2 summarizes the prespecified secondary family and the distinction between measurement routes.

Table S6b-2. Four drug contrasts for each endpoint, with correction over the complete 16-contrast family separately by measurement route.

Endpoint	Unit	Production route	Source-annotation route	Multiplicity correction
Spatial area QRS-T angle	Degrees	Production boundaries and origin	Annotated boundaries, fixed pre-P baseline	Benjamini-Hochberg over the complete family
Tpeak-Tend	ms	Production T peak and offset	Annotated T peak and offset	Benjamini-Hochberg over the complete family
QRS duration	ms	Production QRS onset and offset	Annotated QRS onset and offset	Benjamini-Hochberg over the complete family
Normalized Fréchet coupling	Dimensionless	Production delineation	Unavailable because T onset is absent; retained with $p = 1$	Benjamini-Hochberg over the complete family

The secondary family comprises area angle, Tpeak-Tend, QRS duration and normalized Fréchet for each of the four drugs. Correction is across all 16 contrasts separately by measurement route, including unavailable contrasts with $p = 1$. Source normalized Fréchet is unavailable without annotated T onset; this is non-estimability, not a null effect. No simultaneous secondary-family success or independent validation is claimed.

With the public median-beat signals and baseline fixed, we shifted one of QRS onset, QRS offset or T end by ± 5 , ± 10 or ± 20 ms while holding the remaining boundaries constant. Invalid orderings were excluded. Participant summaries and uncertainty were distinguished from descriptive recording-level quantiles. Moving QRS offset changed the area angle while leaving the complete QRST integral unchanged. This is a definition-sensitivity control, distinct from the separate association-model perturbation study; it does not represent a biological exposure effect or establish test-retest reliability.

Table S6b-3. Complete prespecified secondary family at 2 h: four drugs by four markers, reported for both routes. $\Delta\Delta$ is participant-averaged treatment change minus placebo change; intervals are 95% participant-bootstrap intervals. BH correction includes all 16 contrasts separately by route, including unavailable source Fréchet tests assigned $p=1$. Angle is in degrees; Tpeak-Tend and QRS duration in ms; normalized Fréchet is dimensionless. Nominal intervals need not agree with BH-adjusted significance.

Measurement route	Drug	Marker	Participants	$\Delta\Delta$ [95% CI]	BH16 q
production	Dofetilide	spatial_qrs_t_angle_mean	22	-1.286 [-3.406; 0.800]	0.455
production	Dofetilide	tpeak_tend_ms	22	25.121 [21.061; 29.667]	3.88e-09
production	Dofetilide	qrs_duration	22	3.182 [1.152; 5.242]	0.0249
production	Dofetilide	qrs_t_normalized_discrete_frechet	22	0.019 [-0.050; 0.107]	0.795
production	Quinidine	spatial_qrs_t_angle_mean	21	6.641 [0.835; 14.889]	0.207
production	Quinidine	tpeak_tend_ms	21	31.698 [21.460; 43.779]	0.000248
production	Quinidine	qrs_duration	21	4.000 [1.937; 6.032]	0.00561
production	Quinidine	qrs_t_normalized_discrete_frechet	21	0.114 [0.003; 0.242]	0.207
production	Ranolazine	spatial_qrs_t_angle_mean	22	1.466 [-2.081; 4.746]	0.605
production	Ranolazine	tpeak_tend_ms	22	3.288 [1.667; 5.015]	0.00561
production	Ranolazine	qrs_duration	22	0.636 [-1.091; 2.515]	0.664
production	Ranolazine	qrs_t_normalized_discrete_frechet	22	0.020 [-0.021; 0.057]	0.546
production	Verapamil	spatial_qrs_t_angle_mean	22	2.490 [-1.023; 5.921]	0.372
production	Verapamil	tpeak_tend_ms	22	-0.455 [-2.788; 1.939]	0.813
production	Verapamil	qrs_duration	22	0.212 [-1.303; 1.697]	0.823
production	Verapamil	qrs_t_normalized_discrete_frechet	22	0.004 [-0.032; 0.043]	0.823

Measurement route	Drug	Marker	Participants	$\Delta\Delta$ [95% CI]	BH16 q
source	Dofetilide	spatial_qrs_t_angle_mean	22	-2.819 [-4.221; -1.358]	0.00373
source	Dofetilide	tpeak_tend_ms	22	27.697 [22.303; 33.621]	1.28e-07
source	Dofetilide	qrs_duration	22	-0.379 [-2.470; 1.697]	1
source	Dofetilide	qrs_t_normalized_discrete_frechet	0	not estimable [not estimable; not estimable]	1
source	Quinidine	spatial_qrs_t_angle_mean	21	5.270 [1.384; 10.234]	0.0845
source	Quinidine	tpeak_tend_ms	21	47.349 [35.825; 60.905]	4.56e-06
source	Quinidine	qrs_duration	21	0.190 [-1.905; 2.381]	1
source	Quinidine	qrs_t_normalized_discrete_frechet	0	not estimable [not estimable; not estimable]	1
source	Ranolazine	spatial_qrs_t_angle_mean	22	1.220 [-0.118; 2.455]	0.168
source	Ranolazine	tpeak_tend_ms	22	5.750 [3.970; 7.727]	3.3e-05
source	Ranolazine	qrs_duration	22	-0.030 [-2.045; 1.697]	1
source	Ranolazine	qrs_t_normalized_discrete_frechet	0	not estimable [not estimable; not estimable]	1
source	Verapamil	spatial_qrs_t_angle_mean	22	2.541 [0.852; 4.611]	0.0478
source	Verapamil	tpeak_tend_ms	22	4.053 [2.500; 5.636]	0.000334
source	Verapamil	qrs_duration	22	-0.242 [-2.485; 2.242]	1
source	Verapamil	qrs_t_normalized_discrete_frechet	0	not estimable [not estimable; not estimable]	1

Production area angle did not show a supported response to dofetilide (-1.286° [-3.406, 0.800], $q=0.455$) or quinidine ($+6.641^\circ$ [0.835, 14.889], $q=0.207$). Normalized Fréchet likewise did not show a supported dofetilide or quinidine response ($q=0.795/0.207$). Tpeak-Tend responded to dofetilide, quinidine and ranolazine, and QRS duration to dofetilide and quinidine. Source-route Tpeak-Tend also increased with verapamil ($+4.053$ ms, $q=0.000334$), whereas the production estimate was -0.455 ms ($q=0.813$). With 21-22 participants, absence of a supported response is not evidence of absence. Source Fréchet was unavailable because T onset was missing; it is not a zero response.

S6b-4. Post hoc route differences of the treatment effects

Different significance of a treatment effect on two measurement routes does not prove that the routes differ. For each drug and marker we therefore estimated, per participant, the difference D

= double difference (production route) minus double difference (source-annotation route) at 2 h, using the participants with both values (all 22, or 21 for quinidine). Intervals are 95% percentile intervals of the mean D from 10,000 participant resamples; a paired-t interval is given as a sensitivity analysis. The means formed from the participant values reproduced Tables S6b-1 and S6b-3. Multiplicity: Holm over the four QTcF contrasts and Benjamini-Hochberg over the 16 secondary contrasts (non-estimable source Fréchet contrasts set to $p = 1$); q values below are from the paired-t test, the more cautious reading at 21-22 participants. The analysis is exploratory.

Table S6b-5. Route difference D (production minus source), ms except area angle (degrees). r : correlation of the participant values between routes; q : adjusted p value from the paired-t test.

Marker	Drug	Participants	$\Delta\Delta$ production	$\Delta\Delta$ source	D [95% bootstrap interval]	Paired-t interval	r	q
QTcF	Dofetilide	22	61.96	62.28	-0.32 [-5.30, 3.75]	[-5.34, 4.70]	0.89	0.896
QTcF	Quinidine	21	66.86	78.37	-11.51 [-16.63, -6.47]	[-17.07, -5.94]	0.77	0.00134
QTcF	Ranolazine	22	5.78	7.39	-1.61 [-3.99, 0.60]	[-4.05, 0.83]	0.81	0.368
QTcF	Verapamil	22	-0.48	3.42	-3.90 [-7.95, -0.33]	[-8.08, 0.28]	0.60	0.198
Area angle	Dofetilide	22	-1.29	-2.82	1.53 [-0.02, 2.82]	[-0.02, 3.08]	0.74	0.14
Area angle	Quinidine	21	6.64	5.27	1.37 [-2.21, 5.40]	[-2.77, 5.51]	0.88	0.995
Area angle	Ranolazine	22	1.47	1.22	0.25 [-2.83, 3.04]	[-2.87, 3.36]	0.56	1
Area angle	Verapamil	22	2.49	2.54	-0.05 [-2.91, 2.69]	[-3.08, 2.98]	0.60	1
Tpeak-Tend	Dofetilide	22	25.12	27.70	-2.58 [-6.14, 0.65]	[-6.27, 1.12]	0.81	0.37
Tpeak-Tend	Quinidine	21	31.70	47.35	-15.65 [-20.65, -10.92]	[-20.98, -10.32]	0.92	8.87e-05
Tpeak-Tend	Ranolazine	22	3.29	5.75	-2.46 [-3.92, -0.98]	[-4.08, -0.85]	0.65	0.0247
Tpeak-Tend	Verapamil	22	-0.45	4.05	-4.51 [-6.84, -2.39]	[-6.95, -2.07]	0.39	0.00761
QRS duration	Dofetilide	22	3.18	-0.38	3.56 [0.89, 6.26]	[0.64, 6.49]	0.15	0.062
QRS duration	Quinidine	21	4.00	0.19	3.81 [1.29, 6.52]	[0.95, 6.67]	0.23	0.0462
QRS duration	Ranolazine	22	0.64	-0.03	0.67 [-1.80, 3.21]	[-2.09, 3.43]	0.03	1
QRS duration	Verapamil	22	0.21	-0.24	0.45 [-2.26, 3.02]	[-2.41, 3.32]	0.09	1

The four normalized-Fréchet contrasts are not estimable on the source route (no annotated T on-set). Of the 16 estimable contrasts, 7 had a bootstrap interval for D that excluded zero (6 with the paired-t interval); with the paired-t tests, 4 contrasts had $q < 0.05$ (Tpeak-Tend under quinidine, verapamil and ranolazine, and QRS duration under quinidine). The largest differences were Tpeak-Tend under quinidine (−15.65 ms) and QTcF under quinidine (−11.51 ms). Production QRS duration rose under dofetilide and quinidine by +3 to +4 ms, whereas the annotated route did not; participant values of the two routes were almost uncorrelated for QRS duration (r 0.03-0.23). The sampling rates differ (production 500 Hz, annotations 1,000 Hz), which can explain part of the low correlation but not the direction of the difference. The routes can thus disagree in a treatment-dependent way, but the analysis does not show which route is closer to the true effect, because they differ in boundary definition, origin and baseline and, for QTcF, in the RR used (beatwise versus recording RR). It supports no claim of treatment-dependent measurement bias of the production route. Limits: 21-22 participants, 20 formed contrasts (16 estimable), intervals at small samples tend to be narrow, and the drugs share the placebo condition.

S7. Survival audit only

The historical audit identified 15 index-definition exceptions, of which two subsequently rejected raw conclusions leave 13 active exceptions. Pooled hazard-ratio fitting is not test-partition confirmation; raw-marker C is not a paired increment over a clinical base. Historical horizon-AUC outputs were unavailable for all 16 fits, reflecting their observation and control definitions rather than a zero discrimination value. The historical robust-inference restriction covers robust standard errors, p values and the affected global q families, and it restricts the relevant curve intervals until the reference is corrected. Descriptive point estimates do not repair PH, nonlinearity, censoring or individual time and reference criteria. For future AF prognosis, a pre-event sinus index and verified definition of incident events and observation periods are needed. This supplement reports audit limits, no new survival effect or prognostic validity.

S8. Reporting, literature search and release criteria

Completed documentary GRRAS, STROBE and RECORD item locators are in S8c, with remaining gaps disclosed. Versions/licenses are in Data availability, demographics in S5b and author-screen details in section 2.5/S3a. The article-input audit reproduced core estimates and confirmed person-disjoint development partitions. No checklist mention is a conformity certificate. Figures use aggregate results; no fabricated patient points or examples are included.

The inherited orienting prior search used PubMed and Europe PMC plus forward and backward Europe-PMC citation chains on 9 October 2026. No assertion of systematic-review completeness or priority is made. Representative exact prior queries were:

1. (vectorcardiogra*[Title/Abstract] OR "QRS-T angle"[Title/Abstract] OR "global electrical heterogeneity"[Title/Abstract]) AND (short-interval reproducibility OR reproducibility OR reliability OR "serial

electrocardiograms"), PubMed relevance, maxResults 30; no extra filters, 240 results/30 returned.

- The complete inherited ledger (PubMed and Europe PMC, with search terms, limits, hit counts and review coverage) follows as a table; the counts are reproduced from the dated search protocol.

ID	Block	Database	Search term	Limits	Date	Found / re-turned	Review coverage
S01	Metadata retrieval	PubMed	vectorcardiography AND reproducibility	max results 5; summary count 5	9 Oct 2026	607 / 5	Orienting search; no complete abstract review
S02	repeat	PubMed	(vectorcardiogra*[Title/Abstract] OR "QRS-T angle"[Title/Abstract] OR "global electrical heterogeneity"[Title/Abstract]) AND (short-interval reproducibility OR reproducibility OR reliability OR "serial electrocardiograms")	max results 30; summary count 30	9 Oct 2026	240 / 30	Orienting search; no complete abstract review
S03	repeat	Europe PMC	(vectorcardiography OR "QRS-T angle" OR "global electrical heterogeneity") AND (short-interval reproducibility OR reproducibility OR reliability OR "serial electrocardiograms")	page size 50; result type core	9 Oct 2026	475 / 50	Orienting search; no complete abstract review
S04	transform	PubMed	(Kors OR Dower) AND (agreement OR comparison OR transformation OR reproducibility)	max results 30; summary count 30	9 Oct 2026	197 / 30	Orienting search; no complete abstract review
S05	transform	Europe PMC	(Kors OR Dower) AND (agreement OR comparison OR transformation OR reproducibility)	page size 50; result type core	9 Oct 2026	3,723 / 50	Orienting search; no complete abstract review
S06	artifact	PubMed	(electrocardiogra* OR vectorcardiogra*) AND ("biomarker catalogue" OR "biomarker catalog" OR "measurement artifact" OR "sampling rate" OR "signal length" OR "positive control")	max results 30; summary count 30	9 Oct 2026	466 / 30	Orienting search; no complete abstract review
S07	artifact	Europe PMC	(electrocardiography OR vectorcardiography) AND ("biomarker catalogue" OR "biomarker catalog" OR "measurement artifact" OR "sampling rate" OR "signal length" OR "positive control")	page size 50; result type core	9 Oct 2026	5,513 / 50	Orienting search; no complete abstract review
S08	frank	PubMed	Frank AND (Kors OR Dower OR "reconstructed vectorcardiogram")	max results 30; summary count 30	9 Oct 2026	23 / 23	Orienting search; no complete abstract review
S09	frank	Europe PMC	Frank AND (Kors OR Dower OR "reconstructed vectorcardiogram")	page size 50; result type core	9 Oct 2026	506 / 50	Orienting search; no complete abstract review
S10	repeat_refined	PubMed	("global electrical heterogeneity"[Title/Abstract] OR "QRS-T angle"[Title/Abstract] OR vectorcardiography[Title/Abstract]) AND (reproducibility[Title/Abstract] OR short-interval reproducibility[Title/Abstract])	max results 60; summary count 50	9 Oct 2026	16 / 16	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S11	repeat_refined	Europe PMC	(TITLE_ABS:"global electrical heterogeneity" OR TITLE_ABS:"QRS-T angle" OR TITLE_ABS:vectorcardiography) AND (TITLE_ABS:reproducibility OR TITLE_ABS:short-interval reproducibility)	page size 100; result type lite	9 Oct 2026	15 / 15	Titles used for candidate selection; selected abstracts recorded in the inclusion list

ID	Block	Database	Search term	Limits	Date	Found / re-turned	Review coverage
S12	catalog	PubMed	(electrocardiogra*[Title/Abstract] OR vectorcardiogra*[Title/Abstract]) AND (catalog*[Title/Abstract] OR "high-throughput"[Title/Abstract] OR "large-scale"[Title/Abstract]) AND (reliability[Title/Abstract] OR short-interval reproducibility[Title/Abstract] OR validity[Title/Abstract] OR transformation[Title/Abstract])	max results 60; summary count 50	9 Oct 2026	30 / 30	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S13	catalog	Europe PMC	(TITLE_ABS:electrocardiography OR TITLE_ABS:vectorcardiography OR TITLE_ABS:ECG) AND (TITLE_ABS:catalog* OR TITLE_ABS:"high-throughput" OR TITLE_ABS:"large-scale") AND (TITLE_ABS:reliability OR TITLE_ABS:short-interval reproducibility OR TITLE_ABS:validity OR TITLE_ABS:transformation)	page size 100; result type lite	9 Oct 2026	38 / 38	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S14	control	PubMed	(electrocardiogra*[Title/Abstract] OR vectorcardiogra*[Title/Abstract] OR "QT interval"[Title/Abstract]) AND ("positive control"[Title/Abstract] OR "sampling frequency"[Title/Abstract] OR "sampling rate"[Title/Abstract] OR "signal length"[Title/Abstract])	max results 60; summary count 50	9 Oct 2026	422 / 60	Orienting search; no complete abstract review
S15	control	Europe PMC	(TITLE_ABS:electrocardiography OR TITLE_ABS:vectorcardiography OR TITLE_ABS:"QT interval") AND (TITLE_ABS:"positive control" OR TITLE_ABS:"sampling frequency" OR TITLE_ABS:"sampling rate" OR TITLE_ABS:"signal length")	page size 100; result type lite	9 Oct 2026	166 / 100	Orienting search; no complete abstract review
S16	transform_refined	PubMed	(Kors[Title/Abstract] OR Dower[Title/Abstract]) AND (vectorcardiogra*[Title/Abstract] OR "QRS-T"[Title/Abstract])	max results 60; summary count 50	9 Oct 2026	51 / 51	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S17	transform_refined	Europe PMC	(TITLE_ABS:Kors OR TITLE_ABS:Dower) AND (TITLE_ABS:vectorcardiogra* OR TITLE_ABS:"QRS-T")	page size 100; result type lite	9 Oct 2026	50 / 50	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S18	Metadata retrieval	PubMed	Retrieval of PMIDs 34626835, 32296724, 36457310, 20417936, 2292255, 35769406, 38113771, 17970961, 20570744, 41639151, 42508298, 9279288, 21130355, 18064739, 26440803	metadata retrieval	see note	15 / 15	All returned abstracts and metadata checked
S19	artifact_targeted	PubMed	(electrocardiogram[Title/Abstract] OR ECG[Title/Abstract] OR vectorcardiogra*[Title/Abstract]) AND ("measurement error"[Title/Abstract] OR "signal length"[Title/Abstract] OR "sampling frequency"[Title/Abstract] OR "sampling rate"[Title/Abstract]) AND (morphology[Title/Abstract] OR bi-omarker*[Title/Abstract] OR complexity[Title/Abstract])	max results 50; summary count 50; date range 1900 to 2026/10/09	9 Oct 2026	37 / 37	Titles used for candidate selection; selected abstracts recorded in the inclusion list

ID	Block	Database	Search term	Limits	Date	Found / re-turned	Review coverage
S20	arti-fact_targeted	Europe PMC	((TITLE_ABS:electrocardiogram OR TITLE_ABS:ECG OR TITLE_ABS:vectorcardiogra*) AND (TITLE_ABS:"measurement error" OR TITLE_ABS:"signal length" OR TITLE_ABS:"sampling frequency" OR TITLE_ABS:"sampling rate") AND (TITLE_ABS:morphology OR TITLE_ABS:biomarker* OR TITLE_ABS:complexity)) AND FIRST_PDATE:[1900-01-01 TO 2026-10-09]	page size 100; result type lite	9 Oct 2026	37 / 37	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S21	negative	PubMed	(vectorcardiogra*[Title/Abstract] OR "QRS-T angle"[Title/Abstract]) AND (limitation*[Title/Abstract] OR "no association"[Title/Abstract] OR "not predictive"[Title/Abstract] OR error*[Title/Abstract] OR correction[Title])	max results 50; summary count 50; date range 1900 to 2026/10/09	9 Oct 2026	96 / 50	Orienting search; no complete abstract review
S22	negative	Europe PMC	((TITLE_ABS:vectorcardiogra* OR TITLE_ABS:"QRS-T angle") AND (TITLE_ABS:limitation* OR TITLE_ABS:"no association" OR TITLE_ABS:"not predictive" OR TITLE_ABS:error* OR TITLE:correction)) AND FIRST_PDATE:[1900-01-01 TO 2026-10-09]	page size 100; result type lite	9 Oct 2026	331 / 100	Orienting search; no complete abstract review
S23	guideline	PubMed	(electrocardiogra*[Title/Abstract] OR vectorcardiogra*[Title/Abstract]) AND (standardization[Title/Abstract] OR "scientific statement"[Title/Abstract]) AND (technology[Title/Abstract] OR "QT interval"[Title/Abstract])	max results 50; summary count 50; date range 1900 to 2026/10/09	9 Oct 2026	27 / 27	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S24	guideline	Europe PMC	((TITLE_ABS:electrocardiogra* OR TITLE_ABS:vectorcardiogra*) AND (TITLE_ABS:standardization OR TITLE_ABS:"scientific statement") AND (TITLE_ABS:technology OR TITLE_ABS:"QT interval")) AND FIRST_PDATE:[1900-01-01 TO 2026-10-09]	page size 100; result type lite	9 Oct 2026	29 / 29	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S25	ai	PubMed	(ECG[Title/Abstract] OR electrocardiogra*[Title/Abstract]) AND ("deep learning"[Title/Abstract]) AND ("interval measurement"[Title/Abstract] OR "QT interval estimation"[Title/Abstract])	max results 50; summary count 50; date range 1900 to 2026/10/09	9 Oct 2026	2 / 2	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S26	ai	Europe PMC	((TITLE_ABS:ECG OR TITLE_ABS:electrocardiogra*) AND TITLE_ABS:"deep learning" AND (TITLE_ABS:"interval measurement" OR TITLE_ABS:"QT interval estimation")) AND FIRST_PDATE:[1900-01-01 TO 2026-10-09]	page size 100; result type lite	9 Oct 2026	4 / 4	Titles used for candidate selection; selected abstracts recorded in the inclusion list
S27	Metadata retrieval	PubMed	Retrieval of PMIDs 33537064, 31539628, 24792985, 27597390, 31336798, 26826894, 41561151, 41105678, 40224254, 17349896, 19281931, 41140122, 3241148, 21704219, 25900820	metadata retrieval	see note	15 / 15	All returned abstracts and metadata checked

Note: All searches were run on 9 October 2026 (text above). The two PMID retrievals (S18, S27) carry no separate date in the retained search ledger. Counts are as in the dated search protocol; PMIDs are printed without thousands separators.

Reference identities were refetched from PubMed (PMID 2292255 among them) and publisher pages on 10 October 2026; the identity of the book chapter (Macfarlane 2010) was checked on the

publisher's DOI page and against the printed pages of the book. Manufacturer prescribing information supplies monitored-initiation context. Abstract checking is distinct from full-text checking; correction-page evidence remains inherited.

The subsequent supplementary analysis documented the fixed $>105^\circ$ stress-test before calculation. Its prior source check covered Young (Young *et al* 2021) metadata and abstract and full-text sections 2.4-2.6; the distinction between peak-and-mean and area-window definitions remains unresolved for clinical transport. No new literature conclusion or source-validation judgment is introduced here.

S8a. Result-specific bias checks audit positions

Codes: E = restricted to the stated conclusion; O = open; V = violated for the expressly disallowed interpretation; N = not applicable to pure bookkeeping without a clinical-effect comparison. Detailed evidence remains in the cited audit reports. A code is not a passed scientific criterion.

Supplementary table 040, part 1.

Row	Result	Definition coupling	Selection	Data-derived criteria	F4	F5
1	section 3.1/S5 flow	E	E	N	N	O
2	section 3.2 short-interval reproducibility	E	E	E	E	E
3	section 3.3 transforms	E	E	E	E	E
4	section 3.4 P boundaries	E	E	E	E	E
5	section 3.4 rotation	E	E	E	E	E
6	section 3.5 Frank	E	E	E	E	E
7	Subgroups/S3	E	E	E	E	E
8	S4 (supplement only) repairs	E	E	E	O	E
9	S4 (supplement only) generalists	E	E	E	E	E
10	S4 (supplement only) search keys	E	E	N	E	E
11	section 3.6 QT	E	E	E	E	O
12	section 3.6 claimed signed Digitalis shape	V	E	E	E	O
13	section 3.6 flags	E	E	E	E	E
14	S7 Survival	O	E	O	O	O

Supplementary table 040, part 2.

Row	F6	F7	F8	Consequence
1	N	E	E	Only local disjoint counts; selection and historical losses remain
2	E	E	E	Shared definitions, proxy state and dependent markers; no clinical suitability pass
3	E	E	E	Same ECG, enriched sample, technical rules, availability and pilot limitations
4	O	O	E	Technical adjudication is no independent clinical reference or normal limit
5	O	E	O	Header-normal T point criterion failed; shared boundaries/polarity open; no clinical direction transport
6	E	E	O	Shared fiducials/population restriction; original polarity unresolved
7	E	E	O	Missing verified device/era; no confirmatory interaction
8	O	E	E	Post-hoc variants, simultaneous family and strongest held comparator unresolved
9	O	E	E	Incomplete adjusted domains; no specificity proof
10	N	E	E	Actual key bookkeeping, no effective independent-test count or new FDR pass
11	E	E	O	Partial train control; supported pairs, timing and confounding limit interpretation
12	O	E	V	Signed specificity is disallowed; technical polarity counterexample remains valid
13	E	E	E	Computation/evaluability does not establish verification
14	O	O	O	Audit-only, no publishable robust prognosis inference

S8b. Supplementary restrictions on interpretation

Supplementary table 041, part 1.

Row	Supplementary result	Definition coupling	Selection	Data-derived criteria	F4	F5
1	T3c class uncertainty	N	E	E	E	E
2	T3d threshold stress	N	E	E	E	E
3	T2b paired contrasts	N	E	E	E	E
4	T4c availability	N	E	E	E	E
5	Z/ stress	N	E	E	E	E
6	No-boundary-fusion subset	N	E	E	E	E
7	S1a release specifications	E	E	E	E	E

Supplementary table 041, part 2.

Row	F6	F7	F8	Consequence
1	E	N	E	Fixed selected catalog; technical rules, variable denominators; no clinical interchangeability
2	E	N	E	Definition transport unresolved; no disease reference or diagnostic performance
3	E	E	E	Common-marker/person sensitivity retains proxy/time selection and pair weighting
4	E	O	E	Short/medium and additional P onset not adjudicated; strict onset upper bound 100.00%
5	E	E	E	Fixed origin/limits, right-sagittal view, measured-Frank polarity unresolved
6	O	E	E	Remaining Kors origin and absent blinded medical reference
7	O	O	E	Device labels and automatic routes are working definitions; no diagnostic rule adopted

S8c. Completed documentary reporting locators

These paraphrased item-location tables update the reporting-guideline mapping of an earlier draft to the present manuscript. They disclose gaps rather than certify compliance. Section and table locators refer to this version of the manuscript; final typeset page/line locators depend on the publication layout. These tables do not assert full conformity.

GRRAS item	Content	Location / restriction
1	Design	Title; Abstract; section 2.1
2	Measurement	section 2.2-section 2.5/S1/S2g; executable dictionary release subject to author
3	Target population	section 2.1/section 3.1/S5
4	Raters	section 2.5/S3a; one author, no independent rater sample
5	Prior knowledge	Introduction/section 4.1-section 4.3
6	Sample/size	section 2.1/section 2.3-section 2.7/S3a/S5; available artifacts, no invented power
7	Selection	S5a/S3a; preimport losses unknown
8	Process/blinding	section 2.2-section 2.7/S3a; visible lines and imperfect source blindness
9	Independence	section 2.3-section 2.5; common fiducials and repeated persons
10	Statistics	section 2.3-section 2.4/section 2.8/S2g/S3; bootstrap/native units
11	Units analyzed	Tables 1-7/S2g/S3/S5
12	Characteristics	section 2.8/S5b/S3e; recorded-sex/age strata
13	Estimates/uncertainty	Tables 1-7/S2g/S3/S3a/S3b; LoA are spread
14	Practical meaning	Discussion/clinical box; no certification
15	Details	Supplement/Data S2; public code author decision

STROBE item/subitems	Location and disposition
1a/b	Title; balanced Abstract; test-partition criterion outcomes in section 3.7 and S13
2	Introduction: background
3	Introduction/section 2.1: objectives and fixed replication
4	section 2.1: design
5	section 2.1: source versions/center through citation; local acquisition period/import coverage unresolved
6a/b	section 2.1/section 2.3-section 2.7/S5a: eligibility and support standardization, not case-control matching
7	section 2.2-section 2.7/S1: variables and unknown states
8	section 2.2-section 2.7/S3b: measurement and shared-fiducial restrictions
9	section 2.5/Discussion/Limitations/S8a: bias
10	section 2.1/section 2.3-section 2.7: available size, technical criteria; no retrospective power
11	section 2.3-section 2.7/S2g/S3: categories, units, bounded/periodic measures
12a	section 2.3-section 2.8/S6/S6a: statistics, incomplete routine-care adjustment
12b	section 2.8/S3e: descriptive subgroups, no adjusted interactions
12c	section 2.1/section 2.8/S3a/S3b: informative missingness, no imputation
12d	section 2.3/section 2.5: cluster/weighted sampling; no main-audit outcome follow-up
12e	S2g/S3/S3a/S3b/S6: sensitivities
13a/b/c	section 3.1/S5a/S5b: flow, losses, diagram; preimport losses unknown
14a/b/c	S5b/S3a: characteristics/missingness; complete covariate missingness unavailable; survival only S7
15	Tables 1-7: measurement outcomes
16a/b/c	Results/section 2.3-section 2.7: estimates and categories; no absolute-risk claim
17	S2-S7/S12: supplementary analyses and unfavorable results
18	Discussion: main results
19	Limitations/section 4.2-section 4.3: bias direction and uncertainty
20	Discussion: cautious interpretation
21	section 4.3/section 4.4: generalizability, selected populations and one Frank source
22	Funding: author self-funding

RECORD item	Location and disposition
1.1	section 2.1: routine database names/types
1.2	section 2.1: source center by citation; acquisition period not locally established
1.3	section 2.1: ECG/clinical linkage
6.1	section 2.1/section 2.3-section 2.7/S1/S5a: selection rules
6.2	section 2.5/section 3.6: technical audit, not clinical selection validation
6.3	S5a: linkage flow, incomplete public-to-local coverage
7.1	section 2.2-section 2.7/S1: algorithms; public executable dictionary decision outstanding
12.1	section 2.1/Ethics: access scope and replication
12.2	section 2.1/section 2.8/S5: cleaning, QC and missing states
12.3	section 2.1/S5: subject-study/split/time/cardinality joins; historical binding limits
13.1	section 3.1/S5a: quality/availability losses and selection
19.1	section 4.3/Limitations: routine-data misclassification, confounding, missingness and timing
22.1	Data/Code availability/Data S2: access and release status

S9. Reporting disposition

Main tables report the provenance of the core findings (Table 1), key measures and catalog medians (Table 2), PTB-XL repeat variation (Table 3), matrix classes (Table 4), LUDB boundary errors (Table 5) and randomized QTcF controls with route differences (Table 6). The normal-report P audit is in S3a, rotation classes in S2a-2, Frank agreement in S2a to S2e and the flow in S5a. Complete T2b is in S3; T3c and T3d in S2f; T4c in S3a; all 16 T6 repairs in S4 and all T8 drug and control rows in S6. No result row was dropped for a favorable summary. Supplementary source tables retain exact identities and technical limitations. Sotalol validation is descriptive because it has only 10 exposed persons and remains unresolved for QTcF; QTcB reverses sign. The manufacturer warning page is routine-care context, not a numerical effect target; a dated full prescribing-information version was not used.

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S10. Documentary traceability

Methods section 2.1-section 2.8, Results section 3.1-section 3.7 and Discussion section 4.1-section 4.5 provide current locators. Measurement definitions are in S1; agreement and variation in S2/S3; reference matching in S3b; routine-care context in S6. Historical component identities and exact source bindings remain in a separate table linking numerical statements to their sources; identifiers imply no confirmatory status.

S10a. Additional method and flow details

Source versions and historical generator identity

The provider describes MIMIC-IV-ECG 1.0 as derived from MIMIC-IV 2.2 (Gow *et al* 2023); linked clinical data here used MIMIC-IV 3.1. The local source versions were MIMIC-IV 3.1, MIMIC-IV-ECG 1.0, PTB Diagnostic ECG Database 1.0.0 and PTB-XL 1.0.3. The MIMIC source is identified by its database citations and BIDMC research-resource approval. The available local documentary audit did not establish the ECG acquisition period or public-to-local import coverage. The database documentation (Gow *et al* 2023) describes BIDMC acquisition in 2008-2019, devices from various manufacturers including Burdick/Spacelabs, Philips and General Electric, and 10-s, 500-Hz, 12-lead waveforms; these are database characteristics and should not be read as a measured device distribution for the analyzed subsets. For the analyzed ECGs, neither the acquisition period nor the device manufacturer was established from the local metadata, and deidentified years are not acquisition eras. Current hashes bind the inspected state but do not establish the identity of every historical raw signal or feature generator. The historical repeatability implementation changed hash without an archived transition diff; the current repeatability implementation behind the current core estimates remains byte-identical, and independent aggregation reproduced those estimates.

Calculation state of each main analysis

Analysis	Calculation basis	Open provenance limit
All analyses	LoopLens 10.1, release of 7 October 2026, as the measurement software (the MIMIC-IV-ECG runs used a runtime snapshot that differs from the release folder in seven files of later analysis stages, in association, phenome and broad-adjustment code; the code for signal processing, delineation, reconstruction, marker calculation and feature extraction is identical, as recorded by the feature-code hash of the extraction run); analysis scripts per row below	Analysis scripts and the frozen LoopLens release used for this study (PolyForm Noncommercial 1.0.0) are available at https://github.com/leoprobst/ecg-auswertung-code (release v1.0.0), in line with clause 8 of the PhysioNet Credentialed Health Data License 1.5.0; aggregate results are provided in the Supplementary Material. Further development of LoopLens remains private.
Repeat variation (main Table 2, S3)	Current repeatability implementation, byte-identical to the one behind the current core estimates; a separately written aggregation reproduced them	The historical implementation changed without an archived transition record; historical generator identity incompletely documented
Matrix comparison (main Table 4, S2f)	Current aggregation reproduced the core class counts of the historical set (26 of the 29 circular markers inside it, three among the identical outputs)	Historical generator identity incompletely documented
LUDB boundary errors (main Table 5)	A bound-release rerun reproduced all 14,631 landmark rows exactly	The exact historical runtime copy is inaccessible
Delineator-input check (S2h)	Criterion fixed and hashed before the first delineation; the Kors variant reproduced the stored values (all evaluable ECGs; all 8,110 stored LUDB rows); production release unchanged	None beyond the above

Analysis	Calculation basis	Open provenance limit
Public QT controls (main Table 6, S6b)	Production software per fixed specification; source measurements as a separate route	Prior awareness of results disclosed
Test-partition replication (S13)	Protocol fixed on 12 October 2026 before the test marker values were inspected	Historical generator provenance of the P cache and binary execution identity incompletely documented
Analyses added after the first draft (S2i, S3g, S6b-4, S12a-1, S13e, S14)	Scripts and specifications written and fixed (hashed) before the run; tested on synthetic data with known answers; checked by reproduction of the stored main results to numerical precision; development data only (S13e additionally read gap, rhythm class and QRS class of the test pairs, logged)	Post hoc; scripts in the public release (Code availability in the main text), hash values available on request
PTB-XL repeat variation (S14)	Script fixed before the run; the two measurement chains were compared in source code beforehand	The chains differ in loading, line filter, quality exclusion and P suppression

Analysis scripts and the frozen LoopLens release used for this study (PolyForm Noncommercial 1.0.0) are available at <https://github.com/leoprobst/ecg-auswertung-code> (release v1.0.0), in line with clause 8 of the PhysioNet Credentialed Health Data License 1.5.0; aggregate results are provided in the Supplementary Material. Further development of LoopLens remains private.

Additional definition checks

Fixed development recordings (2,824 persons per fold) were compared with source definitions and synthetic counterexamples. These descriptive checks have no population intervals or medical adjudication. S1a-S1c distinguish production P fusion from lead-extreme duration, unrestricted spatial maximum from QRS maximum, and Q/QS/signed-ST definitions.

Matrix reproduction screening

The enriched fixed catalog sample used one ECG per person, with identical delineation and context under both matrices, that is, at shared, partly Kors-assisted fiducials (S2h). Reproduction screening required $\geq 99/100$ value-and-availability matches (rtol $1e-9$, atol 0); observed implementation discrepancies prohibited admission. Common abstention counts as agreement on availability, not as numerical reproduction. Later historical Kors discrepancies remain reported.

Repeatability sensitivities and redundancy

Original files, hashes and decoded physical signals were compared for equal-time pairs. Sensitivity analyses excluded equal-time pairs, kept one pair per person, or required quality ≥ 0.8 . Supplement S3 reports the current interval definition, numerical thresholds and compatible-marker/person contrasts. Additional descriptive analyses separate recorded-time, heart-rate, rhythm and header-normal strata. Family-specific RC distributions retain native units. Training-defined empirical redundancy components use $|\text{Spearman}| > 0.999$ on at least 100 common persons and one lexicographic representative per connected component; they are not complete-

linkage or algebraic-identity guarantees. Recorded-sex and age-stratified summaries are descriptive. For the unsigned area angle, empirical difference quantiles supplement normal-theory LoA.

Author-rated boundary screen

The normal-report reference was selected before signal or marker success; reports and header diagnoses do not establish clinical health. Historical cache strata were <120, 120-160 and >160 ms. The original coarse review is distinguished from a later protocol-based screen of 60 short, 60 medium and all 34 long cases. The author assessed randomized twelve-lead displays with hidden source labels, strata, durations and prior decisions; the proposed boundary lines remained visible, so their separation could be inferred. Thirty LUDB recordings and 16 repeated cases were interspersed. The MIMIC lines were documented release reconstructions whose durations matched the cache, without proof of identical historical absolute positions. No independent or specialist adjudicator is claimed.

Calibration of the coarse screen

The original visual protocol used ± 20 ms. After weak calibration, extreme and lead-median expert references were evaluated at both ± 20 and ± 40 ms without changing the ratings. The accepted interpretation is a coarse-error screen against lead-median boundaries at ± 40 ms, explicitly post hoc, not a precision reference. Stratum weights describe the fixed cache-available population; uncertainty and unassessable cases remain separate (S3a).

LUDB stored-output reference

LUDB version 1.0.1 contains 200 ten-second, twelve-lead recordings at 500 Hz (Kalyakulina *et al* 2020, 2021). It and QTDB had previously informed development, so neither is independent confirmation. The initial stored-output audit grouped expert waves in anchored 80-ms peak spans across ≥ 3 leads and used one-to-one QRS-peak matches within 80 ms. Extreme references used earliest onset/latest offset; lead medians were a post-hoc sensitivity. Timing errors retain missing boundaries and remain conditional on QRS matches. LUDB amplitudes are normalized per lead to a 1 mV range (S3b), so these errors describe that operating point.

LUDB complete-output matching

The specified production delineator was then rerun using fixed 50-Hz powerline preprocessing and Kors-derived delineation signal. All 14,631 archived final landmark rows were exactly reproduced. Complete predictions were independently matched within ± 150 ms, maximizing pair count then minimizing distance. P/T matching was independent of the earlier QRS assignment. Annotated-envelope and full-record markup domains are reported separately. Nominal intervals resample all 200 recordings in 1,000 draws (S3b). These global references differ from pooled per-lead benchmarks and supported production fusion.

Frank technical comparison

Simultaneously recorded PTB standard and Frank channels share filters, baseline and fiducials; the fiducials are partly Kors-assisted. Integral and peak modes and header groups are kept separate. The coefficient-only sensitivity changes Z/V4 from -0.063 to $+0.063$ while retaining other coefficients, original availability, limits and origin. Trapezoidal segment integrals ($\text{mV}\cdot\text{ms}$) differ from the catalog QRST-minus-QRS angle; projected direction areas use mV^2 . A hash-selected 50-person subset removed VCG boundary-fusion weight and XYZ input; 47 paired persons contributed. The origin region remained Kors-derived, so the reference is not fully independent or medically adjudicated.

Public-control aggregation and uncertainty

Triplicates were averaged within participant, period and nominal time. Changes from each treatment-period baseline were corrected by the same participant's time-matched placebo change. Confidence intervals used 10,000 participant bootstrap samples. Four primary tests were Holm-adjusted. The secondary family comprised four drugs by area angle, Tpeak-Tend, QRS duration and normalized Fréchet coupling, with Benjamini-Hochberg correction over all 16 contrasts separately for each measurement route. Unavailable contrasts remained in the family with $p = 1$. Participant and period effects, with participant-clustered small-sample intervals, were examined separately; prior-treatment sensitivity used periods 2-5. All other scheduled time points were reported descriptively.

Observed search-space denominator

The count covers observed marker $\times$ endpoint $\times$ panel keys, not their Cartesian product; fold rows are not independent hypotheses. Raw alias breadth, adjusted coverage, numerical evaluability and clinical verification remain distinct. Missing adjusted domains cannot establish specificity.

Sex and gender reporting details

We report age and sex as recorded for each analyzed population in Supplementary Table S5b. In MIMIC-IV, the field named gender contains administratively recorded sex; gender identity was not documented. External sex values were taken from PTB source records. We retained the populations selected for the measurement analyses and applied no additional selection by sex for this demographic report. Their composition follows from the eligibility criteria and data availability of each analysis; the reasons for observed sex imbalance were not established. Sex was included as a covariate in the calcium models (S6a). Family-specific reliability and native-unit RC distributions are provided separately by recorded sex and by age below versus at least 65 years, together with marker-level person-bootstrap intervals. These descriptive subgroup analyses do not test adjusted sex or age interactions. No adjusted sex or age interaction is claimed.

Development flow and reconstructed repeat sample

The development master contained 640,376 ECGs from 129,335 persons; selection yielded 640,204 ECGs from 129,259 persons and extraction 632,530 from 128,947. ECG losses were 172 selection exclusions, 6,049 QC exclusions and 1,625 lead-placement exclusions; the marker failures (fewer than 10) are not additional ECG exclusions. The development repeat-sample flow was reconstructed from successful extraction through the original temporal-neighbour, admission, setting, documented event, distinct-signal and quality rules. The final person and pair keys exactly matched the original repeat artifact. Historical public-to-local import losses preceding this branch remain unquantified.

Routine-care control-flag definitions

An evidence record is an internally assembled marker-endpoint evidence record. Endpoints are routine-care label constructs; repairs are 16 post-result implementation variants evaluated against their original comparators. The validation control panel labels a positive control recovered when the expected direction has $p \leq 0.01$ and a negative control false positive when $|AUC-0.5| \geq 0.05$. Its flag requires recovery of at least half of the positives and does not include negative-control failures; we report it descriptively. S4 retains the search, repair and alias bookkeeping.

Historical and later boundary-screen reconciliation

The historical labels resolve to more than 24 onset-error cases among 34, including fewer than 10 also labeled as an end error; primary categories had counted most of them as onset labels and fewer than 10 as end labels. The later screen found onset errors in more than 90% of assessable long cases (fewer than 10 long cases were unassessable), no errors among 60 short cases and fewer than 10 persons with any error among 60 medium cases. These screens use different definitions and cannot establish improvement over the old labels. The weighted frequency of onset-error judgments was approximately 4%, conditional on the fixed cache-available sample; this is a frequency of the author's own judgments, not an error prevalence, and it excludes systematic rater error. The author judged borderline deviations correct; objective calibration and limited precision are in S3a. Selection by the potentially erroneous P duration enriches the tail circularly and does not establish interatrial block (IAB; P wave ≥ 120 ms; Bejarano-Arosemena and Martínez-Sellés 2023) or a local normal limit.

Matrix ranking and interchangeability

On the common 5,648-record sample, area-angle rank correlation was 0.909, bias $+9.593^\circ$ and LoA -30.312° to $+49.498^\circ$; the $>105^\circ$ stress-test changed labels in 710/5,307 finite pairs (13.38%). Its clinical transport remains unresolved. Matrix LoA half-width was 0.484 of the overall repeat RC, which includes clinical change and comes from a different sample. Thus matrix disagreement and temporal variability are complementary quantities, not an instrument-noise decomposition.

The Kors/Kors boundary benchmark produced 295 stable outputs, showing that the rule can be passed but is strict. Cross-fitted conversion made 20 dependent outputs conditional and none stable; residual disagreement remains. The 217 nonconstant outputs identical at shared fiducials (historical count; 214 without the three circular markers) and one constant output are separate from spatial matrix dependence; identity at shared, partly Kors-assisted fiducials does not show independence from the matrix at the delineation step (S2h). Zero stable entries under this technical rule does not establish universal failure.

Public-control table interpretation and prior-treatment sensitivity

Table note: Participant-level mean double differences; percentile 95% bootstrap intervals. Source-reference QTcF uses annotated QT and the corresponding recording RR. Source-reference and production participant sets may differ. Published concentration-response or peak-effect estimates are different estimands and are not treated as exact 2-h numerical targets. In the production prior-treatment sensitivity restricted to periods 2-5, the ranolazine estimate was 5.79 ms (cluster-robust 95% CI, -0.42 to 12.00 ms); recovery was therefore not uniform across all design sensitivities.

Spatial-angle definitions and redundancy

The primary spatial angle uses origin-corrected QRS and J-to-T-end area vectors, whereas the Frank substudy also evaluates magnitude-peak vectors. Andršová *et al* (2022) study peak, area and weighted-integrative formulations; our area formulation is not identical to all three. Young *et al* (2021) report peak and mean formulations with modified boundaries and origins. Exact formula equivalence to Schreurs *et al* (2010) was not established. The complementary eigenvalue fractions $\lambda_1/\Sigma\lambda$ and $(\lambda_2+\lambda_3)/\Sigma\lambda$ sum to one, giving reversed nonconstant ranks ($\rho = -1$); this is algebraic redundancy. Empirical redundancy components were additionally identified in the fixed training sample; these are rank-based components, not a catalog-wide proof of algebraic formula identity (S3).

No-fusion Frank sensitivity

Removing Kors boundary-fusion assistance increased the Kors integral bias from +1.383° to +4.693° on the same 47 persons (50 selected); paired $\Delta +3.31^\circ$ [-4.19, 11.60]. The interval includes zero; the origin remains Kors-derived (S2f).

Uncertainty and resampling specifications

Primary reliability and compatible-marker contrasts use 1,000 person-bootstrap draws (seed 77010); class bootstraps use seeds 77010/77011 by fold. Supplement sections state the distinct historical and new resampling protocols. Pointwise percentile intervals are not simultaneous certification; missing estimates and unsupported controls remain unavailable.

Reporting guidance and remaining gaps

GRRAS, STROBE and RECORD guide reporting (Kottner *et al* 2011, von Elm *et al* 2007, Benchimol *et al* 2015). Age and recorded sex are given in S5b, rater information in section 2.5/S3a, and completed item-location reporting tables in S8c. These locators disclose remaining gaps and do not assert full reporting conformity. S8 documents exact literature queries and dates; identity checks neither validate thresholds nor prove novelty.

AI-assisted documentary workflow

The generative AI tools named in the declaration “Use of generative AI” supported local code development, analysis documentation, bibliographic checking, drafting, figures and structured internal critique. Patient-level computation ran locally. AI output does not supply independent adjudication, validation or author approval.

S12. Physiological expectations and complete component map

This exploratory map retains an exploratory development-only evidence level. It uses existing development-data aggregates, with no patient-level recalculation, new signal review or test-partition access for this component map. Both internal partitions were previously inspected. Split point estimates are not independent confirmation, and pooled nominal intervals are not held validation intervals. The external technical comparisons in this audit do not replicate the physiological components.

The seven examples were chosen after inspecting the results, and neither their frequency nor their nominal intervals can estimate the overall reliability of physiological theories. Component populations overlap, the historical family lacks simultaneous error control, and split consistency is not independent confirmation. The focused display is a communication choice and not a new confirmatory analysis plan.

S12a. Complete inventory and numerical interpretation

All 66 historical component identities are retained. Seven components were selected for the earlier illustrative display after inspecting the results; the earlier main-text display has been removed. This selection does not estimate a success rate. Values below are formatted from stored aggregates, not refitted. Full precision, inherited source binding, source recipe and definition links are in the archived component-provenance matrix. Nominal intervals are not simultaneous and generally pool previously inspected internal development partitions. Blank values remain unavailable. Source *n_units* and *n_subjects* retain their distinct meanings; they are not interchangeable and are not summed across components. T4/T11 etc. may count positives or cases separately from controls; original denominator fields remain in the matrix. Sentinel zeros for absent fits are not population counts.

Thesis / component	Prediction	Estimate [nominal interval]	Train / internal validation point estimate	Source <i>n_units</i> / <i>n_subjects</i> ; unit field	Source verdict	Reviewed interpretation
component 1 / T1 / a_qrs_amplitude_vs_weight	slope < 0	-0.009454 [-0.01234, -0.007026]	-0.00933 / -0.009854	5,613 / 5,307; pair	supported	nominal support
T1 / a_qrs_minus_p_vs_weight	slope = 0 (common factor)	0.0008338 [-0.003295, 0.005593]	0.0005901 / 0.001465	1,606 / 1,576; pair	undecided	undecided
component 3 / T1 / b_spatial_qrs_t_angle_deg_vs_weight	slope = 0 (scale-free)	-0.1366 [-0.4041, 0.1443]	-0.1487 / -0.1003	5,278 / 5,004; pair	undecided	undecided
T1 / b_svg_azimuth_vs_weight	slope = 0 (scale-free)	-0.2305 [-0.5972, 0.09644]	-0.2234 / -0.2473	5,323 / 5,045; pair	undecided	undecided
T1 / b_svg_elevation_vs_weight	slope = 0 (scale-free)	0.1083 [-0.1100, 0.3005]	0.1045 / 0.1219	5,323 / 5,045; pair	undecided	undecided
T1 / c_qrs_duration_vs_qrs_amplitude	slope > 0	-1.800 [-3.862, 0.3094]	-2.425 / -0.1013	5,613 / 5,307; pair	undecided	undecided
T1 / c_qt_vs_qrs_amplitude	slope > 0 (descriptive)	-2.174 [-9.181, 3.998]	-5.007 / 5.437	5,278 / 5,004; pair	undecided	undecided
T2 / i_r_peak_time_vs_wall	slope in 1.7-4 ms/mm (A) or ~0 (B)	-0.096 [-0.136, -0.057] (ordinary least squares; <i>r</i> -0.029; reliability-corrected -0.21 [-0.29, -0.12]); the earlier value -3.347 [-3.412, -3.277] is withdrawn (S12a-1)	-0.0976 / -0.0915	27,810 / 27,810; person	historical label withdrawn	mechanism A not supported; association practically null
T2 / ii_sex_difference_mediated_by_mass	share ≥ 0.8	0.3644 [0.3327, 0.3971]	0.3830 / 0.3162	27,798 / 27,798; person	refuted	operational counterdirection
T2 / iii_voltage_concentric_minus_eccentric	> 0	0.06293 [0.01279, 0.1099]	0.0542 / 0.0886	6,647 / 6,647; person	supported	nominal support

Thesis / component	Prediction	Estimate [nominal interval]	Train / internal validation point estimate	Source n_units / n_subjects; unit field	Source verdict	Reviewed interpretation
T3 / st_duration_vs_ica	< 0	-15.53 [-21.06, -10.31]	-15.68 / -15.10	6,397 / 6,397; person	supported	nominal support
T3 / tpe_vs_k	< 0	-0.1010 [-6.303, 0.01972]	-0.05983 / -5.547	about 6,200 / about 6,200; person	undecided	undecided
T3 / t_magnitude_vs_k	> 0	0.7494 [0.07977, 37.70]	0.5424 / 28.05	6,027 / 6,027; person	supported	nominal support
T3 / calci-um_specific_to_st	b_iCa,ST - b_iCa,Tpe > 0	0.05914 [0.0205, 0.07459]	0.05822 / 0.02776	about 6,200 / about 6,200; person	supported	nominal support
T3 / potassi-um_specific_to_tpe	b_K,Tpe - b_K,ST > 0	0.01256 [-0.008233, 0.1850]	0.005544 / 0.1647	about 6,200 / about 6,200; person	undecided	undecided
T4 / t_vector_magnitude_nonhemolytic_auc	aligned AUC > 0.5	0.5126 [0.5066, 0.5190]	0.5145 / 0.5070	9,281 / 96,548; person	supported	nominal support
T4 / t_vector_magnitude_nonhemolytic_minus_hemolytic	> 0	0.04073 [0.0282, 0.05419]	0.04369 / 0.03189	2,260 / 96,979; person	supported	nominal support
T4 / tpeak_tend_ms_nonhemolytic_auc	aligned AUC > 0.5	0.5801 [0.5742, 0.5865]	0.5827 / 0.5723	9,281 / 96,548; person	supported	nominal support
T4 / tpeak_tend_ms_nonhemolytic_minus_hemolytic	> 0	0.0621 [0.04948, 0.0752]	0.06416 / 0.05594	2,260 / 96,979; person	supported	nominal support
T5 / order	$K(T) < K(P) < K^*(QRS)$	0.2390 [not available, not available]	not available / not available	302,985 / 96,548; ECG	undecided	undecided
T6 / dofetilide_delta_j_tpeak_c_ms	> 0	22.20 [13.31, 30.53]	26.75 / 9.677	about 90 / about 90; pair	supported	nominal support
T6 / dofetilide_delta_tpeak_tend_ms	> 0	7.111 [1.578, 12.50]	5.419 / 12.63	about 80 / about 80; pair	supported	nominal support
T6 / so-talol_delta_j_tpeak_c_ms	> 0	9.311 [4.767, 14.40]	8.584 / 11.66	about 90 / about 90; pair	supported	nominal support
T6 / so-talol_delta_tpeak_tend_ms	> 0	2.568 [-1.631, 7.138]	0.9836 / 7.400	about 80 / about 80; pair	undecided	undecided
T6 / ranolazine_delta_j_tpeak_c_ms	≤ 0 (exploratory)	-2.523 [-8.891, 3.809]	-2.800 / -2.008	63 / 63; pair	undecided	undecided
T6 / mex-iline_delta_j_tpeak_c_ms	≤ 0 (exploratory)	not available [not available, not available]	not available / not available	0 / 0; source units; not evaluable	not evaluable	not estimable
T6 / dofetilide_delta_vs_potassium	slope < 0	-0.5031 [-22.66, 18.97]	-1.741 / 7.521	about 90 / about 90; pair	undecided	undecided
T6 / dofetilide_female_minus_male	> 0	-14.18 [-35.52, 6.099]	-1.269 / -40.93	about 90 / about 90; pair	undecided	undecided
T7 / relative_qt_interval_ms_per_degree_cooling	> 0	0.03214 [0.02222, 0.04256]	0.02904 / 0.04238	777 / 767; pair	supported	nominal support

Thesis / component	Prediction	Estimate [nominal interval]	Train / internal validation point estimate	Source n_units / n_subjects; unit field	Source verdict	Reviewed interpretation
T7 / relative_j_tpeak_c_ms_per_degree_cooling	> 0	0.03509 [0.01594, 0.05312]	0.02359 / 0.07433	777 / 767; pair	supported	nominal support
T7 / relative_qrs_duration_ms_per_degree_cooling	> 0	0.02774 [0.01095, 0.04677]	0.0359 / 0.0006408	777 / 767; pair	supported	nominal support
T7 / relative_pr_interval_ms_per_degree_cooling	> 0	0.04021 [-0.002772, 0.08458]	0.05254 / -0.01989	777 / 767; pair	undecided	undecided
T7 / qt_minus_qrs_sensitivity	QT - QRS > 0	0.0044 [-0.01524, 0.02094]	-0.00686 / 0.04174	777 / 767; pair	undecided	undecided
T7 / qrs_minus_pr_sensitivity	QRS - PR > 0	-0.01247 [-0.05898, 0.02835]	-0.01664 / -0.01925	777 / 767; pair	undecided	undecided
T7 / j_wave_below_35	> 0	-6.874 [-29.38, 14.53]	1.936 / -38.00	136 / 136; pair	undecided	measurement criterion violated
T8 / log_crp_coefficient	> 0	0.2468 [-0.2046, 0.7246]	0.2644 / 0.2037	4,256 / 4,256; person	refuted	undecided / source-expert disagreement
T8 / log_crp_by_male	> 0	1.775 [0.9228, 2.631]	1.653 / 2.294	4,256 / 4,256; person	supported	nominal support
T9 / rate_adjusted_quadratic	= 0 (no U)	0.9191 [0.7210, 1.119]	0.8941 / 0.9992	32,607 / 32,607; person	refuted	operational counterdirection
T9 / rate_adjusted_linear	> 0	1.101 [0.7450, 1.485]	1.039 / 1.283	32,607 / 32,607; person	supported	nominal support
T9 / ba-zett_quadratic	> 0 (U with Ba-zett)	1.045 [0.8000, 1.307]	1.075 / 0.9420	31,703 / 31,703; person	supported	nominal support
component 41 / T10 / median_R	< 1	2.036 [1.986, 2.081]	2.043 / 2.012	12,700 / 12,700; open	refuted	operational counterdirection
T10 / median_cosine	< 0	0.3462 [0.3016, 0.3820]	0.3457 / 0.3499	12,700 / 12,700; open	refuted	operational counterdirection
T10 / R_vs_coupling	Spearman < 0	0.4176 [0.4005, 0.4350]	0.4209 / 0.4087	11,948 / 11,948; open	refuted	operational counterdirection
T11 / pacing_angle_cases_minus_controls	< 0	27.72 [25.32, 30.33]	27.14 / 29.25	2,856 / 62,212; pair	refuted	operational counterdirection
T11 / pacing_angle_vs_days	slope > 0	0.5381 [0.2999, 0.7727]	0.5672 / 0.4709	2,856 / 1,961; pair	supported	nominal support
T11 / lbbb_angle_case_s_minus_controls	< 0	41.00 [39.33, 42.68]	40.77 / 41.71	3,273 / 61,096; pair	refuted	operational counterdirection
T12 / qt_night_minus_day	> 0	2.177 [1.279, 3.101]	1.808 / 3.174	4,174 / 3,867; pair	supported	nominal support
T13 / axis_modulation_vs_tidal_volume	Spearman > 0	-0.0140 [-0.0367, 0.0071]	-0.0137 / -0.0154	7,568 / 7,568; person	refuted	undecided / source-expert disagreement
T14 / apical_takotsubo_minus_lad	< 0	-2,686 [-5,532; 2,250]	-4,494 / 6,708	347 / 675; person	undecided	undecided
T14 / sah_closer_to_takotsubo	> 0	-2,686 [-5,562; 2,082]	-4,494 / 6,708	347 / 1,228; person	undecided	undecided

Thesis / component	Prediction	Estimate [nominal interval]	Train / internal validation point estimate	Source n_units / n_subjects; unit field	Source verdict	Reviewed interpretation
T15 / pr_segment_to_s_t_vector_angle_deg_pericarditis_minus_stemi	> 0	1.474 [-4.113, 7.019]	1.077 / 1.888	408 / 1,168; person	undecided	undecided
T15 / pr_segment_to_p_vector_ratio_pericarditis_minus_stemi	> 0	0.3716 [0.1791, 0.5735]	0.3331 / 0.4780	408 / 1,168; person	supported	nominal support
T16 / avr_projection_vs_mismatch	Spearman > 0	0.1020 [0.0898, 0.1137]	0.1044 / 0.0948	39,578 / 19,787; ECG	supported	nominal support
T17 / f_wave_vs_la_volume_index	Spearman < 0	-0.1409 [-0.1883, -0.0969]	-0.1317 / -0.1688	1,782 / 1,782; person	supported	nominal support
T18 / epinephrine_qt_effect	> 0	9.886 [3.258, 16.32]	12.56 / 1.312	(311+<10) / 311; pair	supported	nominal support
T18 / epinephrine_share_via_potassium	≥ 0.5	0.0005579 [-0.03309, 0.1248]	-0.0008524 / -0.8566	(311+<10) / 311; pair	undecided	nominal prediction-region exclusion / source undecided
T18 / norepinephrine_qt_effect	> 0	3.607 [0.8854, 6.127]	4.127 / 2.082	1,343 / 1,302; pair	supported	nominal support
T18 / phenylephrine_qt_effect	> 0	6.061 [3.178, 8.860]	5.722 / 7.044	1,012 / 999; pair	supported	nominal support
V1 / initial_force_directon_vs_q_waves	≥ 0.05 sensitivity over the standard at equal specificity	-0.08408 [-0.1420, -0.02408]	not available / not available	333 / 8,082; held positive reference units	refuted	operational counterdirection
V2 / t_loop_shape_vs_peaked_t	≥ 0.05 sensitivity over the standard at equal specificity	0.03805 [-0.002582, 0.07502]	not available / not available	1,130 / 23,419; held positive reference units	undecided	undecided
V2 / trigger_nonhemolytic_minus_hemolytic	not estimable control branch	not available [not available, not available]	not available / not available	0 / 0; source units; not evaluable	not evaluable	not estimable
V3 / vector_alternans_vs_device	≥ 0.05 sensitivity over the standard at equal specificity	0 [0, 0]	not available / not available	48 / 118; held positive reference units	undecided	degenerate band / no equivalence
V4 / abnormal_echo_vcg_abnormal_minus_normal	> 0	0.06992 [0.05355, 0.08412]	not available / not available	4,932 / 33,277; person	supported	availability criterion violated
V5 / delta_svg_vs_lvef_drop	Spearman < 0	0.0742 [-0.3027, 0.3945]	not available / not available	31 / 31; pair	undecided	undecided
V5 / delta_qrs_area_vs_lvef_drop	Spearman < 0	0.0742 [-0.2599, 0.3708]	not available / not available	31 / 31; pair	undecided	undecided
component 66 / V9 / terminal_p_loop_over_clinical	delta AUC > 0 on validation	0.0044 [0.0015, 0.0073]	not available / not available	8,185 / 8,185; person	supported	nominal support

Source verdicts are historical labels, translated without changing their meaning: supported, refuted, undecided and not evaluable. Other source labels retain their meaning. These labels are separate from reviewed interpretations; they do not confer independent confirmation. In particu-

lar, the respiratory component remains unresolved despite its source refutation, and the epinephrine attenuation region is nominally excluded while its source verdict remains undecided. No thesis-wide pass percentage is calculated.

S12a-1. Correction of the T2 (i) estimate

The stored T2 (i) value (-3.347 [-3.412 , -3.277] ms/mm; training -3.341 , validation -3.367 ; 27,810 persons) came from a Deming regression of z-standardized variables with an error ratio of 1. In that case the standardized slope is algebraically ± 1 and, after back-transformation, equals $\pm \text{SD}(Y)/\text{SD}(X)$ (here 6.528 ms divided by 1.950 mm = 3.347 ms/mm), whatever the strength of the association. The value therefore carries no information about the association and is withdrawn; the historical label “refuted / operational counterdirection” is withdrawn with it. A post hoc re-analysis in original units (same population and rules, development folds only, 10,000 person resamples) gave:

Estimator	Slope, ms/mm [95% interval]
Pearson r	-0.029 [-0.041 , -0.017]
Ordinary least squares, R-peak time on wall thickness	-0.096 [-0.136 , -0.057] (training -0.098 , validation -0.092)
Reliability-corrected least squares (division by wall-thickness reliability 0.462)	-0.21 [-0.29 , -0.12]
Deming, error ratio $7.02 \text{ ms}^2/\text{mm}^2$ from repeat measurements	-43.7 [-75.1 , -30.3] (not interpretable, see below)
Deming, error ratio four times larger	-0.16 [-0.23 , -0.09]

The error ratio was fixed before any slope was computed, from repeat measurements: V6 R-peak time in consecutive ECGs up to 24 h apart (15,886 pairs, error variance 14.36 ms^2) and posterior wall thickness in consecutive echocardiography reports up to 7 days apart (1,111 pairs, error variance 2.05 mm^2). Both are upper bounds because they contain true change. With a correlation near zero ($r = -0.029$) a Deming regression is not identified: its slope switches between the two ordinary-regression bounds according to the assumed error ratio, so its magnitude carries no information, whichever ratio is chosen. A sensitivity analysis without 40 persons with implausible values (R-peak time ≤ 20 ms or wall thickness ≥ 20 mm) gave an ordinary least-squares slope of -0.099 ms/mm ($r = -0.030$). The direction is reliably negative; the magnitude is practically null (-0.19 ms per SD of wall thickness, against an SD of R-peak time of 6.5 ms). Constant transmural conduction velocity (mechanism A, $1.7\text{--}4$ ms/mm) is not supported by any estimator. No other component of this module uses a Deming regression.

S12b. Measurement definitions and populations

The historical T components use nominal patient-cluster percentile intervals, with 1,000 requested resamples and seed 20,260,924 in the inherited implementation. Most pool the two internal partitions. These intervals were not independently rebuilt here. Finite-draw counts, model rank and conditioning, and pooled-dependence checks remain incompletely documented. The V components retain their separately implemented internal-validation contrasts. No new p-values are derived from interval endpoints. Numerical equality or a degenerate zero band does not establish equivalence.

Native interval outputs are times between fiducials of the fused delineation, which combines lead-based candidates with Kors-XYZ candidates (nominal weight 0.25). In the prespecified delineator-input check (S2h), QRS duration and QT interval were practically independent of the delineator's VCG input, whereas P-wave based markers depended on it, mainly through availability. Spatial quantities use inherited reconstructed XYZ signals. Formula, unit and segment remain distinct from the endpoint and model procedure. Historical code review does not certify every matrix, fiducial or version setting of the run. The measurement audits in S1a-S1c apply as interpretive limits and do not retrospectively correct these component models.

Component family	Implemented definition, population and interpretation limit
T1: Weight change and amplitude/geometry	Early/late recording pair within an admission; weight within ± 24 h, potassium within ± 6 h and $ \Delta K < 0.3$ mmol/L. Change in log spatial peak amplitudes versus weight change; circularly folded angular changes; QRS/QT timing changes versus change in log QRS. Weight is an edema proxy. Amplitude scaling and geometric invariance are separate statements.
T2: LV mass, activation timing and voltage	Archived thesis-test implementation; first ECG per person with TTE ≤ 30 d; pacing, LBBB, old MI and QRS ≥ 120 ms excluded. (i) V6 R-peak time versus posterior wall thickness: ordinary least squares in original units (ms/mm) with a reliability-corrected variant; the originally stored Deming regression after standardization with error ratio 1 equals $-\text{SD}(Y)/\text{SD}(X)$ and has been withdrawn (S12a-1). (ii) 1-adjusted sex coefficient/raw sex difference in QRS duration, dimensionless; this is coefficient attenuation, not causal mediation analysis. (iii) Concentric-eccentric Cornell voltage difference within LVMI tertiles; tertiles do not provide exact mass matching. Module/version identity is that of the specified development software and the specification dated 24 September 2026.
T3: Ion-specific repolarization components	First ECG per person; ionized calcium and whole-blood potassium at a common recorded sampling time within ± 1 h (50808/50822); OLS with both ions, HR/HR ² , age and sex, excluding LBBB/pacing. Native ST and Tpeak-Tend timings (ms) versus spatial T-peak amplitude (μV); specificity expressed as differences between absolute standardized coefficients.
T4: Hemolysis flag and potassium-associated morphology	First ECG per person/group, potassium within ± 6 h (50,971), normal group 3.5-5 mmol/L, high potassium > 5.5 with/without hemolysis_reported. Direction-oriented AUC: positive T amplitude, negative Tpe; AUC difference using a common normal control population. Individuals may belong to several groups. The hemolysis flag is not a gold standard for pseudohyperkalemia.

Component family	Implemented definition, population and interpretation limit
T5: Potassium change-point ordering	Archived thesis-test implementation; nonhemolytic potassium measurements within the specified ± 6 h window, P analysis excluding AF, pacing/LBBB excluded. For each marker, hinge/segmented regression on potassium with a change-point grid search from 4.5-8.0 mmol/L in 0.1 steps. Subject-weighted bootstrap with 1,000 draws, seed 20,260,924; the order result is the fraction of draws with $K(T) < K(P) < K^*(QRS)$. T, P and QRS do not necessarily use the same evaluable observations. 0.239 is not a posterior probability that a theory is correct.
T6: Drug-associated repolarization changes	First eMAR administration; ECG up to 48 h before and 2-72 h after. $J\text{-Tpeakc} = (T_{\text{peak}} - J) / RR_{\text{seconds}}^{0.58}$ (ms), with r_{offset} as the fallback for J; $T_{\text{pe}} = T_{\text{end}} - T_{\text{peak}}$. Representative fiducials with T availability/confidence. The nearest potassium measurement to the pre-ECG within ± 12 h is not necessarily before the dose. Observational before/after comparison.
T7: Cooling, intervals and J surrogate	Coldest ECG $< 36^\circ\text{C}$ and nearest normothermic ECG at $36\text{--}37.5^\circ\text{C}$ within the same admission; temperature within ± 1 h, adjusted for $\Delta HR / \Delta K$. Relative changes per $^\circ\text{C}$ are dimensionless fractions/ $^\circ\text{C}$, not ms/ $^\circ\text{C}$. J proxy: maximum vector magnitude from the last three QRS samples/first ST half minus baseline, $\times 1,000 \mu\text{V}$; not an adjudicated Osborn notch.
T8: Inflammation and sex interaction	J-Tpeakc versus logCRP: main model without interaction and a separate model with $\log\text{CRP} \times \text{male}$. Both $n = 4,256$; HR/HR^2 , age, potassium, temperature/missing flag, QT-drug flag and sex as contextual covariates. The main coefficient from model one is not the female reference coefficient from model two.
T9: Thyroid-associated curvature	First ECG/person, TSH within ± 7 days; amiodarone before ECG excluded. Raw $QT \sim \log\text{TSH} + \log\text{TSH}^2 + HR + HR^2 + \text{age} + \text{sex}$ versus Bazett $QTc \sim \log\text{TSH} + \log\text{TSH}^2 + \text{age} + \text{sex}$. Complete-case populations differ (32,607 versus 31,703); slopes are not interchangeable.
T10: Secondary morphology and gradient differences	Secondary and primary morphology clusters are compared within a recording. The first finite secondary-morphology recording per person contributes. $R = \ \Delta\text{SVG}\ / \ \Delta\text{QRS area}\ $, with $\Delta\text{SVG} = \Delta\text{QRS area} + \Delta\text{JT area}$, is dimensionless. This is not longitudinal change after a controlled activation perturbation; shared algebra, cluster selection and small denominators remain unresolved. The original denominator-unit field remains unresolved.
T11: Cardiac-memory operational contrasts	Archived thesis-test implementation; identifies the last abnormally activated ECG and first subsequent native ECG ≤ 30 d; angle between the T-area vector of the follow-up ECG and the QRS-area vector of the first. The specification requires controls with an interval matched within ± 2 d. The implementation groups intervals into bins at 0, 1, 3, 7, 14 and 30 d and compares controls in those bins: this is not identical ± 2 d pairing. Report states do not measure cumulative pacing duration/burden. The additional LBBB arm must be kept separate from the primary pacing specification. In addition, <code>_transition_pairs</code> selects follow-up states using <code>~positive</code> , not explicitly <code>state = negative</code> . An unknown follow-up state can therefore be treated as nonpositive in the function body; whether such cases occur in the run is unchecked.
T12: Night/day QT difference	One best day/night pair per admission, selected by minimum $ \Delta HR \leq 5/\text{min}$; night 0-5 h, day 10-17 h; identical QT-drug flag, without demonstrated identical dose/drug. Native QT difference, night minus day, in ms.

Component family	Implemented definition, population and interpretation limit
T13: Tidal volume and axis modulation	Archived thesis-test implementation; archived marker implementation (INVARIANT_VERSION 1.1.1). Maximum–minimum of angles between normalized beatwise mean QRS axes and the mean axis, at least six usable beats; degrees, unsigned. Run specification: first evaluable record per person, tidal volume item 224,685 within ± 1 h, 50–2000, at least two estimated respiratory cycles. No actual respiratory-phase synchronization; between-person correlation, not a within-person dose response.
T14: Takotsubo/LAD/SAH operational contrasts	Archived thesis-test implementation; archived marker implementation (1.0.0). Y component of the origin-corrected QRST-area vector, +Y inferior, $\mu\text{V}\cdot\text{ms}$. First ECG per admission, mutually exclusive ICD groups for Takotsubo/LAD-STEMI/SAH; median difference and difference between absolute SAH median distances. No direct anatomical mapping of the apex and no audited ST-direction component in the T14 branch.
T15: PR/P ratio and vector angle	Archived thesis-test implementation; archived marker implementation. $T_a = \text{PR mean} - \text{TP reference}$, angle $\arccos(T_a \cdot \text{ST} / (T_a \text{ST}))$ in degrees; $ T_a / P \text{ mean} $ dimensionless. XYZ segments, mean ST rather than ST integral; joint PR/P/ST measurability also required for the ratio. Pacing/LBBB excluded; pericarditis XOR MI proxy, first row per person and group.
T16: ST-aVR projection and mismatch index	Archived thesis-test implementation; archived marker implementation ST-XYZ integral in $\text{mV}\cdot\text{ms}$, scalar product with normalized $(-0.30, -0.23, -0.25)$. Index $\log(\text{HR_chart-systolic pressure} / (\text{Hb} \cdot \text{SpO}_2))$; Hb within ± 6 h, chart observations within ± 1 h. No first-ECG-per-person filter in the direct T16 branch; between-person/multiple ECGs, patient clustering required. The index is a proxy, not measured oxygen consumption or adjudicated type 2 MI.
T17: Atrial RMS/QRS ratio and LA size	Archived thesis-test implementation; archived marker implementation, <code>_atrial_rms</code> (1.2.0). $\sqrt{\text{mean}(\text{detrend}(\text{XYZ})^2)}$ in the T-end→next-QRS-onset window, mV; divided by <code>qrs_vector_magnitude</code> , dimensionless. First ECG with a device report of AF per person, TTE ≤ 30 d, LAVI in mL/m^2 . RMS of the detrended vector magnitude is not V1 FWA and does not directly measure fibrosis.
T18: Catecholamine-associated QT and attenuation ratio	Archived thesis-test implementation; archived interval-feature implementation. $\text{QT} = (\text{T end} - \text{QRS onset}) / \text{fs} \cdot 1,000$ ms, native timing. Temporally nearest on/off catecholamine pair per ICU stay, ΔQT intercept adjusted for ΔHR and ΔHR^2 ; potassium within ± 6 h, complete ΔK cases. Historical “mediation share” = $(\text{HR-adjusted intercept} - \text{intercept additionally adjusted for } \Delta\text{K}) / \text{first intercept}$, dimensionless; no identified causal mediation and no prescribed before→after chronology.

Component family	Implemented definition, population and interpretation limit
V1: Initial force versus Q waves	Archived thesis-test implementation; uses old_mi_icd as the positive reference; controls without old infarction/revascularization, first ECG/person, no pacing/LBBB. Initial 30-ms azimuth/elevation are converted to a unit vector. Control mean/covariance from training, pseudoinverse and Mahalanobis distance form the directional measure. Q waves and initial force are compared at equal specificity in training; the held internal sensitivity difference is evaluated in validation. The reference is not CMR-LGE evidence of scar. The specified minimum time of ECG ≥ 30 d after infarction is not explicitly filtered in the thesis_v1 function body; the upstream label definition must establish this condition. According to _criterion_result, n_units = 333 denotes held positive reference cases, not the total of 8,082 persons.
V2: T-loop score versus peaked-T heuristic	Archived thesis-test implementation; and the archived criterion and training-score functions. Three markers are oriented using the training case/control direction, z-standardized and summed. $t_loop_compactness = \pi\sqrt{(\lambda_1\lambda_2)}/\text{path length, mV}$ (archived compactness implementation); apex sharpness = 3-point curvature within ± 8 ms around the T peak, 1/mV (archived apex-sharpness implementation); $\max/\min = \sqrt{(\lambda_1/\max(\lambda_2, 1e-10))}$ of centered T-XYZ in μV , archived T-loop max/min-ratio implementation, dimensionless. Nonhemolytic potassium ≥ 6.5 versus 3.5-5.0; paced/LBBB excluded, first row per person/label. Training threshold at the specificity of the binary peaked-T heuristic, internal-validation sensitivity difference.
V3: Magnitude alternans versus device text	Archived thesis-test implementation; archived marker implementation Absolute difference between the mean beatwise maxima of $\ XYZ\ $ for even/odd beats, mV. At least 4 fully consecutive usable beats; incompatible rhythm leads to abstention. No vector-direction difference. Cases: ECG 0-1 calendar days before puncture; controls: effusion without documented puncture; device alternans = text contains alternans, training-fixed threshold/internal-validation contrast.
V4: VCG classification and echo composite	Archived thesis-test implementation; archived marker implementation ($\text{angle}/\ SVG\ $, degrees/ $\mu\text{V}\cdot\text{ms}$); archived marker implementation (mV). At least one marker outside stratified P2.5/P97.5 from reference stage 25, OR flag. Text contains normal ecg, without a validated complete normal-ECG assessment. First ECG per person with TTE ≤ 90 d; echo composite EF <50 /LVH flag/valvular disease $\geq$ moderate. Nonmeasurable values/missing boundaries do not trigger outside-range status in the code; unevaluable echo components may act as nonpositive.
V5: Anthracycline-associated ratios / later EF	Archived thesis-test implementation; archived marker implementation and origin-corrected integrals. SVG in $\mu\text{V}\cdot\text{ms}$, P peak in mV; SVG/P therefore has a scaled time unit and is not dimensionless; the implementation audit must verify the actual input units. QRS-area magnitude in $\text{mV}\cdot\text{ms}/\text{P}$ in $\text{mV}\rightarrow\text{ms}$. Each Δ is after-before, 30-365 d after first anthracycline administration. The endpoint in code is minimum subsequent EF <50 , a binary flag, not continuous EF decline relative to baseline. Last ECG before/first after per person; correlation of ratio change with the binary flag.

Component family	Implemented definition, population and interpretation limit
V9: Terminal P-loop addition to a clinical model	Archived thesis-test implementation; and the archived prognostic-result function. Training logistic regression+Standard Scaler, internal-validation Δ AUC with fixed models/patient bootstrap. Baseline age, male, heart_failure, classical_p_duration_ge_120 (binary, not continuous P duration); four added markers. Terminal force= $ \text{mean XYZ over final 20 ms of P} $ in mV (archived marker implementation); reversal = angle between sums of the first/last P-third steps in degrees, archived marker implementation (1.1.1); area fraction = absolute PCA sectors in final third/total, dimensionless:856-886; IAB score = P duration(ms) $\cdot$ max(0,-terminal Z-terminal Y), mV $\cdot$ ms, archived marker implementation/2339 ff. new_onset_af_1y label, first record per person; temporal label/follow-up validity remains open.

T15 has a documented post-outcome origin in the inherited source docstring; the dated specification does not establish outcome-blind inception.

For T1, the QRS-minus-P component compares nonidentical peak and mean amplitude summaries. For T13, tidal volume lacks synchronized respiratory phase, so a between-person near-null result does not establish within-person invariance. For T18, the potassium-adjustment ratio does not identify causal mediation; its training and internal-validation estimates differ markedly. Historical T3 and the later calcium model in S6a use different calcium types, intervals, timing and covariates and cannot be substituted for each other.

Recording-change controls for the within-person components remain subject to the requirement described in S6. A within-recording rest comparison does not replace state-stable pairs of different recordings with comparable gaps. Missing exposure estimates, degenerate alternans bands, the J-proxy measurement failure and incomplete-to-normal echo handling remain distinct from biological null findings. Component demographics and informative missingness remain incomplete. No diagnostic accuracy, treatment response or risk benefit is established.

S12c. Inherited analytic-pitfall statuses and dissent

All inherited statuses below are preserved in English. Within-person and between-person designs remain distinct. They are not newly adjudicated passes. Open or violated criteria restrict physiological interpretation even when estimates are finite.

Supplementary table 045, part 1.

Row	Thesis	Design	Review limit	Definition coupling	Selection	Data-derived criteria
1	T1	within-person	Nominal amplitude support; pure scaling and angle invariance undecided. Weight is an edema surrogate.	unresolved	unresolved	unresolved
2	T2	between-person	Mixed operational components. The standardized Deming slope was withdrawn (S12a-1); coefficient attenuation is not mediation.	unresolved	unresolved	unresolved
3	T3	between-person	Nominal component support; potassium specificity and unit/leverage/model stability remain open.	unresolved	unresolved	unresolved
4	T4	between-person	Nominal support with low absolute discrimination; hemolysis is not a verified pseudo-hyperkalemia reference.	unresolved	unresolved	unresolved
5	T5	between-person	Undecided ordering. Bootstrap fraction is neither a confidence interval nor a posterior probability; positive sinus population not established.	unresolved	unresolved	unresolved
6	T6	within-person	Nominal dofetilide and sotalol component support; exposure timing/confounding open. Mexiletine not estimable.	unresolved	unresolved	unresolved
7	T7	within-person	Duration components remain exploratory. The J surrogate has a violated measurement criterion and does not validate Osborn physiology.	unresolved	unresolved	unresolved

Row	Thesis	Design	Review limit	Definition coupling	Selection	Data-derived criteria
8	T8	between-person	Main coefficient undecided according to the methodological and clinical reviews despite source refutation; interaction from a different fit cannot be added to it.	unresolved	unresolved	unresolved
9	T9	between-person	Operational counterevidence to zero adjusted curvature; a positive quadratic term does not establish a universal U-shape.	unresolved	unresolved	unresolved
10	T10	intra-ECG / between-person summary	Operational counterdirection, not a general disproof of gradient invariance. Shared-vector algebra, denominator and cluster selection remain open.	unresolved	restricted	not applicable
11	T11	within-person transitions / between-person controls	Angle contrasts oppose the prediction; time slope supports its direction. Transition states and time-bin matching deviate from the specification.	unresolved	unresolved	unresolved
12	T12	within-person	Small nominal night/day mean difference; dose/drug stability and individual relevance not established.	unresolved	unresolved	unresolved
13	T13	between-person	Near-zero cross-sectional correlation; the methodological review notes interval inside a candidate region, the clinical review requires justified equivalence and valid respiratory measurement.	unresolved	unresolved	unresolved
14	T14	between-person	Both components undecided with changing fold direction. Body-axis projection and ICD groups do not establish anatomical localization.	unresolved	unresolved	unresolved

Row	Thesis	Design	Review limit	Definition coupling	Selection	Data-derived criteria
15	T15	between-person	Ratio nominally positive, angle undecided. Small P denominators/baseline open; marker docstring identifies post-outcome origin.	unresolved	unresolved	unresolved
16	T16	between-person	Weak positive surrogate association; no adjudicated demand-ischemia reference or causal oxygen mismatch.	unresolved	unresolved	unresolved
17	T17	between-person	Negative cross-sectional ratio association; numerator/denominator and window need audit, no individual fibrosis/remodeling claim.	unresolved	unresolved	unresolved
18	T18	within-person	QT components positive. Specified potassium attenuation region is nominally excluded; source verdict remains undecided, no causal mediation.	unresolved	unresolved	unresolved
19	V1	between-person	Operational sensitivity contrast negative; infarct age and held specificity equality unverified, no scar-diagnostic accuracy claim.	unresolved	unresolved	unresolved
20	V2	between-person	Minimum sensitivity gain unconfirmed; specificity equality open and hemolysis branch not estimable.	unresolved	unresolved	unresolved
21	V3	between-person	Degenerate zero band is not equivalence. Magnitude rather than directional alternans; procedure reference and discordance need audit.	unresolved	unresolved	unresolved

Row	Thesis	Design	Review limit	Definition coupling	Selection	Data-derived criteria
22	V4	between-person	Only raw implemented contrast describable. Unknown-to-normal handling violates availability criterion; biological added-value claim blocked.	unresolved	unresolved	unresolved
23	V5	within-person / subsequent EF threshold	Both components imprecise. Later EF below threshold is not individual EF decline; no anthracycline causality.	unresolved	unresolved	unresolved
24	V9	between-person	Small positive held contrast against binary P duration; strongest continuous comparator and time validity remain open.	unresolved	unresolved	unresolved

Supplementary table 045, part 2.

Row	Multiplicity	Availability	Comparator	Verification	Signal/report artifacts
1	unresolved	unresolved	unresolved	unresolved	unresolved
2	unresolved	unresolved	unresolved	unresolved	unresolved
3	unresolved	unresolved	unresolved	unresolved	unresolved
4	unresolved	unresolved	unresolved	unresolved	unresolved
5	unresolved	unresolved	unresolved	unresolved	unresolved
6	unresolved	unresolved	unresolved	unresolved	unresolved
7	unresolved	unresolved	unresolved	unresolved	violated
8	violated	unresolved	unresolved	unresolved	unresolved
9	unresolved	unresolved	unresolved	unresolved	unresolved
10	restricted	unresolved	unresolved	restricted	unresolved
11	unresolved	unresolved	unresolved	unresolved	unresolved
12	unresolved	unresolved	unresolved	unresolved	unresolved
13	unresolved	unresolved	unresolved	unresolved	unresolved
14	unresolved	unresolved	unresolved	unresolved	unresolved
15	unresolved	unresolved	unresolved	unresolved	unresolved
16	unresolved	unresolved	unresolved	unresolved	unresolved
17	unresolved	unresolved	unresolved	unresolved	unresolved
18	unresolved	unresolved	unresolved	unresolved	unresolved
19	unresolved	unresolved	unresolved	unresolved	unresolved
20	unresolved	unresolved	unresolved	unresolved	unresolved
21	unresolved	unresolved	unresolved	unresolved	unresolved
22	unresolved	violated	unresolved	unresolved	unresolved
23	unresolved	unresolved	unresolved	unresolved	unresolved
24	unresolved	unresolved	unresolved	unresolved	unresolved

F1 concerns mathematical or definitional coupling; F2 selection; F3 data-dependent operating points; F4 selection and multiplicity; F5 informative availability; F6 the comparison standard; F7 reference verification and analysis unit; F8 signal quality, delineation and device text. The meas-

urement audit does not automatically clear a component's unresolved criteria. Favorable and adverse estimates require the same scrutiny.

S12d. Documentary provenance and release limits

Method provenance	Integrated location	Scope
	S12 introduction/S12d	Exploratory documentary synthesis; no patient calculation or test access
	section 4.4; S12a	Complete assigned inventory and post-result illustrative selection
	section 4.4; S12b	Nominal pooled development intervals, not independent validation
	S1c-P; S12b/V9	P duration depends on lead and boundary rule; historical V9 unchanged
	S6a; S12b/T3	Calcium definitions distinguish ion type/time/interval/model
	S12b	Matrix technical classes do not certify thesis interchangeability
	S1a-S1c; S12b/V9	Automatic criteria/terminal-P names are working operational descriptors
	S12c	bias checks and dissent retained without new passes
	S12d	No physiological validation citation without applicable critical literature-review judgment
	S12a/S12b	Historical definitions translated; all component values and IDs retained

The historical separate-paper declaration and submission plan, source corrections and ethics packaging, and reference and word packaging are not transferred as assertions of this report. The declarations and references of the main article remain authoritative. Their original records stay in the archived component-provenance matrix. The separate-submission clause is superseded by integration; no new author approval or literature check is asserted.

The integrated map replaces the separate S1 manuscript plan. It imports no measurement-result tables from that manuscript and adds no new literature validation or clinical threshold. Historical unassigned V6-V8/V10 identifiers remain inventory outside the assigned 66 component identities; they are not silently recoded as absent or successful results.

Provenance item	Preserved source and scope
Component identities	Archived physiological-component provenance matrix: every original field is retained in the integrated provenance matrix, with the original source verdict separate from the expert interpretation
Displayed numbers	Archived physiological-component supplement, component rows, copied verbatim; the component values are retained in this supplement, without a current main-text numerical display
Definitions and dissent	Archived physiological-component supplement, definitions by evidence record and historical audit; the full historical measurement and analytic-pitfall audit remains the source
Analysis provenance and extraction recipe	The archived component source, evidence record, source-record and recipe fields bind each component to its historical file/row and extraction recipe; inherited source binding is retained, not recomputed against patient data
Historical code	archived development software, component implementation version = 1.0.0; definitions inherit the code audit rather than a new code inspection
P01a/P01b/P01c	Current documentary identity preserved; historical input/generator binding incomplete. Component display/row identity checked; no independent original-patient aggregate rebuild or individual recalculation
uncertainty criterion	Original component interval targets retained; finite-draw, model and pooled-dependence checks remain open
Selection history	Integration into the main measurement audit; seven original illustrations selected post-result; T15's documented post-outcome origin remains in the inherited definition audit
Portable publication package	Executable algorithms and analysis scripts are public (Code availability in the main text); historical component flow/demographics are incompletely documented, and a human release approval is separate from this report.

The historical category/boundary-label discrepancy was resolved by the independent original-label reconciliation: more than 24 onset-error cases among 34, fewer than 10 also with an end error. Primary categories counted most of them as onset labels and fewer than 10 as end labels (S3a-3).

S12e. Exploratory physiological illustrations

Directional association, invariance, prediction-region exclusion and non-estimability are different outcomes. Weight change was associated with attenuation of log spatial QRS peak magnitude: -0.009454 $[-0.012335, -0.007026]$ per kg in selected within-person pairs. This supports a direction,

while edema causality remains unresolved. The spatial QRS-T angle slope was -0.136577 $[-0.404053, 0.144345]$ $^{\circ}/\text{kg}$. Its interval contains zero, but angular invariance requires a justified equivalence region and valid measurement.

The median gradient-change ratio was 2.036341 $[1.986285, 2.080547]$, dimensionless, contrary to the specified region $R < 1$. Here $R = \|\Delta\text{SVG}\|/\|\Delta\text{QRS area}\|$ compares secondary and primary morphology within a recording. Shared-vector algebra, small denominators and morphology selection limit the physiological interpretation. This excludes the operational region nominally; it does not establish general physiological disproof. Missing estimates and degenerate bands likewise concern measurement and estimability, not biological absence.

The seven examples were chosen after inspecting the results, and neither their frequency nor their nominal intervals can estimate the overall reliability of physiological theories. Component populations overlap, the historical family lacks simultaneous error control, and split consistency is not independent confirmation. The focused display is a communication choice and not a new confirmatory analysis plan.

This exploratory synthesis retains an exploratory development-only evidence level. The intervals above are inherited nominal component intervals from development data; both internal partitions were previously inspected. We did not independently rebuild these intervals. Supplement S12 retains the complete component map, including unfavorable results and unresolved measurement definitions. No causal mediation or clinical utility is established.

S13. Fixed test-partition replication protocol

The protocol was fixed on 12 October 2026 before authorized replication access. The partition had been opened for unrelated exploratory research. Three previously computed matrix markers (svg_qrs_area_ratio, spatial_qrs_t_angle_deg, qrs_t_hausdorff_distance) are excluded from the primary question-blinded matrix criterion and reported separately. Temporal repeatability is a separate question; P-marker historical reuse has a separate provenance/blinding criterion.

Definitions, benchmarks, sampling, exclusions and conjunctive criteria cannot change after result inspection. Missing binding, non-estimability or insufficient valid resampling can cause non-assessment or stopping the analysis, not success. These margins are author-fixed technical replication criteria, not clinical equivalence limits. Development benchmarks are fixed; their uncertainty is not re-estimated in criterion intervals.

Criterion	All required conditions
Repeatability, all and proxy separately	≥ 90% development-estimable marker coverage; entire 95% person-bootstrap median-ICC CI within development median ±0.05; markerwise development/test ICC Spearman ≥ 0.80, lower 95% limit ≥ 0.75
Median-ICC bands	All [0.41669363, 0.51669363]; proxy [0.47475238, 0.57475238]
RC/bias, both populations	≥ 80% fixed positive-RC markers satisfy $0.80 \leq \text{test/development RC} \leq 1.25$; ≥ 80% fixed positive between-person-SD markers satisfy absolute bias difference/SD ≤ 0.25; missing values fail coverage
Matrix	≥ 90% estimability in fixed blinded development-class universe; exact class concordance ≥ 85%, lower 95% limit ≥ 80%; $\kappa \geq 0.60$, lower limit ≥ 0.50; entire 95% CI of full-universe dependence-fraction difference within ±0.05
P availability	≥ 1,000 selected persons; entire 95% person-bootstrap CI of test availability minus 932/1,500 within ±0.05; failures retained in denominator
Secondary P duration	≥ 500 finite cached durations; entire median CI within [94, 114] ms and P97.5 CI within [160.9, 200.9] ms

The displayed median-ICC bands use the development-only benchmarks rebased before test values under Amendment 1 (13 October 2026): 0.46669363 overall and 0.52475238 in the proxy, each ±0.05. The tolerance did not change. Historical development intervals in S3 describe the original 2,005-marker catalog; they are not relabelled as uncertainty intervals for these reduced-universe benchmarks.

An overall replication statement requires both repeatability populations and all their conditions, the complete matrix criterion and P-availability criterion, plus provenance/blinding validity. Secondary duration and pooled sensitivities cannot rescue a failed primary criterion. Success, non-replication, non-estimability and analysis stopped must be equally prominent. Family and redundancy summaries use development-defined groups.

S13a. Freeze, exclusions and source binding

The protocol was fixed on 12 October 2026; the recorded access authorization was at 20:30 UTC (coordination decision dated access authorization). Amendment 1 was fixed on 13 October before

any new test marker values, after development-only extraction equivalence failed for `beatwise_p_loop_axis_stability_deg` and `t_loop_to_qrs_loop_complexity_ratio`. Both remain visible as technically non-reproducible development markers rather than biological or statistical non-replications. The same selections, tolerances and seeds were retained, with no further result-dependent exclusion.

The repeatability universe was reduced from 2,005 to 2,003 markers; development-estimable denominators were 1,985 overall and 1,972 in the proxy. The fixed RC denominators were 1,985/1,972 and the bias denominators 1,986/1,978. After the two technical exclusions and the three pre-exposed matrix exclusions, the primary matrix universe was 2,000 markers, with 1,751 development-class markers. The three pre-exposed matrix markers (`svg_qrs_area_ratio`, `spatial_qrs_t_angle_deg` and `qrs_t_hausdorff_distance`) remained outside the primary blinded matrix criterion and in separate descriptive reporting; this restriction does not automatically exclude temporal-repeat measurements.

The current source versions, fixed specifications, extraction comparison and statistical adapter are documented in the internal table linking numerical statements to their sources. Hash binding establishes current identity, not every historical runtime. The complete person-disjointness check found no overlap between 129,335 development and 32,017 test persons; these are source-partition counts rather than substudy denominators. The development extraction comparison used 200 ECGs, $\text{rtol}=10^{-8}$ and $\text{atol}=0$, with fewer than 10 historical mismatches of unproven cause. P test values came from the fixed-release cache, while development P used historical values.

S13b. Selection, resampling and all criterion decisions

Repeat-pair candidates were fixed before extraction: 4,098 pairs from 2,647 persons, with adjacency before QC and gaps of 0-2 h inclusive. Removal of 201 pairs (identical decoded signals, fewer than 10 pairs, and subsequent QC failures) left 3,897 pairs from 2,549 persons; the proxy contained 1,174 pairs from 931 persons. There were no replacement pairs or persons. All 83 retained equal-time pairs had unequal nonmissing decoded-signal hashes. These checks do not demonstrate physiological stability.

Matrix comparison used the same preprocessing and fiducials (partly Kors-assisted; S2h) under Kors and inverse Dower, in fixed technical test halves of 2,587/2,619 persons. Positive pools were smaller than the intended 706 per half (469/501); they were not replenished. Both halves belong to the test partition. Primary full-universe classes were 216 identical at shared fiducials, 677 conditional, 1,074 transformation-dependent, 32 non-estimable and one constant-identical output. Class agreement is evaluated on the 1,751-marker development-class universe; the dependence fraction uses all 2,000 primary markers. These denominators must not be interchanged.

P used the newly extracted release cache for all 1,500 prespecified report-normal records, with no retrospective visual correction or clinical health adjudication. Availability was $921/1,500 = 0.614$

[0.5893, 0.6367], with 579 unavailable and no finite nonpositive durations. Availability failures stayed in the selection denominator; duration quantiles used the 921 finite durations.

All criterion intervals are pointwise 95% percentile intervals with linear interpolation, based on 1,000 shared person resamples and a prespecified requirement of at least 950 finite replicates. Every reported criterion interval had 1,000 valid replicates. W retains all pairs of each resampled person with common weights across markers and populations; point estimates remain pair-weighted while between-person SD is person-weighted. M resamples within the fixed technical halves, recalculating weighted average ranks and quintiles in every draw. P retains failures in the selected-person denominator. Development benchmarks are fixed, so these intervals do not include newly estimated development uncertainty. RC denotes 1.96 SD of differences; native dispersion and estimator uncertainty are distinct.

Element	Criterion	Estimate	95% interval	Numerator / fixed denominator	Required band or lower limit	Decision
Repeatability, overall	Coverage	0.997	n/a	1,979 / 1,985	≥ 0.9	met
Repeatability, overall	Median ICC	0.507	[0.4893, 0.5374]	n/a / 1,979	[0.4167, 0.5167]	not met
Repeatability, overall	Marker-wise rank correlation	0.9276	n/a	n/a / 1,979	≥ 0.8	met
Repeatability, overall	Rank correlation, interval criterion	0.8855	[0.8855, 0.9374]	n/a / 1,979	≥ 0.75	met
Repeatability, overall	RC-band share	0.8519	n/a	1,691 / 1,985	≥ 0.8	met
Repeatability, overall	Bias-band share	0.995	n/a	1,976 / 1,986	≥ 0.8	met
Repeatability, proxy	Coverage	0.9894	n/a	1,951 / 1,972	≥ 0.9	met
Repeatability, proxy	Median ICC	0.5586	[0.5447, 0.5827]	n/a / 1,951	[0.4748, 0.5748]	not met
Repeatability, proxy	Marker-wise rank correlation	0.9433	n/a	n/a / 1,951	≥ 0.8	met
Repeatability, proxy	Rank correlation, interval criterion	0.9174	[0.9174, 0.94]	n/a / 1,951	≥ 0.75	met
Repeatability, proxy	RC-band share	0.7967	n/a	1,571 / 1,972	≥ 0.8	not met
Repeatability, proxy	Bias-band share	0.9838	n/a	1,946 / 1,978	≥ 0.8	met
Matrix classes	Coverage	1	n/a	1,751 / 1,751	≥ 0.9	met
Matrix classes	Class agreement	0.9372	n/a	n/a / 1,751	≥ 0.85	met
Matrix classes	Class agreement, interval criterion	0.9178	[0.9178, 0.9446]	n/a / 1,751	≥ 0.8	met
Matrix classes	κ	0.8678	n/a	n/a / 1,751	≥ 0.6	met
Matrix classes	κ , interval criterion	0.8243	[0.8243, 0.8827]	n/a / 1,751	≥ 0.5	met
Matrix classes	Dependence-fraction drift	0.003	[0.0005, 0.031]	1,074 / 2,000	[-0.05, 0.05]	met
P availability	Selected persons	1,500	n/a	n/a / 1,500	$\geq 1,000$	met
P availability	Availability drift	-0.007333	[-0.032, 0.01535]	921 / 1,500	[-0.05, 0.05]	met
P duration, secondary	Finite durations	921	n/a	n/a / 1,500	≥ 500	met
P duration, secondary	Median, ms	102	[100, 104]	n/a / 921	[94, 114]	met
P duration, secondary	P97.5, ms	182	[166.4, 194]	n/a / 921	[160.9, 200.9]	met
Repeatability, overall	Conjunctive criterion	n/a	n/a	n/a / n/a	all component criteria	not met

Element	Criterion	Estimate	95% interval	Numerator / fixed denominator	Required band or lower limit	Decision
Repeatability, proxy	Conjunctive criterion	n/a	n/a	n/a / n/a	all component criteria	not met
Matrix classes	Conjunctive criterion	n/a	n/a	n/a / n/a	all component criteria	met
P availability	Conjunctive criterion	n/a	n/a	n/a / n/a	all component criteria	met
P duration, secondary	Conjunctive criterion	n/a	n/a	n/a / n/a	all component criteria	met

The displayed limits are rounded only for readability; all decisions use the unrounded fixed thresholds and estimates in the source CSV. Matrix classification and P availability replicated in a test partition. P duration met its separate secondary criterion: median 102 ms [100, 104] and P97.5 182 ms [166.4, 194], against development values 104 and 180.9 ms. W did not meet the prespecified repeatability replication criteria overall or in the proxy. The upper median-ICC limits (0.537/0.583) were above the fixed upper bands (0.51669363/0.57475238), with test ICCs higher than development; the proxy also failed the RC-band-share criterion (79.7% versus 80%). Coverage, rank correlation and bias criteria were met. Neither the direction of the ICC difference nor these component passes rescues the conjunctive W criteria.

S13c. Original-denominator sensitivity

The original denominators retained both development-equivalence failures as unavailable outputs. This was a fixed sensitivity, not a replacement criterion or rescue analysis.

Element	Original universe / class denominator	ICC interval	Coverage	RC-band share	Bias-band share	Criterion outcome
Repeatability, overall	2,005 / original fixed lists	[0.489, 0.537]	0.9960	0.8510	0.9940	not met
Repeatability, proxy	2,005 / original fixed lists	[0.545, 0.583]	0.9883	0.7958	0.9828	not met
Matrix classes	2,002 / 1,752	not applicable	0.9994	not applicable	not applicable	met

For M, original-denominator class agreement was 0.9366 [0.9172, 0.9441], κ 0.8667 [0.8233, 0.8817], and the dependence fraction 0.5365 versus 0.5340, with drift interval [0, 0.03047]. These sensitivity outcomes do not change the primary verdicts. The two technical exclusions and three pre-exposed matrix exclusions remain explicitly visible in the status rows of the aggregate source CSV.

S13d. Deviations, blinding limits and interpretation

The partition had been opened for unrelated research, so blinding is question-specific: when the specification was fixed, neither the author nor the coordinating AI-assisted workflow had seen test results for the repeatability, matrix or P-availability questions (three matrix markers computed earlier were excluded from the primary matrix criterion), test access was released once through a logged register entry, and the test statistics were computed by an AI-assisted analysis workflow following the fixed specification. No human analyst other than the author took part, so this is not analyst blinding. Historical F22 generator provenance and historical binary/ICU execution identity remain incompletely documented. The additional development check of the

weighted statistical adapter occurred after blind technical W extraction but before test statistics and result inspection; it is not described as a complete new runner check before every technical test access. Development aggregate point reproduction and the development-input development extraction comparison remain historical prechecks, not a new historical interval rerun.

An options-comparison stop before W signal access arose from an empty JSON list versus an empty Python tuple; canonicalization allowed a separately bound technical continuation without changing parameters or selections. The first manifest byte hash preceded its public register entry, a documented protocol deviation without measurement-result inspection. A synthetic rank test stopped before M extraction and any test statistic because integer weights truncated half-ranks; floating-point weights corrected that implementation error before the bound development comparison and test statistics. No criterion, seed or selection was adjusted to test results, and no second statistical fit was used.

The five technical decisions are Repeatability, overall not met, Repeatability, proxy not met, M met, P availability met and secondary P duration met. A fully blinded overall replication claim is unsupported, and no external or clinical validation follows. Informative availability, report-based selection, QC, segmentation and coordinate dependence remain limitations; no prevalence, diagnostic PPV or treatment threshold is established. The result-specific bias checks restrictions in S8a remain applicable.

S13e. Post hoc explanation of the repeatability criterion outcome

The repeatability criteria are unchanged. To explain the outcome we compared the test median ICC with the development benchmark, including the uncertainty of both, and compared the composition of the pairs. Aggregates of the replication and, from the test pair list, only the gap between recordings, the rhythm class and the QRS class (no marker values and no identifiers) were used; the access was logged. The benchmark and test medians refer to the 2,003-marker replication universe, which includes the circular markers (historical set); the matrix criteria were likewise fixed on the historical classification including them and were not recomputed without them.

The test median ICC (0.507, 95% interval 0.489 to 0.537) lay above, not below, the development benchmark (0.467); the difference was +0.040 (0.014 to 0.066, normal approximation with both uncertainties). The criterion failed because the upper interval limit exceeded the prespecified band (0.417 to 0.517), not because reproducibility was lower in the test partition. The test ICC was higher in 74% of the 1,979 jointly estimable markers. A one-way random-effects illustration (the recordings of a pair treated as exchangeable repeat measurements; within-person variance from RC, between-person variance from the reported ICC(A,1)) gave a similar between-person SD (median ratio 1.01) and a within-person SD about 3% smaller (0.97) in the test partition. It ignores systematic differences between the first and second recording and the pair weighting, its within-person component contains clinical change, and it is a model illustration, not an estimate of error or an explanation. A direct comparison of the between-person spread of the markers in the test

pairs was not made. Age, sex, device and directly observed spread should be considered in any later explanation of the ICC increase.

Table S13e-1. Composition of the pairs (development / test, %).

Variable	Categories
Gap between recordings	0-15 min 38.7 / 38.3; 15-60 min 31.2 / 30.8; 60-120 min 30.1 / 30.9
Rhythm class	Sinus 32.2 / 33.3; atrial fibrillation 13.8 / 14.2; other 21.9 / 21.6; changing 32.1 / 31.0
QRS class	Narrow 71.0 / 69.6; wide 18.3 / 18.8; changing 6.5 / 6.9; missing 4.1 / 4.7
Proxy-eligible pairs	29.3 / 30.1

Standardizing the development pairs to the test distribution of gap, rhythm and QRS class left the median ICC nearly unchanged (0.4663 [0.4593, 0.4782] versus 0.4667 unstandardized) under the examined analyses. Age, sex, device, the share of repeat persons and the between-person spread of the markers in the test pairs were not analyzed, so the reason for the higher test ICC is not established. A result in the favorable direction does not rescue a failed two-sided criterion.

S14. External repeat variation in PTB-XL pairs

This module reports repeat variation of the same markers in pairs of ECGs from the open PTB-XL database and compares it with the clinical pairs of the main analysis. It is a limited transport check of repeat variation, not an independent tool validation: LoopLens was used in development and calibration with PTB-XL, and repeatability is not accuracy. The specification (pair definition, markers, roles, band, interval construction, wording and sensitivities) was fixed before the repeat values were read; the comparison of the two measurement chains (below) was completed and fixed before any marker value was read.

S14a. Design. Pairs were two recordings of one person with a gap of at most 24 h (primary) or at most 168 h (sensitivity), excluding pairs that involve one of 40 recordings of an earlier pilot list (excluded from all analyses of this module) and pairs with identical decoded signals (none were found). The primary population had 312 pairs from 259 persons and included 12 pairs with pacemaker-flagged recordings (fewer than 10 persons); excluding them is the sensitivity of S14b. Table S14-1 therefore refers to a population that contains these pairs. The delineation-quality score of the main analysis is not available in this data; extraction success on both recordings replaced it. For each marker, R is the RC in PTB-XL divided by the RC in the clinical pairs of MIMIC-IV-ECG; the interval combines a person-cluster bootstrap in PTB-XL (2,000 draws) with a lognormal uncertainty of the MIMIC RC (median equal to the reported RC; $\sigma = [\ln(\text{upper}) - \ln(\text{lower})] / (2 \times 1.96)$ from its 95% bootstrap interval). Classes: concordant (whole interval within 0.80-1.25), lower (below), higher (above), undecided (interval overlaps a band edge); at least 100 persons were required for a class. Roles were set by a source-code comparison of the two chains: QRS duration, QTcF, QT, PR and the peak angle use the same code and were primary or secondary; the area angle differs in its availability rule and P duration in its cache and atrial-fibrillation handling, so

both are descriptive only. The chains also differ in loading and gap repair, line-filter handling (60 Hz with omission when the recorder notch is present versus 50 Hz), signal-quality exclusion and suppression of P waves in atrial fibrillation.

Table S14-1. Primary and secondary markers (R = RC PTB-XL / RC MIMIC; combined 95% interval).

Marker	Role	Pairs / persons	ICC (MIMIC)	Bias (MIMIC)	RC PTB-XL [95% interval]	RC MIMIC	R [combined interval]	Class
QRS duration (ms)	primary	312 / 259	0.888 (0.867)	0.57 (0.22)	21.06 [15.93, 27.03]	27.27	0.77 [0.58, 1.01]	undecided
QTcF (ms)	primary	267 / 223	0.595 (0.715)	1.15 (1.98)	60.86 [49.64, 72.10]	61.78	0.99 [0.80, 1.17]	undecided (band edge, S14c)
Area QRS-T angle (°)	descriptive	283 / 232	0.697 (0.617)	2.98 (0.13)	69.84 [61.02, 78.16]	82.41	0.85 [0.74, 0.95]	no class
P duration (ms)	descriptive	80 / 77	0.436 (0.492)	0.23 (0.29)	42.22 [27.96, 56.98]	47.84	0.88 [0.58, 1.20]	no class
PR interval (ms)	secondary	111 / 99	0.557 (0.559)	-1.80 (0.02)	59.71 [45.08, 74.05]	66.71	0.90 [0.67, 1.11]	not decidable (<100 persons)
QT interval (ms)	secondary	292 / 241	0.621 (0.781)	7.60 (8.01)	82.75 [69.24, 96.92]	76.85	1.08 [0.90, 1.26]	undecided
Peak QRS-T angle (°)	secondary	282 / 231	0.780 (0.642)	1.05 (-1.79)	70.49 [60.25, 80.76]	91.39	0.77 [0.66, 0.88]	undecided

The permitted statement for every undecided marker is that the interval of R overlaps the band edge, so that agreement is neither shown nor excluded. Amplitude and area markers (vector magnitudes, QRS area magnitude, spatial gradient, loop length) depend on the amplitude scale of each database and are described only (R between 0.45 and 1.19, with wide intervals). The between-person SD was smaller in PTB-XL than in MIMIC-IV-ECG for QTcF (31.3 versus 37.8 ms) and P duration (17.2 versus 20.6 ms) and almost equal for the area angle (41.6° versus 42.2°); the ICC depends on it.

S14b. Robustness and sensitivities. The classical QRS RC (21.06 ms) was carried by a few pairs: the robust RC was 11.62 ms (median of the difference 0.0 ms; 95th percentile of the absolute difference 18.9 ms). Without the 12 pairs with pacemaker-flagged recordings the classical RC fell to 17.84 ms and R to 0.65 [0.54, 0.77] (“lower”, sensitivity only). In the 168-h window (864 persons) QTcF (R 1.04 [0.91, 1.18]) and QT (1.07 [0.99, 1.15]) lay within the band, QRS duration (0.79 [0.66, 0.93]) and the peak angle (0.86 [0.79, 0.92]) did not. R for QRS duration was 0.90, 0.70 and 0.80, and for QTcF 0.93, 1.01 and 1.06, in the gap windows up to 2 h (77 persons), 2-24 h (191) and 24-168 h (682); there was no consistent trend and the intervals overlapped strongly. The QT RC grew with the heart-rate change between the ECGs (R 0.49, 1.03 and 1.56 for changes below 5, 5-15 and above 15 /min). Strata by sex, age and device group are descriptive; groups below 100 persons carry that caveat. None of these sensitivities changes a primary class, and they are not averaged.

S14c. Monte Carlo error at the QTcF band edge. The original class used 2,000 draws (seed 223010). Because the lower combined limit for QTcF (0.798) lay 0.002 below the band edge, the computation was repeated post hoc as ten independent runs of 2,000 draws (20,000 in total) with

criteria, band, data and estimators unchanged (run 0 reproduced the stored values of all 13 markers to a relative difference below $1e-9$). Monte Carlo error is the SD of the limits across independent runs, not the difference of two bootstrap halves.

Table S14-2. Combined interval of R in the original run and pooled over 20,000 draws.

Marker	Persons	R	Interval, original run	Interval, pooled	Between-run SD (lower / upper)	Monte Carlo SE of pooled limits (lower / upper)	Class: origi- nal run (retained) / pooled (not adopted)
QRS duration	259	0.772	0.578 to 1.014	0.578 to 0.997	0.0019 / 0.0086	0.0006 / 0.0027	undecided / undecided
QTcF	223	0.985	0.798 to 1.168	0.802 to 1.171	0.0067 / 0.0058	0.0021 / 0.0018	undecided / concordant
Area QRS-T angle	232	0.847	0.740 to 0.952	0.742 to 0.953	0.0028 / 0.0031	0.0009 / 0.0010	no class / no class
P duration	77	0.883	0.580 to 1.201	0.574 to 1.202	0.0064 / 0.0098	0.0020 / 0.0031	no class / no class
PR interval	99	0.895	0.672 to 1.111	0.669 to 1.105	0.0045 / 0.0057	0.0014 / 0.0018	not decidable / not decida- ble
QT interval	241	1.077	0.905 to 1.263	0.905 to 1.260	0.0034 / 0.0055	0.0011 / 0.0017	undecided / undecided
Peak QRS-T angle	231	0.771	0.658 to 0.882	0.654 to 0.882	0.0030 / 0.0018	0.0009 / 0.0006	undecided / undecided

For QTcF the pooled lower limit was 0.802 (Monte Carlo SE 0.002), five of ten runs lay below 0.80 and five above, and the upper limit was 1.171. The recomputation therefore yielded no robust class at this band edge: the margin is smaller than one Monte Carlo standard error and much smaller than the sampling uncertainty of 223 persons. Additional draws would reduce Monte Carlo error only; they were not run beyond 20,000. The original class (undecided) is retained and the recomputation is a supplement. For QRS duration, QT and the peak angle the classes did not change (upper limit for QT 1.26, 5.7 Monte Carlo standard errors above 1.25).

Table S14-3. Lognormal uncertainty of the MIMIC RC used in the combined interval.

Marker	RC MIMIC	95% bootstrap interval	σ	2.5th to 97.5th percentile of the fitted distribution
QRS duration	27.27	[25.86, 28.77]	0.0273	25.85 to 28.77
QTcF	61.78	[59.48, 63.99]	0.0186	59.57 to 64.08
Area QRS-T angle	82.41	[80.85, 83.91]	0.0095	80.89 to 83.95
P duration	47.84	[44.71, 50.97]	0.0334	44.81 to 51.08
PR interval	66.71	[64.07, 69.75]	0.0217	63.94 to 69.61
QT interval	76.85	[74.84, 78.77]	0.0130	74.91 to 78.84
Peak QRS-T angle	91.39	[89.58, 93.22]	0.0102	89.59 to 93.23

Because the MIMIC intervals are not exactly symmetric on the log scale, the percentiles of the fitted distribution lie within 1.3% of the reported limits for all 13 markers.

S14d. Identical pair sets for LoopLens and BRAVEHEART. BRAVEHEART was run on the same PTB-XL recordings; the values are the BRAVEHEART 1.8.2 outputs of the separate benchmark run (native PTB-XL arm, locked before the comparison). It was used in version 1.8.2 as the compiled Windows batch application with MATLAB Runtime R2022a (update 6), with its unchanged default

annotation settings (Kors transform, internal filters, median-beat annotation by its neural network, one median beat per recording); QRS duration and QT are median-beat values, and QTcF was derived from its QT and heart rate with the Fridericia formula. A first comparison used different pair sets for the two tools. As a post hoc sensitivity, repeatability was recomputed for both tools on exactly the same pairs for each marker (pairs up to 24 h, no pair that involves a recording of the pilot list, no identical signals, finite values from both tools on both recordings; pacemaker-flagged recordings were not excluded), with shared bootstrap weights (2,000 draws).

Table S14-4. Identical pair sets, nine markers measured by both tools. RC ratio = BRAVEHEART / LoopLens.

Marker	Pairs / persons	LoopLens: ICC; RC [95%]	BRAVEHEART: ICC; RC [95%]	RC ratio [95%]
QRS duration (ms)	296 / 246	0.891; 21.06 [15.66, 27.51]	0.876; 19.10 [13.13, 24.93]	0.91 [0.68, 1.24]
QTcF (ms)	257 / 215	0.611; 58.23 [46.41, 69.60]	0.499; 76.76 [55.95, 99.07]	1.32 [0.95, 1.82]
Area QRS-T angle (°)	275 / 226	0.701; 69.65 [61.10, 77.87]	0.848; 50.09 [39.60, 60.62]	0.72 [0.57, 0.88]
QT interval (ms)	280 / 231	0.667; 75.63 [64.89, 86.55]	0.633; 86.40 [72.61, 99.56]	1.14 [0.99, 1.35]
Peak QRS-T angle (°)	273 / 224	0.784; 70.03 [58.84, 79.86]	0.850; 60.38 [47.20, 71.72]	0.86 [0.68, 1.06]
QRS vector magnitude (mV)	290 / 240	0.906; 0.653 [0.389, 0.937]	0.899; 0.448 [0.352, 0.544]	0.69 [0.46, 1.03]
QRS area magnitude (mV·ms)	290 / 240	0.828; 35.34 [23.25, 50.56]	0.895; 27.44 [12.81, 43.30]	0.78 [0.50, 0.89]
Sum of absolute QRS-T integrals (mV·ms)	274 / 225	0.826; 91.85 [69.55, 117.01]	0.872; 75.85 [46.02, 109.54]	0.83 [0.61, 0.96]
QRS loop length (mV)	296 / 246	0.955; 1.347 [0.855, 1.913]	0.908; 0.985 [0.798, 1.167]	0.73 [0.49, 1.08]

On identical pairs the LoopLens values changed little from the primary column (QTcF RC 58.2 versus 60.9 ms, QT 75.6 versus 82.8 ms, QRS duration unchanged). The intervals of the RC ratio excluded 1 only for the area angle, the QRS area magnitude and the sum of absolute QRS-T integrals. These comparisons describe repeatability of two tools on the same recordings, not accuracy: no reference standard is available, the beat definitions differ (median beat versus fused beat), and LoopLens was used in its development and calibration with this database. BRAVEHEART does not define PR or P duration in PTB-XL.

S14e. Class changes at thresholds and P availability. For the area angle, the stress-test label changed between the two recordings in 24.7% [19.9, 29.9] of 283 pairs at >90°, 20.1% [15.6, 24.9] at >105° and 17.0% [12.5, 21.7] at >120° (κ 0.503, 0.589 and 0.628); P duration crossed 120 ms in 28.7% [19.1, 39.3] of 80 pairs. These are class changes between two recordings, not misclassification. P duration and PR are structurally incomplete (80 and 111 of 312 pairs with both values); in the primary recordings P duration was available in 43.6% of 574 recordings and was missing in 36.0% of the 114 recordings with a normal-report code and sinus rhythm, a comparison with the 37.9% of P

durations missing from the stored release output in the MIMIC report-selected sample that is descriptive because the references differ.

S14f. Limits. (1) 13 of 2,005 identifiers were covered; no catalog statement follows. (2) The gap is up to 24 h in PTB-XL versus 0-2 h in MIMIC-IV-ECG, there is no setting, procedure or infusion exclusion, the population differs, and the devices differ (Schiller 1989-1996 versus Burdick/Spacelabs, Philips and General Electric); these factors act together and cannot be separated. (3) LoopLens is the author's tool and was used in development and calibration with PTB-XL; this is no independent check of the tool. (4) Repeatability is not accuracy. (5) Percentile intervals of SD-type statistics can be too narrow with about 260 clusters. (6) There is no counterpart to the replication criteria of S13; a statement of external replication of the audit as a whole is excluded. The finding is stated as: compatible with the MIMIC repeat variation, not conclusive.

S15. Repeat variation of adjacent windows in healthy volunteers

Context only; no hypothesis of the main audit depends on this module. Autonomic Aging (Schumann and Bär 2021, 2022; open, ODbL) provides resting single-lead ECG recordings of 8 to 36 min (by file header) in healthy volunteers (1,121 recordings; one has no signal file). They were analyzed with a single-lead chain (NeuroKit2 wavelet delineation on lead II), not with the 12-lead production chain, to describe the repeat variation of consecutive 10-s windows. The dataset is not an unseen external confirmation (24 recordings had been read earlier).

Repeat variation (RC) of adjacent 10-s windows in 1,107 persons with a primary window was 19.1 ms [18.2, 20.1] for P duration, 22.4 [20.5, 24.3] for PR, 20.3 [18.4, 22.1] for QRS duration, 28.9 [25.3, 32.7] for QT and 30.9 [27.4, 34.5] for QTcF. These values are driven by a few outlier windows: the median absolute difference of adjacent windows for QRS duration was 0.5 ms and the robust RC 1.5 ms. Part of the QRS excess is a property of the single-lead chain (154 of 1,099 healthy volunteers had a QRS duration of at least 120 ms in at least half of their windows), so QRS values of this chain are not reference values. Without further assumptions (independent errors in adjacent windows, no systematic change between them, no selection of outlier windows), the repeat variation of adjacent windows is not a secured lower bound of the measurement error of that chain; it is a descriptive spread, neither a tolerance nor a null distribution for changing the recording. We therefore make no statement comparing the clinical RC with this spread for QRS duration; the SD-based RC and the robust summaries are both reported above for description.

Technical failure of P duration in healthy volunteers was 11.1% [9.4, 13.1] (123 of 1,107 persons). The single-lead chain, the healthy population and the plausibility limits differ from the MIMIC sample, so no comparison with the P availability of the MIMIC release output is made. The failure did not rise with a heart-rate noise index and was lower on one of the two recording devices.

Comparisons of QRS and QTc classification across ECG programs, including LoopLens and BRAVEHEART, are reported in a related manuscript in preparation.