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ORIS v0.1 — Open Radiographic Imaging Schema for Dental Panoramic Reports: A Digital Dental-Formula Analogue for Documenting Imaging Findings

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Article

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ORIS v0.1 — Open Radiographic Imaging Schema for Dental Panoramic Reports: A Digital Dental-Formula Analogue for Documenting Imaging Findings

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Abstract

Panoramic radiographs are a high-volume two-dimensional imaging modality in dentistry, depicting the dentition, maxillomandibular bone, temporomandibular joint, and upper-airway projections. The imaging findings section of panoramic-radiograph reports has been standardised in general radiology at the level of templates and lexicons, and a community-endorsed open machine-readable lexicon already exists for one specific imaging modality — the lexicon for perfusion magnetic resonance imaging from the Open-Source Initiative for Perfusion Imaging. For dental panoramic findings, however, no equivalent open, panoramic-specific, report-level, executable schema has been published. Here we propose ORIS v0.1, the Open Radiographic Imaging Schema: an MIT-licensed schema that satisfies five intersecting criteria — open, panoramic-specific, report-level, executable, and intended as an intermediate representation for findings — none of which holds together for the existing alternatives. Each tooth position is encoded by a universal six-character code whose final character is the Occupant, with fourteen object types covering natural teeth, implants, autotransplants, absence, root remnants, supernumerary teeth, and the principal fixed and removable prosthetic designs. Tooth findings are described by a layered status formula over five surfaces, with three additional ontologies for anatomical landmarks, the temporomandibular joint, and the airway and sinuses. The reference parser achieved complete technical encodability within the internal adult OPG cohort (136 radiographs; 4 352 expert-curated tooth-position records). Computational convergence between thirty-one independent algorithms ranged between 0.94 and 1.00. The schema complements the radiologist's clinical reasoning rather than replacing it, and is released as an open starting point for community development.

Keywords: dental panoramic radiography, structured reporting, imaging findings schema, universal tooth nomenclature, temporomandibular joint, maxillary sinus, mandibular canal, dental implants, machine-readable, candidate open schema.

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1 Introduction

Panoramic radiography (OPG) is the most widely used two-dimensional imaging modality in dentistry.[1, 31] A single panoramic image visualises not only the 32 teeth but also the body of the mandible, the ramus with its coronoid and condylar processes, the mandibular canal and mental foramina, the maxillary sinuses with their floors and pneumatization patterns, the projection of the nasal cavity with septum, the zygomatic arch, the hyoid bone, and the projection of the cervical spine. When a radiologist reports an OPG, they construct a structured "imaging findings" section that is conceptually separate from the clinical diagnosis: imaging findings describe what is visible on the radiograph, whereas the diagnosis integrates anamnesis, intra-oral examination and radiographic interpretation, with the clinical examination always preceding the radiograph per the ALARA principle.[4, 5] In general radiology this section has long been standardised at the level of communication guidance,[2, 3] templates (RSNA RadReport), and lexicons (RadLex; AIM standard, RSNA 2011[6]), and in specific modalities at the level of community-endorsed open machine-readable lexicons — most notably the OSIPI LL-XML lexicon for perfusion MRI.[7]

For dental panoramic imaging, however, the equivalent infrastructure does not yet exist. Existing approaches cover important parts of the problem but stop short of a reusable findings schema. Proprietary AI platforms (Diagnocat, Pearl, Overjet, Planmeca Romexis, Carestream AI Insights, Vatech) may structure their outputs internally, but their representations are not academically citable as open schemas. Generic clinical-workflow standards[8, 9, 10] cover the wider electronic-health-record workflow rather than a dental radiographic-finding output; terminology vocabularies[11, 12, 13] provide dictionaries of codes rather than report-level documents; and generic radiology containers[6, 7, 11] are precedents in general radiology but are not dental-specific. Per-paper annotation forms in open datasets — OdontoAI,[37] DENTEX,[38] DenPAR, vzrad2 (10 580 OPGs × 93 classes) — and the clickable-decision-tree structured-reporting system of Schnitzer et al.[14] likewise provide per-dataset or per-tool structures, not a cross-paper, cross-system, citable, reusable representation. Fewer than 2% of dental AI studies share datasets in machine-actionable form,[41] and the broader scoping literature on dental artificial intelligence has repeatedly identified the absence of a common output format as a barrier to cross-study comparison.

In this paper we propose ORIS v0.1 (Open Radiographic Imaging Schema; Latin oris — "of the mouth"). ORIS v0.1 simultaneously satisfies five criteria — (i) open (MIT-licensed, citable, redistributable); (ii) panoramic-specific (tooth-level + non-tooth findings of the OPG modality, not generic EHR or cross-modality); (iii) report-level (an output for the imaging findings section, not a label format for a dataset or a controlled vocabulary); (iv) executable (formally specified by JSON Schema Draft 2020-12 with a Python parser, EBNF grammar, and bridges to FHIR Dental and DICOM-SR); and (v) an intermediate representation for findings (designed to be produced by AI prefill, corrected by an expert, and consumed by chart prefill or multimodal AI context). None of the alternatives in the five categories above holds all five criteria simultaneously; closed AI systems may meet (iii) and (iv) but not (i); FHIR Dental and OpenEHR-DENT meet (i) but not (ii); SNODENT and RadLex meet (i) but not (iii); and per-paper dataset schemas meet (i) and (ii) but not (iii) or (v). We therefore use "first" in this restricted technical sense; we do not claim that ORIS is the first attempt to structure dental findings, dental terminology, dental charting, or

panoramic-image annotations.

The complete specification — the 52-entry numbering mapping table, the 18-status grammar with EBNF parser, the 23-code prosthetic-complication ontology, the JSON Schema Draft 2020-12 (including the three extension ontologies as separately specified objects with controlled fields, allowed values, and example instances), the Python and JavaScript reference implementations, the FHIR/DICOM-SR/MIS/MMOral bridges, 255 unit tests, and anonymised synthetic example documents — is published under MIT licence at https://github.com/zmeik/oris. This v0.1 release is explicitly an open starting point for iterative community development rather than a final standard. The repository is therefore intended not only to document the present schema but also to absorb future extensions, including orthodontics, paediatric mixed dentition, oral surgery, and full three-dimensional cone-beam computed-tomography scope in v0.2 — for which recent oral-CBCT AI-segmentation work in this journal provides a relevant technical precedent[30] — without fragmenting the trunk. In this paper we present the architectural overview and validation results on a real-world internal cohort. Two companion papers extend the ecosystem: a companion methodology manuscript currently in preparation describes an evolutionary AI-validation framework with ORIS as the fitness target, and a companion paper submitted to AIPR 2026 describes 80-voter committee aggregation that uses ORIS as the intermediate representation when mapping outputs onto the independent MMOral-OPG-Bench (implementation pipeline at github.com/zmeik/OPTG_Analizer).[16]

By converting panoramic-radiograph findings into a reproducible oral-health data layer, ORIS addresses a practical bottleneck in digital oral science: the absence of a shared, machine-readable representation for radiographic findings that can support clinician-verified reporting, longitudinal follow-up, AI benchmarking, and multi-centre oral-health research. The present Article evaluates whether panoramic findings can be represented reproducibly in a machine-readable oral-radiology format; it does not claim clinical validation of ORIS as a diagnostic standard.

2 Results

2.1 Schema architecture

The resulting ORIS document is organised around three semantic levels: per-tooth findings (32 permanent + 20 primary teeth under ISO 3950[17]), anatomical structures (eleven regions per the AAOMR Position Paper Normal Radiographic Anatomy of the Jaws, 2018[22]), and patient-level imaging metadata (acquisition device, kilovoltage peak, tube current, and image-quality score aligned with panoramic quality-assurance recommendations[23]). Each tooth is identified by a six-character code [Jaw][Side][Position][Dentition][Class][Occupant] — for example, LLCPIN corresponds to Lower Left Central Permanent Incisor, Natural tooth (= FDI 31, Universal 24, Palmer ⌜1) (Fig. 1).

A tooth position is described by a layered formula status1:surfaces1+status2+status3, where each layer captures one radiographically observable finding on up to five surfaces (m=mesial, d=distal, o=occlusal, v=vestibular, l=lingual). The example endo:mo+post+crowned reads as "endodontically treated mesio-occlusally, with a post and a crown" — a combination that single-status-per-tooth representations cannot preserve. The use of v (vestibular) rather than

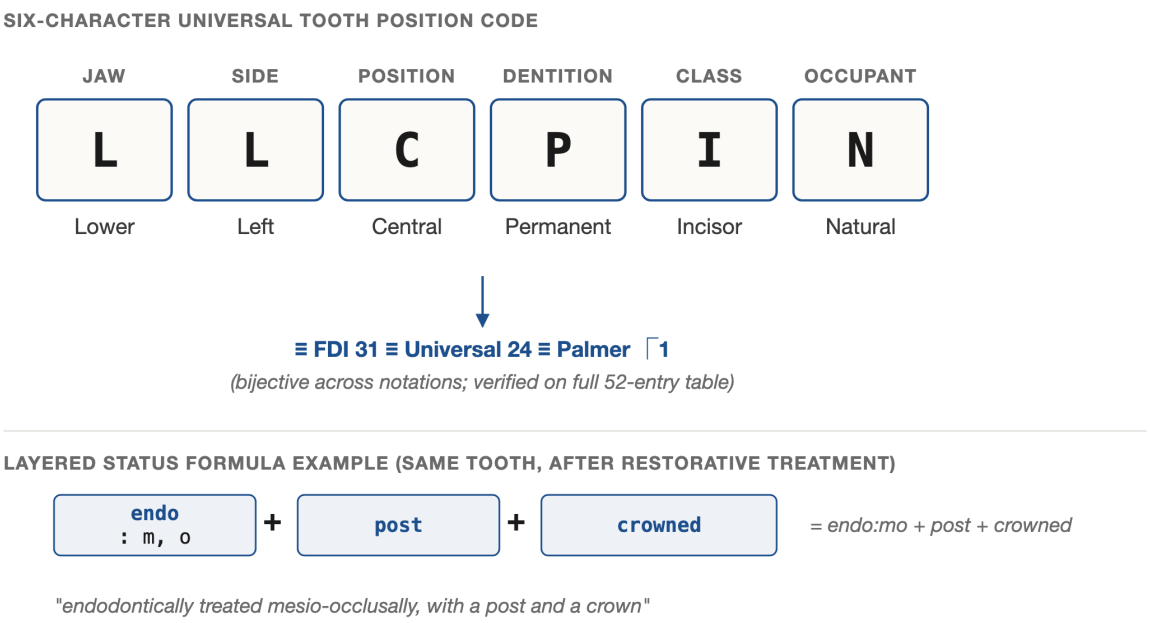


Figure 1. Architecture of the ORIS v0.1 six-character universal tooth-position code (top), with the worked example LLCPIN resolved into FDI 31, Universal 24, and Palmer ⌜1 — verified bijective across notations on the full 52-entry numbering table. Below: the layered status formula composed from three layers (endo:mo, post, crowned), demonstrating how a single tooth carrying multiple radiographically observable findings is preserved as one parsable string rather than reduced to a single primary status.

b (buccal) is justified by the fact that vestibular applies to all teeth, whereas buccal applies only to posterior teeth.[21] The full EBNF grammar and the list of 18 statuses, derived from the production constant ARENA_STATUS_CYCLE, are documented in the repository.

The 14 occupant codes that may occupy the final position of the tooth-position code are listed in Table 1; together they span natural dentition, all standard prosthetic designs (per ACP GPT-9 / GPT-10), and the structural states (absent, root remnant, supernumerary, unknown) that a radiograph may reveal.

Beyond teeth, ORIS specifies three extension ontologies reflecting the full scope of an "imaging findings" report on an OPG. Each ontology is published in the repository as a controlled JSON object with allowed fields and example instances. The per-tooth block remains the most fully elaborated component of v0.1, with EBNF grammar and full surface taxonomy, whereas the extension ontologies are released as v0.1 controlled objects to be tightened in v0.2 in response to community feedback. The Anatomical Landmarks ontology contains nine principal structures: mandibular canal (visibility, course, distance to alveolar crest), mental foramen (location, visibility, bilateral), maxillary sinus, nasal cavity, incisive canal, ramus, coronoid process, zygomatic arch, and projection of the cervical spine. As a worked example, the Maxillary Sinus object specifies the controlled field status with allowed values {normal, mucosal-thickening, opacification, antrolith, polyp, oroantral-communication, sinusitis-acute, sinusitis-chronic}, plus numeric fields for floor integrity, pneumatization pattern, and distance to alveolar crest. The TMJ Findings ontology specifies condyle, articular eminence, joint space, and pathology fields; the Airway/Sinus ontology covers pharyngeal airway dimensions, nasal-cavity septal deviation, and maxillary-sinus pneumatization patterns with associated pathology. These ontologies are derived from the production scene-graph in our project (see dental_scene_graph.py in the repository).

Table 1. Occupant taxonomy of ORIS v0.1 — single-letter codes that may appear at the sixth position of a tooth-position code. The taxonomy extends ACP GPT-9 (2017)[18] and GPT-10 (2023)[19] with the inlay-bonded retainer per Garrofé-Mejillón (2023).[20]

Code	Occupant	Brief description
N	Natural	Natural tooth in its alveolar socket
F	Fixture	Endosseous dental implant fixture (osseointegrated)
T	Transplant	Autotransplanted tooth in an alveolar socket
B	Bridge pontic	Conventional fixed-bridge pontic supported on adjacent abutments
D	Denture	Removable denture tooth (full or partial)
H	Hybrid	Hybrid prosthesis component (e.g., All-on-4)
O	Overdenture	Overdenture support (root or implant abutment)
A	Absent	Position is absent — no tooth and no replacement
R	Root remnant	Retained root fragment without coronal portion
S	Supernumerary	Supernumerary tooth (additional to the normal 32-tooth set)
U	Unknown	Cannot be classified from the present radiograph
C	Cantilever	Cantilever pontic supported on a single abutment
M	Maryland-bonded	Maryland-bonded resin retainer (winged)
I	Inlay-bonded	Inlay- or onlay-bonded resin retainer

2.2 Technical encodability on the RUDN internal cohort

The internal cohort consists of 136 panoramic radiographs originally collected at the RUDN Diagnostic Centre between 2024 and 2026 as part of routine clinical practice (ICD-10 K08.1 = "loss of teeth due to extraction, accident or local periodontal disease"). Use of these radiographs in the present work constitutes secondary analysis of fully de-identified retrospective records for software-engineering purposes — no interventions, no prospective data collection, and no individually identifiable patient information were involved. Under institutional policy and Federal Law No. 152-FZ on personal data (Russian Federation), this category of secondary use of de-identified data is exempt from ethics-committee review as standalone research; passport-level identifiers were removed at the source, and patient_id mapping was retained only in encrypted form in a separate registry inaccessible to the analysis pipeline. The broader clinical-research programme that motivates this work is reviewed by the Local Ethics Committee of the RUDN Medical Institute as a routine component of the author's doctoral dissertation procedure; that approval document, when issued, will be deposited in the public ORIS repository for transparency (see §4.4). The cohort contained 4 352 expert-curated tooth-position records (32 teeth × 136 OPGs ≈ 4 352, after exclusion of irreproducibly degraded cells). The Python reference parser achieved complete technical encodability — every record was successfully recognised by the EBNF grammar with no edge-case violations, and JSON Schema Draft 2020-12 validation passed without errors on all 136 documents. The bijection ORIS ↔ FDI ↔ Universal ↔ Palmer ↔ anatomical ↔ layperson was verified on the full 52-entry table. We interpret these results as evidence that ORIS can encode all radiographically observable findings encountered in this adult cohort; we do not interpret them as evidence of complete coverage across all panoramic pathology, nor as

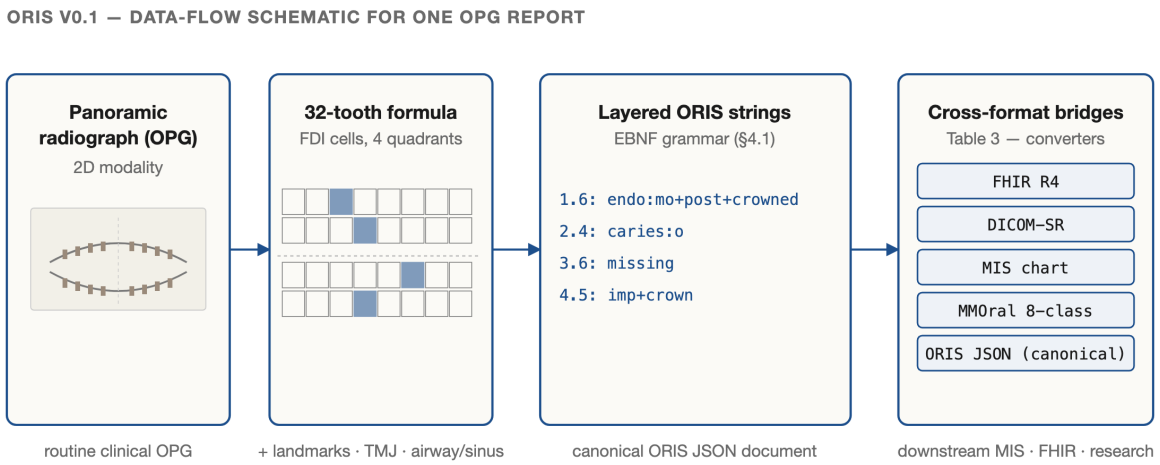


Figure 2. Data-flow schematic of ORIS v0.1 for a single OPG report. Stage 1 — a panoramic radiograph (the only modality in scope for v0.1) is acquired by routine clinical OPG. Stage 2 — the radiograph is mapped to a 32-tooth formula whose cells follow FDI numbering across four quadrants; the highlighted cells (FDI 1.6, 2.4, 3.6, 4.5) correspond to the worked examples in stage 3. The dashed line marks the occlusal midline. The same per-OPG document additionally carries the three extension ontologies — anatomical landmarks, TMJ findings, and airway/sinus — which appear in the canonical JSON but are not separately drawn here. Stage 3 — each tooth cell carries a layered ORIS string parsed by the EBNF grammar of §4.1; representative strings are shown for an endodontically restored upper-right first molar with post and crown (1.6), an occlusal-surface caries (2.4), a missing lower-left first molar (3.6), and an implant crown (4.5). All teeth and the three extension ontologies together form one canonical ORIS JSON document. Stage 4 — that canonical document is converted by the bridges of Table 3 into four downstream representations (FHIR R4, DICOM-SR, MIS chart, MMOral 8-class) plus the canonical ORIS JSON itself, supporting medical-information-system prefill, archival in DICOM-SR repositories, mapping onto the independent MMOral-OPG-Bench benchmark, and longitudinal cross-cohort research. The radiologist validation interface used in the reference workflow is shown in Supplementary Fig. S1; the AI-prefill workflow that produces the initial ORIS document is shown in Fig. 3.

a measure of clinical reliability, which requires inter-rater testing on independent radiologists (planned for Q3 2026).

2.3 Computational convergence under the reference workflow

The reference radiologist-validation interface used to correct the AI-prefilled ORIS documents is provided as Supplementary Fig. S1. In a companion methodology manuscript currently in preparation we deploy a 31-algorithm evolutionary population in which each algorithm reads an OPG and produces an ORIS document, with mutual Cohen's κ between algorithms serving as the fitness function. On the 136-OPG cohort, inter-algorithm κ fell within [0.94, 1.00] with a median of 0.97. Because the population was evolved with agreement as the selection criterion, this number must be interpreted as computational convergence within the reference workflow, not as a clinical inter-rater reliability between two independent radiologists. The result establishes that the layered encoding does not introduce artefactual variability — algorithms targeting the same schema converge — and is positioned in the present paper as a property of the schema's encodability under multi-algorithm evaluation, not as a clinical reliability claim. Inter-rater κ between two independent oral-and-maxillofacial radiologists is on the multi-centre roadmap (Q3 2026; see §3, Limitations).

2.4 Downstream feasibility on MMOral-OPG-Bench

In a companion submission to AIPR 2026, with the implementation pipeline available at https://github.com/zmeik/OPTG_Analizer, ORIS serves as the intermediate representation in an 80-voter committee aggregation pipeline. On the independent benchmark MMOral-OPG-Bench (Hao et al., NeurIPS Datasets and Benchmarks Track, 2025; arXiv:2509.09254[15]) — an external reference dataset of 8 500 panoramic radiographs with 8 finding types × 32 teeth — the ORIS-based committee reached 75.36% deployment accuracy by mapping ORIS outputs onto the MMOral 8-class taxonomy. We present this number as downstream feasibility evidence that ORIS can serve as an intermediate representation across distinct training and evaluation taxonomies, not as core validation of the schema itself. The mapping is implemented in bridges/mmoral.py of the repository; without a unified intermediate schema, an equivalent mapping would require re-implementation for each new benchmark.

2.5 Practical deployment: three open-infrastructure use cases

Three clinical and research use cases of ORIS become substantially more reproducible and scalable with a structured intermediate format.

First, an ORIS document can serve as a source for prefilling the clinical dental chart in a Medical Information System (MIS), by mapping ORIS codes to FDI numbers and radiographic statuses to MIS chart categories. This prefill remains advisory: the transition from a radiographic finding to a clinical diagnosis remains the prerogative and responsibility of the treating clinician, who verifies and, where needed, corrects the record before it enters the patient's chart. In the RUDN deployment we observed a reduction in chart-filling time from 10–15 minutes (manual) to approximately 1 minute, limited to correction of clinical-only findings — sensitivity, vitality, occlusion — which the radiograph cannot show, with the clinician retaining final sign-off authority on every cell.

Second, prior ORIS documents of the same patient serve as structured multimodal context for AI when reading the next OPG: the model receives both the new image and a parsable textual summary of prior findings (for example: "Patient history 2025-06-15: 1.2 endo+post+crowned, 4.5 implant IRIS MBL=1.2 mm, 4.6 missing extracted 2024"), which supports baseline awareness, change-detection priority, and longitudinal MBL tracking on follow-up visits. Free-text reporting cannot deliver this effect because the prior findings cannot be passed to the AI as parsable context.

Third, ORIS structured records enable multi-centre longitudinal clinical research and dental registries: prosthetic-complication rates, peri-implantitis incidence, marginal-bone-level (MBL) trajectories, and cross-cohort treatment-outcome statistics can be queried against the structured layer using standard SQL/JSONB queries, without ad-hoc re-coding for each study. This use case is particularly relevant for cross-border treatment workflows — including the dental-tourism setting — in which a portable structured record must travel with the patient between centres of care.

3 Discussion

ORIS v0.1 demonstrates that an open, panoramic-specific, report-level, executable schema for the imaging findings section of OPG reports is feasible. The evidence is deliberately technical rather than diagnostic: complete technical encodability on a 136-OPG cohort, computational convergence $\kappa = 0.94$–1.00 under the reference workflow, and downstream mapping to the independent MMOral-OPG-Bench in a companion submission together support readiness for external evaluation and community testing, with multi-centre inter-rater validation as the next step. This positioning also defines the intended OSIPI comparison. The OSIPI LL-XML lexicon[7] provides a precedent for community-facing, machine-readable terminology infrastructure in imaging research; the analogy is therefore limited to the infrastructure principle — an open, machine-readable, reusable representation for a specific imaging domain — not to the maturity of governance or community endorsement. ORIS follows the same open-infrastructure logic as OSIPI LL-XML but remains an author-proposed v0.1 schema pending external validation and community endorsement.

The key architectural choice in ORIS is the layered per-tooth encoding (status:surfaces+status+status). This representation is required by the reality of dental radiology: one tooth often carries multiple findings simultaneously — for example, an endodontically treated tooth with a post and a crown plus secondary caries on the distal coronal surface. Layered encoding endo:mo+post+crowned+caries:d preserves all of this information in a single parsable string, enabling downstream queries (longitudinal change detection, cross-cohort statistics) that single-status models cannot support. Several proprietary AI platforms (Diagnocat, Pearl, Overjet, Planmeca Romexis, Carestream AI Insights, Vatech) operate in this space; we do not assert that their internal representations are unable to encode multi-finding teeth — we lack the evidence to do so. The defensible claim is narrower: in the citable academic literature considered here, we did not identify, from these systems, a reusable, layered, externally citable representation that could serve as the basis for cross-paper comparison, dataset interoperability, or independent reproducibility — which is the niche ORIS addresses.

Extending the schema beyond teeth to anatomical landmarks, TMJ findings, and airway/sinus blocks reflects the full clinical reality of OPG reading. A radiologist describing an OPG in full[21, 22, 32] evaluates all of these structures. Mucosal thickening of the maxillary sinus may be critical for planning an implant in the posterior maxilla, a workflow elaborated in the supervisor's group monograph on alveolar-bone reconstruction,[34] while condylar erosion at the TMJ may explain clinical complaints of pain and limited mouth opening. By specifying these extension ontologies as controlled JSON objects with allowed fields and example instances (see §2.1 for the worked Maxillary Sinus example), ORIS addresses the full scope of "imaging findings", not the dental formula alone, while leaving room to deepen the formal grammar of the extension ontologies in v0.2 in response to community feedback.

Expanding the occupant list to 14 codes — including Cantilever pontic, Maryland-bonded retainer, and Inlay-bonded retainer per ACP GPT-9 (2017), GPT-10 (2023), and the Garrofé-Mejillón scoping review (2023)[18, 19, 20] — covers the principal clinical designs of fixed prosthodontics. Without this distinction, a Maryland bridge becomes indistinguishable from a conventional bridge in the structured output, losing diagnostically relevant information (different risk profile, different radiographic appearance, different treatment plan). The prosthetic-complication

ontology is mapped to the international classifications and to the Russian-language clinical handbooks of surgical and prosthetic dentistry,[27, 33] which the supervisor's group at RUDN has used in routine clinical practice and in the dental-tourism cohort that motivates this work. The Fixture/implant occupant type is also designed to accommodate non-standard implant designs — including bicortical two-stage systems for type-IV bone in the posterior maxilla[35] — with manufacturer-, geometry- and surface-specific subfields reserved for v0.2.

ORIS does not replace existing standards; it bridges to them. The reference Python parser includes converters to_fhir() (HL7 FHIR DiagnosticReport + Observation resources), to_dicom_sr() (DICOM Structured Reporting with RadLex Dental Subset codes), and recommended mapping to SNODENT/ICDAS/ICD-10 at the diagnosis stage (Table 3). This positions ORIS as an addition to existing infrastructure rather than a replacement, while the schema versioning roadmap (v0.1 → v0.2 → ... → v1.0) gives external contributors a defined route for extensions. The same bridge logic underlies the three use cases described in §2.5: MIS prefill under specialist sign-off, longitudinal multimodal AI context, and cross-cohort registry research. The third use case is particularly relevant for cross-border treatment workflows, including the dental-tourism setting, where structured records must travel with the patient between care centres.

Table 2. Bridges from ORIS v0.1 to existing standards. Each bridge is a Python converter in bridges/ of the repository, with round-trip unit tests against canonical ORIS examples. Mappings are intentionally non-lossy where the target standard has a corresponding concept and explicitly partial where it does not (the right column flags which ORIS fields cannot be expressed in the target representation and are therefore preserved only in the canonical ORIS document).

Bridge	Target standard / format	ORIS-side function	Status preserved	Information lost in target
FHIR R4	HL7 FHIR Dental Data Exchange (DiagnosticReport + Observation resources, RadLex Dental Subset codes for Observation.code)	to_fhir(doc)	per-tooth occupant, primary status, surfaces, anatomical-landmark observations	layered status order; root_data Vertucci sub-fields; sequence_num
DICOM-SR	DICOM PS3.16 Structured Reporting (TID 5000-series template)	to_dicom_sr(doc)	imaging metadata, per-tooth findings as numbered measurement groups	layered status as parsable string (flattened to enumerated list)
MIS chart	ANSI/ADA 1084 dental discrete-data chart (flat per-FDI status table)	to_mis(doc)	FDI number, primary status, occupant flag, basic surface marks	layered status (collapsed to primary); extension ontologies
MMOral 8-class	MMOral-OPG-Bench taxonomy[15] (8 finding types × 32 teeth)	to_mmoral(doc)	per-tooth presence of each MMOral class via deterministic mapping rules	occupant taxonomy; root_data; anatomical-landmark / TMJ / airway extensions
ORIS canonical	JSON Schema Draft 2020-12 (round-trip identity)	to_oris(doc)	everything (lossless)	—

The single-source AI prefill workflow that produces ORIS documents is summarised in Fig. 3. A new OPG is processed by AI inference, the output ORIS document is reviewed and corrected by

the radiologist in the Arena interface, and the diff between the AI-prefilled and the expert-corrected document is recycled as a training pair for the next AI iteration. Multi-source extensions of this workflow — optical character recognition of patient cards and snapshot copy from prior visits of the same patient — are out of scope for the present paper and will be specified in a planned future paper.

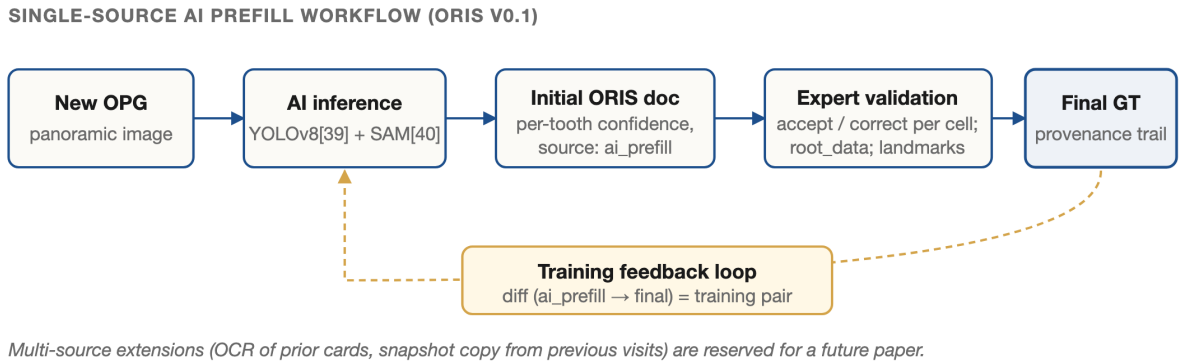


Figure 3. Single-source AI prefill workflow for ORIS v0.1. A new panoramic radiograph is processed by AI inference (YOLOv8[39] for object detection plus Segment Anything Model (SAM)[40] for refined tooth segmentation), producing an initial ORIS document with per-tooth confidence scores and the provenance flag source: ai_prefill. The radiologist validates the document in the Arena interface, accepting or correcting each cell, filling root_data for endodontic and periapical findings, and recording anatomical-landmark, temporomandibular-joint, and airway/sinus findings. The final ground-truth document is stored with a complete provenance trail in gt_change_history, and the diff ai_prefill → final is recycled as a training pair for the next AI iteration (yellow dashed line). Multi-source extensions are reserved for a future paper.

The limitations of our validation are clear and bounded. The cohort is single-centre (RUDN Diagnostic Centre); a multi-centre study with inter-centre and inter-rater κ between two independent oral-and-maxillofacial radiologists is planned for Q3 2026 (RUDN Moscow and NVU Tbilisi). The current validation establishes technical encodability and computational convergence under the reference workflow, not clinical inter-rater reliability. Coverage breadth is limited to basic restorative + implant cases; orthodontic cases, multiple impactions, and severe pathology cases remain untested edge cases. Paediatric / mixed-dentition validation is planned but has not yet been performed; the schema already includes ISO 3950 primary-teeth codes — the 52-entry mapping table covers all 20 primary teeth, but empirical validation on paediatric panoramic radiographs is part of the v0.2 roadmap. 3D CBCT extension also requires v0.2 — the current v0.1 is specific to panoramic 2D modality. Versioning and provenance are supported but not yet stress-tested against adversarial provenance attacks; cryptographic signing for regulated environments is also v0.2 scope. Formal community endorsement (AAOMR, IADMFR, ESHNR) has not yet been obtained; the expected workflow is paper acceptance in IJOS → presentation at AAOMR / IADMFR → community feedback → v0.2. External validity remains untested outside the RUDN cohort; therefore, ORIS v0.1 should be read as a candidate community schema requiring multi-centre radiologist validation before any claim of standard status.

To our knowledge, ORIS v0.1 is the first open, panoramic-specific, report-level, executable intermediate representation for the structured imaging findings section of dental panoramic reports; it applies an open-infrastructure principle that has a precedent in OSIPI LL-XML for

perfusion MRI, while remaining at an earlier stage of community validation. The MIT-licensed reference implementation enables independent replication; complete technical encodability on the 136-OPG RUDN cohort, computational convergence $\kappa \in [0.94, 1.00]$ under a 31-algorithm evolutionary reference workflow, and downstream mapping to the independent MMOral-OPG-Bench in a companion submission together are consistent with readiness for external evaluation and community testing. ORIS v0.1 is presented as an open starting point for iterative community development rather than a final standard, and the public repository allows colleagues to fork the schema, extend the ontologies, and contribute through pull requests. ORIS complements the radiologist's work by structuring the descriptive section of the report without replacing clinical reasoning; the transition from a radiographic finding to a clinical diagnosis remains the prerogative and responsibility of the treating clinician. Future work focuses on multi-centre and inter-rater validation (Q3 2026), CBCT 3D extension (v0.2), paediatric / mixed-dentition validation, and community endorsement through AAOMR / IADMFR.

The ORIS ecosystem is being developed through a sequence of papers: the present foundation paper specifies the schema and its single-source AI workflow, and a companion methodology manuscript currently in preparation describes the evolutionary 31-algorithm validation framework that uses ORIS as the fitness target. A future paper on history-aware multi-source prefill (OCR of prior patient cards + snapshot copy from earlier visits) is in preparation as a separate manuscript and is out of scope here.

4 Materials and methods

4.1 Schema specification

The complete formal specification of ORIS v0.1 is published at https://github.com/zmeik/oris under the MIT licence; here we summarise the architectural contract. The 6-character code structure is [Jaw=U/L][Side=L/R][Position=C/L/X/1/2/3][Dentition=P/D][Class=I/C/P/M][Occupant]. The 14-code occupant taxonomy (Table 1) extends the ACP GPT-9 (2017) and GPT-10 (2023) prosthodontic terminology. The 18 layer statuses for tooth positions (full grammar EBNF in grammar.md of the repository) are derived from the production constant ARENA_STATUS_CYCLE. The 5 surface codes (m, d, o, v, l) follow standard radiographic nomenclature. The three extension ontologies — Anatomical Landmarks, TMJ Findings, Airway/Sinus — are each published as a controlled JSON object with allowed fields and example instances (see anatomy/ontology.md, tmj/ontology.md, airway_sinus/ontology.md); the per-tooth block remains the most fully elaborated component of v0.1, with the EBNF grammar and the full surface taxonomy documented above. The extension ontologies will be tightened to grammar-level formality in v0.2, in response to community feedback. The 23-code prosthetic complication ontology is mapped to Pjetursson et al. (2012),[28] Misch (2008),[27] Schwarz et al. (2018)[29] and to the Russian-language national handbook of surgical dentistry.[33] The root morphology library includes Vertucci I–VIII canal classification (Vertucci, 1984),[25] PAI (Ørstavik et al., 1986),[24] and Furcation grading (Glickman, 1953).[26] A representative sample of the 52-entry numbering mapping table — verifying the bijection ORIS ↔ FDI ↔ Universal ↔ Palmer — is shown in Table 2. All tables and mappings are documented in the numbering/, grammar/, anatomy/ subfolders.

Table 3. Sample rows from the 52-entry numbering mapping table demonstrating the bijection between ORIS six-character codes and the three established notations (ISO 3950 / FDI; ADA Universal; Palmer). The full table is in numbering/permanent-teeth.csv and numbering/primary-teeth.csv of the repository.

ORIS code	FDI	Universal	Palmer	Anatomical name & occupant
UR1PMN	1.6	3	6⌝	Upper Right First Permanent Molar — Natural
URXPCN	1.3	6	3⌝	Upper Right Permanent Canine — Natural
ULCPIN	2.1	9	1⌞	Upper Left Permanent Central Incisor — Natural
LLCPIN	3.1	24	⌜1	Lower Left Permanent Central Incisor — Natural
LR1PMF	4.6	30	⌟6	Lower Right First Permanent Molar — implant Fixture
UR1DMA	5.4	B	D⌝	Upper Right First Primary Molar — Absent
LLXDCN	7.3	M	⌜C	Lower Left Primary Canine — Natural

4.2 Reference implementation

The reference implementation comprises a Python parser/serialiser (7 core functions: parse_tooth_layers, encode_tooth_layers, derive_numbering, validate_oris, compute_kappa, to_fhir, to_dicom_sr) and a JavaScript Arena UI of 14 modules (25 000 lines in total). PostgreSQL JSONB storage uses two tables — panorama_analysis (the current ORIS document as JSONB) and gt_change_history (versioned ground-truth history with sequence_num, source field, session_id). The complete JSON Schema Draft 2020-12 specification is at https://github.com/zmeik/oris/schema. A public, browser-only reference application is hosted at https://zmeik.github.io/oris/ and is reproducible locally with python3 mock_app.py after pip install -r requirements.txt from the cloned repository.

4.3 AI workflow

The single-source AI prefill workflow of Fig. 3 is linear. A new OPG is first processed by AI inference (YOLOv8[39] for tooth-level object detection, plus Segment Anything Model (SAM)[40] for refined segmentation), producing an initial ORIS document with per-tooth confidence scores and source: 'ai_prefill'. This design follows the author's earlier work on computer-based expert-system algorithms for maxillofacial-disease diagnosis,[36] but narrows the present task from diagnostic decision-making to structured representation of radiographic findings. The radiologist then validates the document in the Arena UI by accepting or correcting each cell, filling root_data for Vertucci/PAI/periapical findings, and recording anatomical-landmark / TMJ / airway findings. The final ground truth is stored with a full provenance trail in gt_change_history, and the diff ai_prefill → final becomes a training pair for the next AI iteration. Multi-source extensions —

OCR of patient cards and snapshot copy from prior visits of the same patient — are out of scope for the present paper; a future paper on this topic is in preparation.

4.4 Cohort, ethics, and validation

Cohort. 136 panoramic radiographs from the RUDN Diagnostic Centre, 2024–2026 (loss of teeth due to extraction, accident, or local periodontal disease — ICD-10 K08.1). 4 352 expert-curated tooth-position records.

Ethics and data privacy. The present work is a software-engineering study based on secondary analysis of fully de-identified retrospective records. No interventions, no prospective data collection, and no individually identifiable patient information were involved in the analyses reported in this paper. All data were anonymised at the source: passport-level identifiers were removed, and patient_id mapping was retained only in encrypted form in a separate registry inaccessible to the analysis pipeline. The de-identification procedure was aligned with Federal Law No. 152-FZ on personal data (Russian Federation), with GDPR-equivalent operational practice and HIPAA Safe-Harbor de-identification logic. Under institutional policy on secondary use of de-identified data, the present work as such is exempt from standalone ethics-committee review.

The broader clinical-research programme that motivates this software-engineering work is reviewed by the Local Ethics Committee of the RUDN Medical Institute as a routine component of doctoral dissertation work at RUDN University. Every aspirant submits the protocol of their dissertation research to that committee under the standard candidacy procedure; the corresponding submission has been made. Once the formal approval is issued, the document will be deposited in the public ORIS repository (oris-repo/ETHICS/) for transparency and the citation updated in subsequent revisions of the manuscript. A separate ethics-committee submission will accompany the planned prospective multi-centre clinical validation (Q3 2026), which is the principal item on the multi-centre roadmap (§3, Limitations).

Annotation. The primary annotator was an oral-and-maxillofacial radiologist on the RUDN staff. A secondary expert validated only those cells where the AI prefill disagreed with the primary expert (single-rater design with conflict-only second review). Inter-rater κ between two fully independent radiologists was not computed on the present cohort; it is the principal item on the multi-centre roadmap (Q3 2026).

Validation performed. Parser coverage = 100% (technical encodability); JSON Schema Draft 2020-12 validation = 100%; mapping bijection — verified against ISO 3950, ADA Universal, Palmer, and ACP GPT-9 / GPT-10. Inter-algorithm Cohen's κ was computed as a fitness function in the 31-algorithm evolutionary population of the companion methodology manuscript in preparation and is reported in the present paper as computational convergence under the reference workflow. Downstream deployment accuracy on MMOral-OPG-Bench[15] was measured in a companion submission to AIPR 2026 (implementation pipeline at github.com/zmeik/OPTG_Analizer). Software reliability: 255 unit tests passing on Python 3.10 (python3 -m pytest tests/ -q), covering parser, bridges, examples, kappa, numbering, and validation.

4.5 Data availability

Code: https://github.com/zmeik/oris (MIT licence) — Python parser/serialiser, JavaScript Arena UI (14 modules), JSON Schema Draft 2020-12, FHIR Dental + DICOM-SR + MIS + MMOral bridges, 255 unit tests, anonymised synthetic example documents (the in-repository examples are fully synthetic, not derived from any real patient image), full numbering / grammar / anatomy / complication mapping tables, version roadmap, and an open contribution guide for community development of v0.2. A static reference application is hosted at https://zmeik.github.io/oris/.

The 136 OPGs of the RUDN internal cohort remain under RUDN data ownership and cannot be redistributed publicly because of institutional data-protection policy and Federal Law No. 152-FZ on personal data; queries for a Data Sharing Agreement may be addressed to the corresponding author. Companion code: OPTG_Analizer pipeline at https://github.com/zmeik/OPTG_Analizer (the implementation accompanying the AIPR 2026 submission).

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Competing interests

The authors declare no commercial conflicts. The ORIS schema is offered under the MIT licence; no patents are pending. Reference [35] cites the corresponding author's prior 2018 dental-implant patent (assigned to the inventor) as background on non-standard implant geometry; reference [36] is a prior peer-reviewed conference article by the same author on expert-system algorithms in maxillofacial diagnosis.

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References

[1] Perschbacher S. Interpretation of panoramic radiographs. Aust Dent J 2012;57 Suppl 1:40–45.

[2] ACR (American College of Radiology). Practice Parameter for Communication of Diagnostic Imaging Findings. 2020.

[3] ESHNR. Recommendations on radiology reporting. 2022.

[4] ADA/AAOMR. Patient Selection for Dental Radiographs. 2026 update.

[5] ADA/FDA. Dental Radiographic Examinations: Recommendations for Patient Selection and Limiting Radiation Exposure. 2012.

[6] Channin DS, Mongkolwat P, Kleper V, Sepukar K, Rubin DL. The Annotation and Image Mark-up project. Radiology 2010;253(3):590–592.

[7] Dickie BR, Ahmed Z, Arvidsson J, et al. A community-endorsed open-source lexicon for contrast agent–based perfusion MRI. Magn Reson Med 2023;91(5):1761–1773. doi:https://doi.org/10.1002/mrm.29840.

[8] HL7 International. FHIR Dental Data Exchange Implementation Guide. v2.0.0; 2024.

[9] OpenEHR Foundation. Dental Archetypes Reference. 2023.

[10] American Dental Association. ANSI/ADA 1084 Dental Discrete Data Elements. 2022.

[11] DICOM Standards Committee. Structured Reporting (PS3.16). 2024.

[12] RSNA. RadLex Dental Subset. v4.1; 2024.

[13] SNODENT Foundation. Systematized Nomenclature of Dentistry. v9.0; 2024.

[14] Schnitzer ML, et al. Structured reporting of dental panoramic images in a hospital-based radiology setting. Front Dent Med 2026;7:1769864.

[15] Hao J, et al. Towards Better Dental AI: A Multimodal Benchmark and Instruction Dataset for Panoramic X-ray Analysis. NeurIPS Datasets and Benchmarks Track; 2025. arXiv:https://arxiv.org/abs/2509.09254.

[16] Manukov SG. Committee aggregation on MMOral-OPG-Bench. Manuscript submitted to AIPR 2026; implementation: https://github.com/zmeik/OPTG_Analizer.

[17] International Organization for Standardization. ISO 3950:2016 Dentistry — Designation system for teeth and areas of the oral cavity. 2016.

[18] The Academy of Prosthodontics. The Glossary of Prosthodontic Terms (GPT-9). J Prosthet Dent 2017;117(5S):e1–e105.

[19] The Academy of Prosthodontics. The Glossary of Prosthodontic Terms (GPT-10), 2023. J Prosthet Dent 2023.

[20] Garrofé-Mejillón A, et al. Terminology focused on design and retention methods used for anterior resin-bonded fixed partial dentures: A scoping review. J Esthet Restor Dent 2023;35(8):1219–1232.

[21] White SC, Pharoah MJ. Oral Radiology: Principles and Interpretation. 8th ed. St. Louis: Elsevier; 2019.

[22] AAOMR. Position Paper: Normal Radiographic Anatomy of the Jaws. 2018.

[23] AAOMR. Position Paper: Quality Assurance for Panoramic Radiography. 2020.

[24] Ørstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system for radiographic assessment of apical periodontitis. Endod Dent Traumatol 1986;2(1):20–34.

[25] Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58(5):589–599.

[26] Glickman I. Clinical Periodontology. 1st ed. Saunders; 1953.

[27] Misch CE. Contemporary Implant Dentistry. 4th ed. St. Louis: Elsevier; 2020.

[28] Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported FDPs and implant-supported FDPs and SCs. Clin Oral Implants Res 2012;23 Suppl 6:22–38.

[29] Schwarz F, Derks J, Monje A, Wang HL. Peri-implantitis. J Clin Periodontol 2018;45 Suppl 20:S246–S266.

[30] Liu Y, Xie R, et al. Fully automatic AI segmentation of oral surgery-related tissues based on cone beam computed tomography images. Int J Oral Sci 2024;16(1):34. doi:https://doi.org/10.1038/s41368-024-00294-z.

[31] Васильев АЮ, Терновой СК, ред. Лучевая диагностика в стоматологии: национальное руководство. М.: ГЭОТАР-Медиа; 2010. 288 с. ISBN: 978-5-9704-1349-4. (in Russian) [Vasiliev AYu, Ternovoy SK, editors. Radiological diagnosis in dentistry: national guideline. Moscow: GEOTAR-Media; 2010.]

[32] Чибисова МА, Батюков НМ. Методы рентгенологического обследования и современной лучевой диагностики, используемые в стоматологии. Институт стоматологии 2020;3(88):24–33. eLIBRARY ID: 44076240. (in Russian) [Chibisova MA, Batyukov NM. Methods of X-ray examination and modern radiation diagnostics used in dentistry. The Dental Institute 2020;3(88):24–33.]

[33] Кулаков АА, Робустова ТГ, Неробеев АИ, ред. Хирургическая стоматология и челюстно-лицевая хирургия: национальное руководство. М.: ГЭОТАР-Медиа; 2010. 928 с. ISBN: 978-5-9704-1701-0. (in Russian) [Kulakov AA, Robustova TG, Nerobeev AI, editors. Surgical dentistry and maxillofacial surgery: national guideline. Moscow: GEOTAR-Media; 2010.]

[34] Иванов СЮ, Мураев АА, Ямуркова НФ. Реконструктивная хирургия альвеолярной кости. М.: ГЭОТАР-Медиа; 2016. 360 с. ISBN: 978-5-9704-3813-8. (in Russian) [Ivanov SYu, Muraev AA, Yamurkova NF. Reconstructive surgery of the alveolar bone. Moscow: GEOTAR-Media; 2016.]

[35] Manukov S. Bicortical dental implant with one- and two-stage bicortical dental implants system for type IV bone in premolar and molar areas of maxillas. WIPO Patent WO 2018/224848 A1; published 13 December 2018. (self-citation, on the author's request — bicortical implant geometry, §3 paragraph 4).

[36] Manukov S, Manukov M, Tevdoradze M. Diagnostic tasks solving algorithms of computer-based expert system for diagnosis of maxillofacial diseases. Transactions of Georgian Technical

University. Automated Control Systems 2016;1(21):169–176. (self-citation, on the author's request — earlier expert-system work, §4.3 AI workflow).

[37] Silva G, Oliveira LF, Pithon M. OdontoAI: a human-in-the-loop labelled data set and an online platform to boost research on dental panoramic radiographs. arXiv 2021. arXiv:https://arxiv.org/abs/2103.03205.

[38] Hamamci IE, Er S, Sezgin OS, Bagci U, Menze BH. DENTEX: An Abnormal Tooth Detection challenge with panoramic X-rays. MICCAI 2023 Challenge; 2023. arXiv:https://arxiv.org/abs/2305.19112.

[39] Jocher G, Chaurasia A, Qiu J. Ultralytics YOLOv8. Software release; 2023. https://github.com/ultralytics/ultralytics.

[40] Kirillov A, Mintun E, Ravi N, et al. Segment Anything. Proc IEEE/CVF Int Conf Comput Vis (ICCV) 2023:4015–4026. arXiv:https://arxiv.org/abs/2304.02643.

[41] Schwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res 2020;99(7):769–774. doi:https://doi.org/10.1177/0022034520915714. —