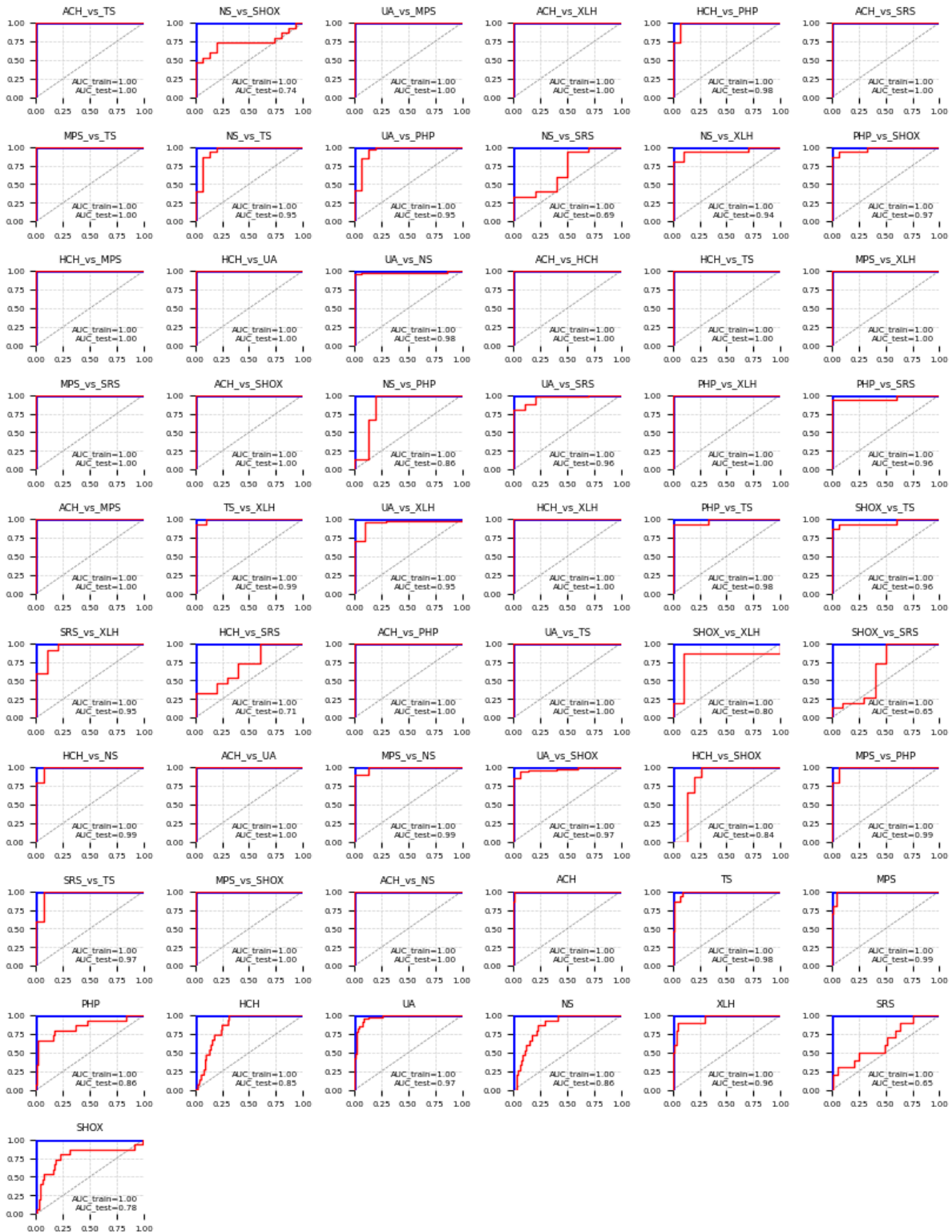


**Supplementary Figure 1: UMAP projection of the *HSPS*.**

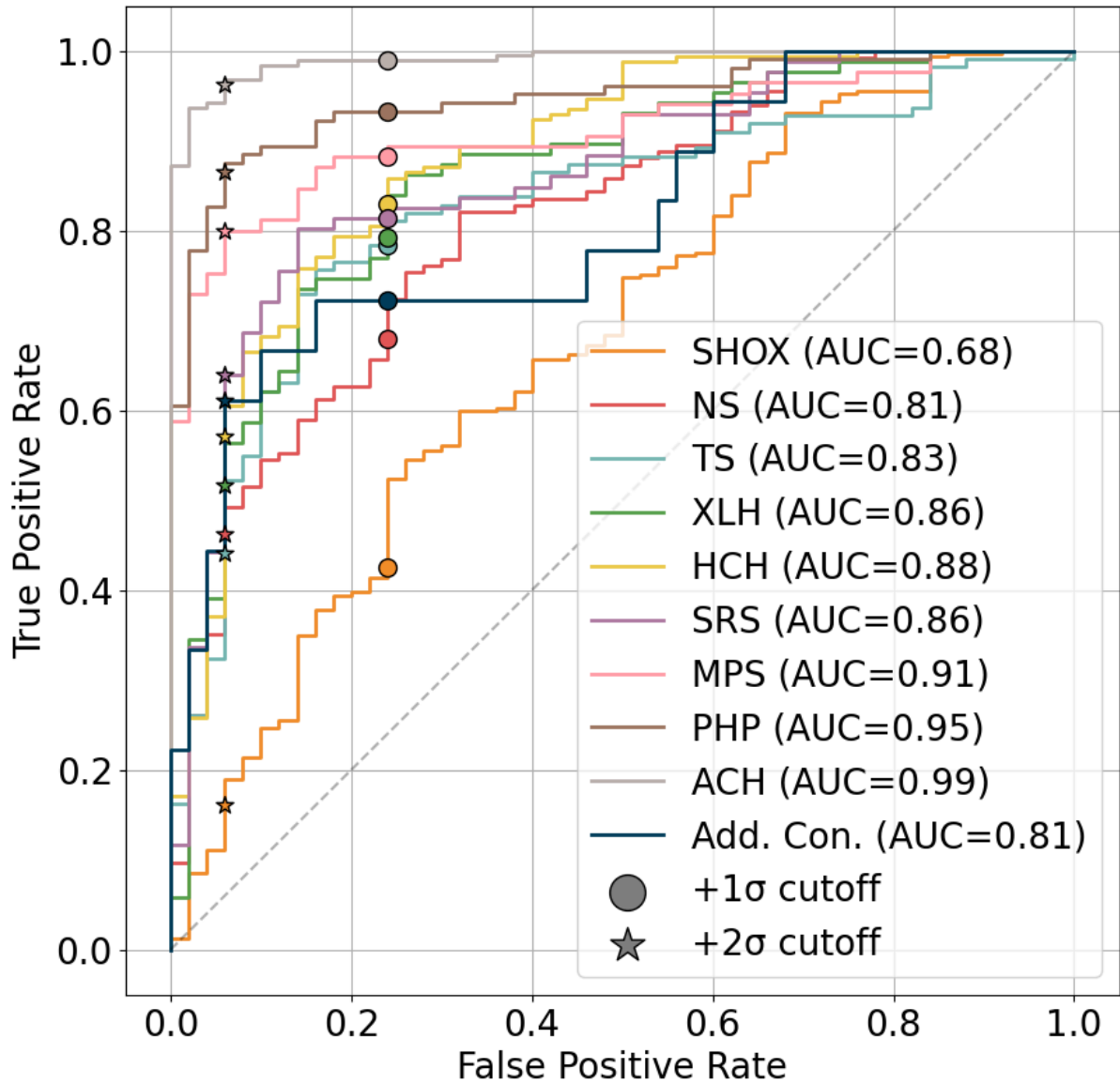
All data of the UA cohort and nine affected cohorts in the *HSPS* (high-dimensional standardized phenotypic space) reduced onto two dimensions. Colors indicate cohorts: UA (blue), SHOX deficiency (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Training and test samples are shown together in the *HSPS*. The big black dot marks the position of the 550-dimensional zero vector (i.e., the UA reference center).

ROC Curves of All OVO & OVR SVMs (Train=Blue, Test=Red)



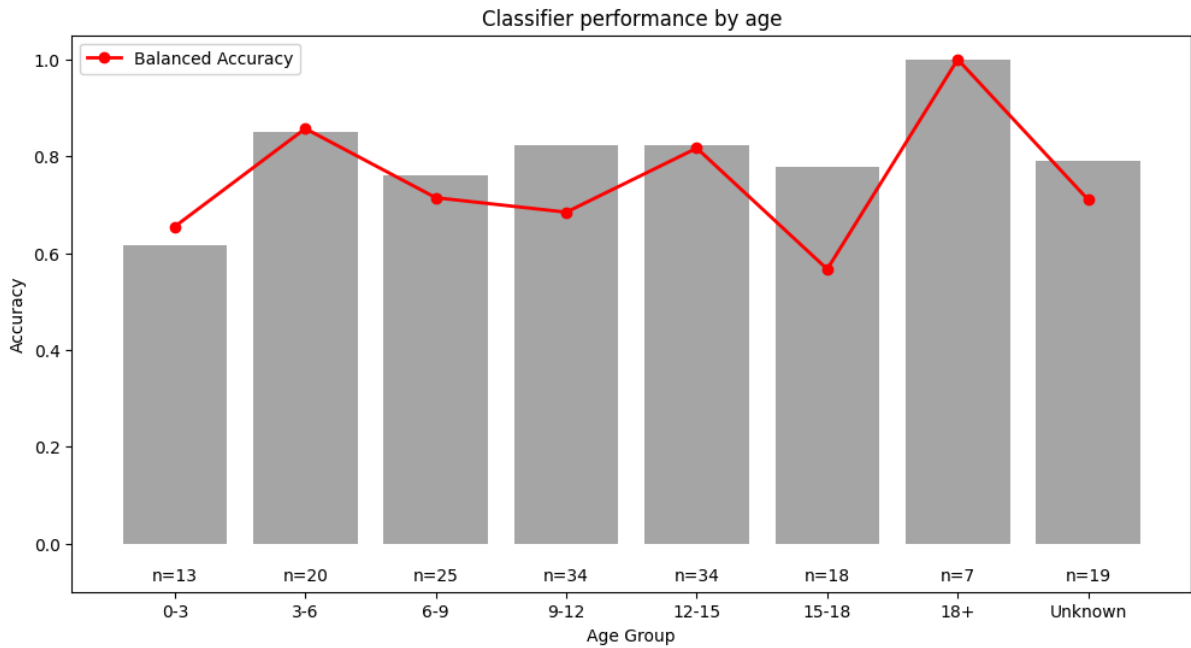
**Supplementary Figure 2: ROC AUC plots of all SVMs**

The Performance of 45 One vs One SVMs (e.g. ACH vs TS) and 10 One vs Rest SVMs (e.g. ACH = ACH vs Rest) are shown with red line indicating the test sets, blue line the training sets on which the SVMs were trained on. Due to overfitting, all ROC–AUC values on the training set reached a perfect score of 1.0.

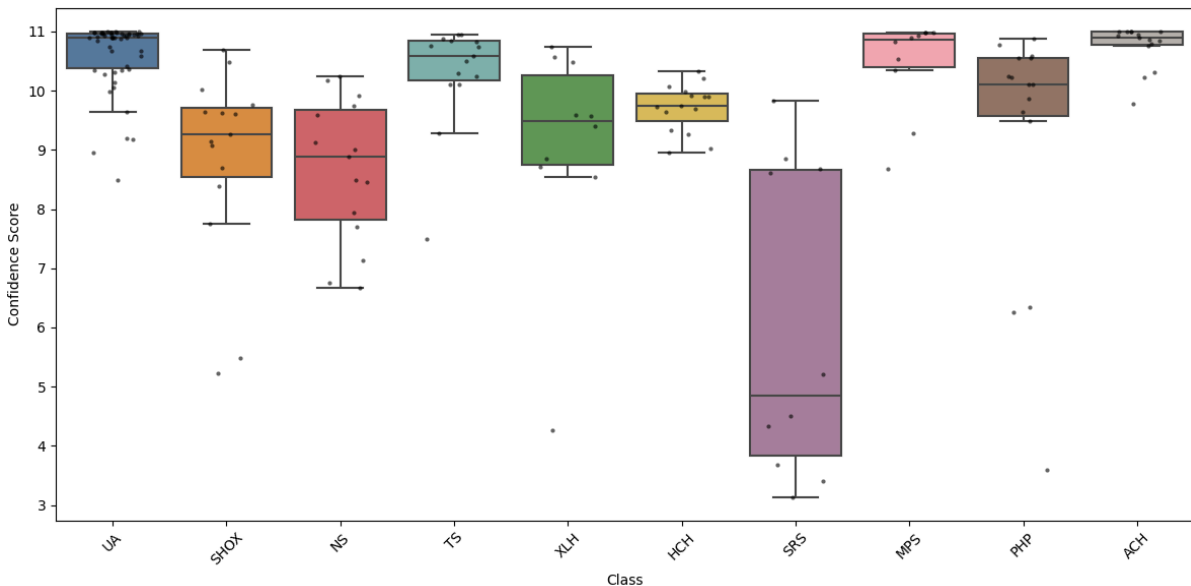


**Supplementary Figure 3 Predictive Power of L1-Norm of  $HSPS$**

ROC-AUC performance of the L1-Norm ( $= ||x_{HSPS}_1||$ ) of the  $HSPS$  for classification of all radiographs (test set and train set) of all nine affected cohorts (and additional conditions) versus the UA cohort test set. Circles and stars indicate threshold of mean L1 Norm of the UA ( $=433.3$ ) reference  $+1\sigma$  ( $=72.6$ ) or  $+2\sigma$  ( $=145.2$ ) respectively.

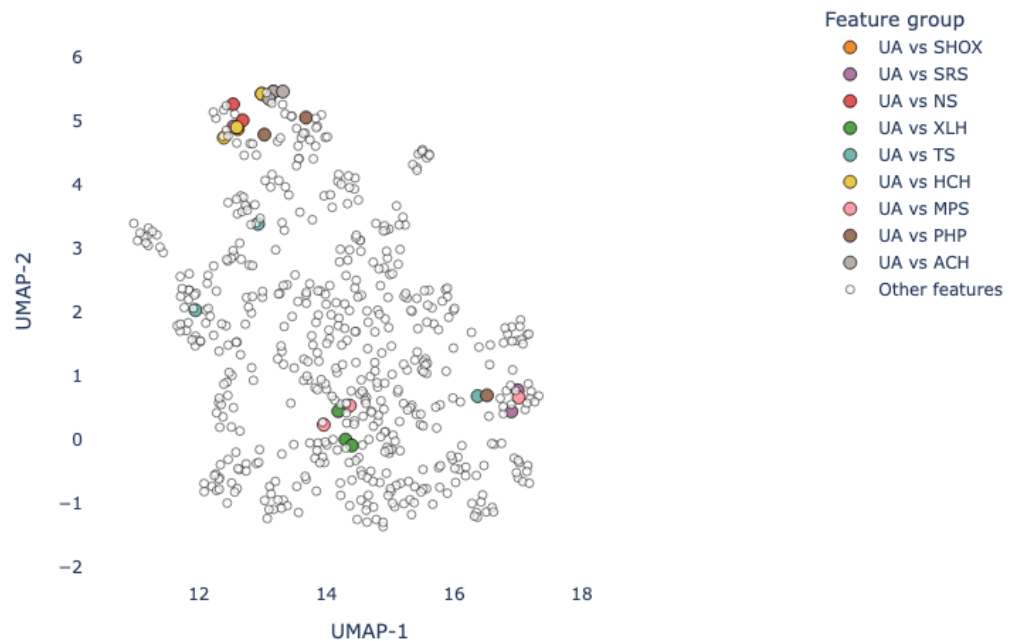


**Supplementary Figure 4.** Performance of the 10-class meta-classifier across age groups. The x-axis shows age groups in 3-year intervals, while the red line indicates the balanced accuracy of the meta-classifier on the test set. Performance remains stable across age groups, indicating consistent classification accuracy throughout childhood and adolescence. Balanced accuracy accounts for the unequal representation of the ten cohorts by weighting individual cohort performances equally. Gray bars indicate the number of radiographs per age group.

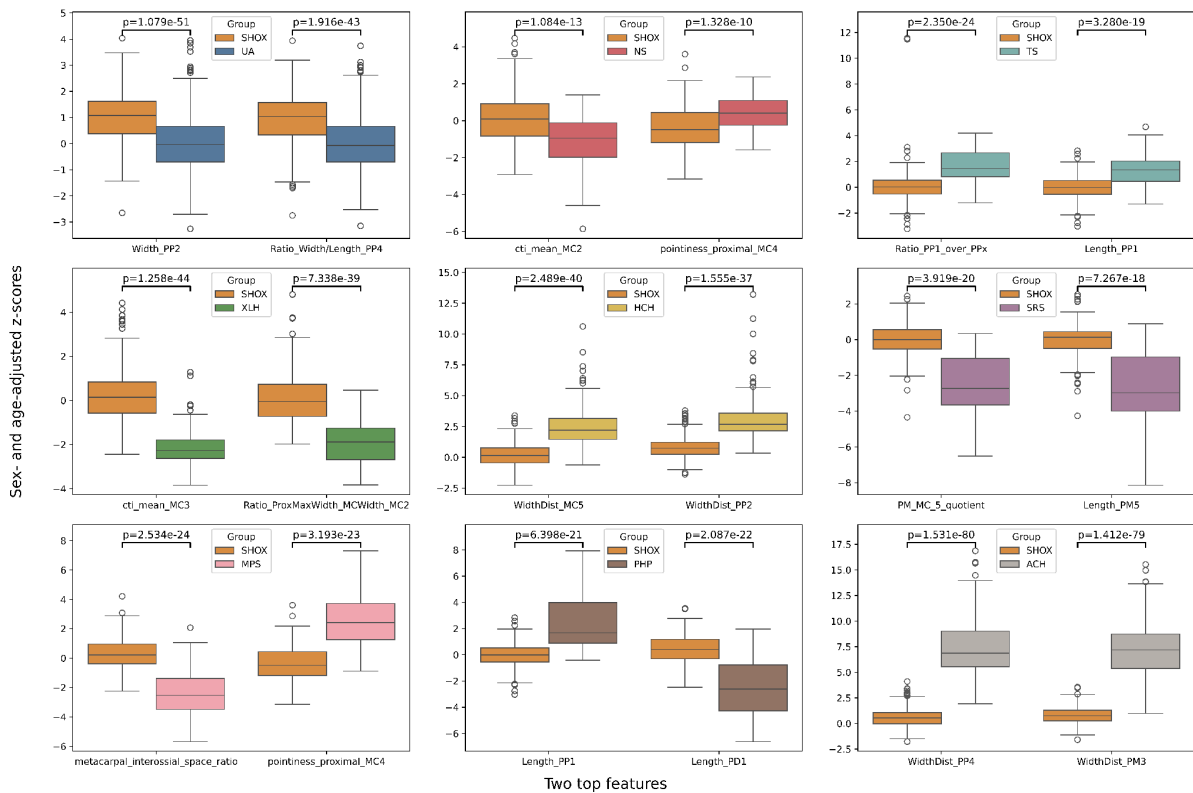


**Supplementary Figure 5** Confidence score boxplot of the 10 cohorts test sets on the 10 class soft majority meta-classifier of their true class. (of Cohort A only class A scores are shown). The maximum confidence scores that can be achieved is  $1 + 9 * (1 + 1/9) = 11$ . The mean confidence is  $55/10 = 5.5$ . Note the difference in scattering between the different classes (ACH, HCH and UA vs SRS)

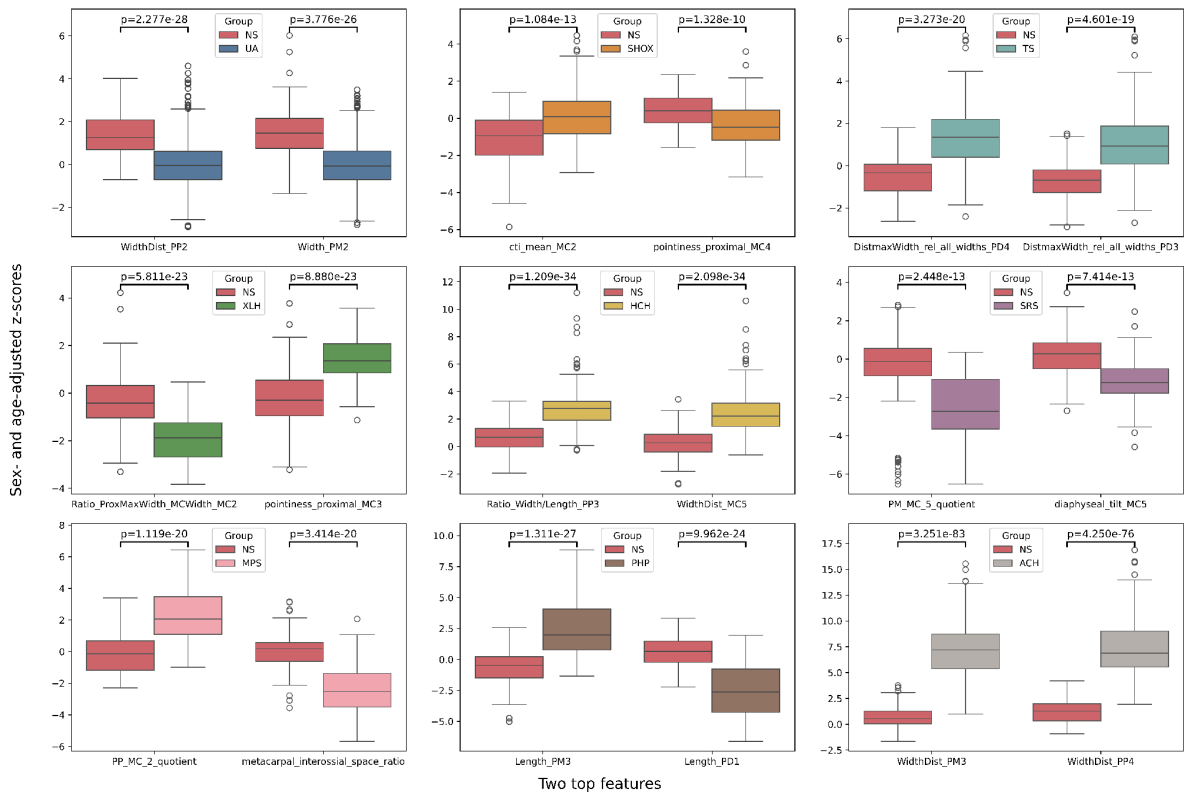
### UMAP projection of feature space with disease-specific highlighted features



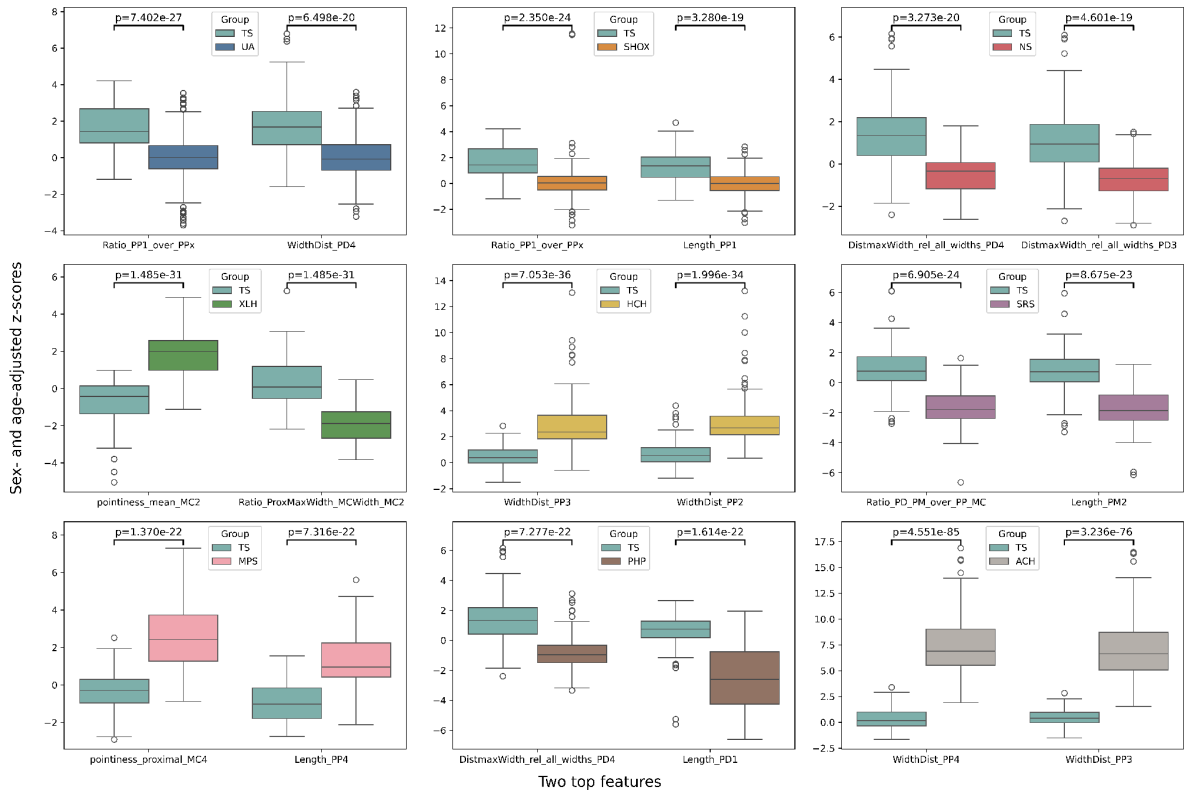
**Supplementary Figure 6.** UMAP projection of the 550-dimensional interpretable morphometric feature space. Each point represents a single morphometric feature embedded into two dimensions using UMAP (Manhattan distance). White points with black outlines indicate features not selected as most discriminative for any specific condition (“other features”). Colored points highlight the top discriminative features for individual disease cohorts (UA vs. SHOX, SRS, NS, XLH, TS, HCH, MPS, PHP, and ACH), as identified in the corresponding one-vs-UA SVM models. The clustering illustrates that disease-specific features occupy distinct regions within the global feature space. UMAP visualization showed that discriminative features for achondroplasia and hypochondroplasia cluster closely together, while features associated with XLH and MPS partially overlap, whereas TS displayed a more widely distributed feature pattern (Figure 6). An interactive version is available here: <https://bone2gene.github.io/Morphometric-Bone2Gene/>



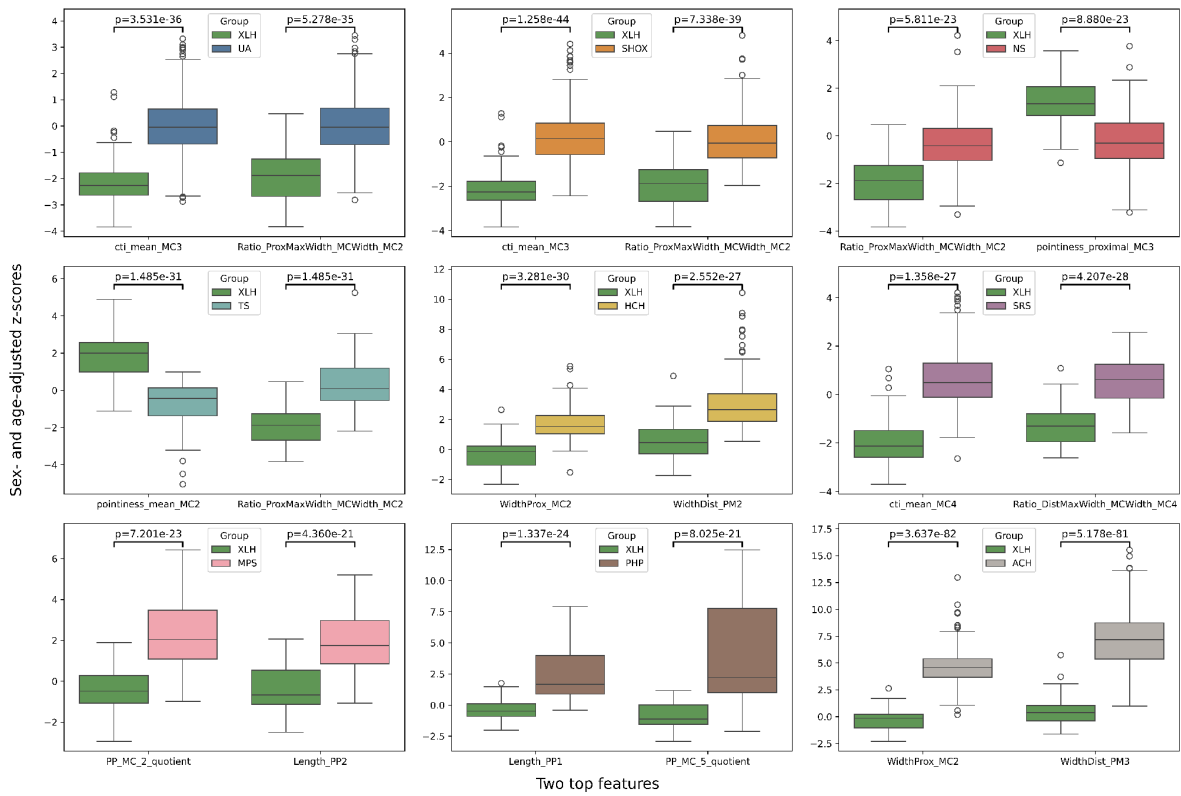
**Supplementary Figure 7 Boxplots of the top-ranked features in the nine “SHOX vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare SHOX images to each condition (UA, NS, TS, XLH, SRS, HCH, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



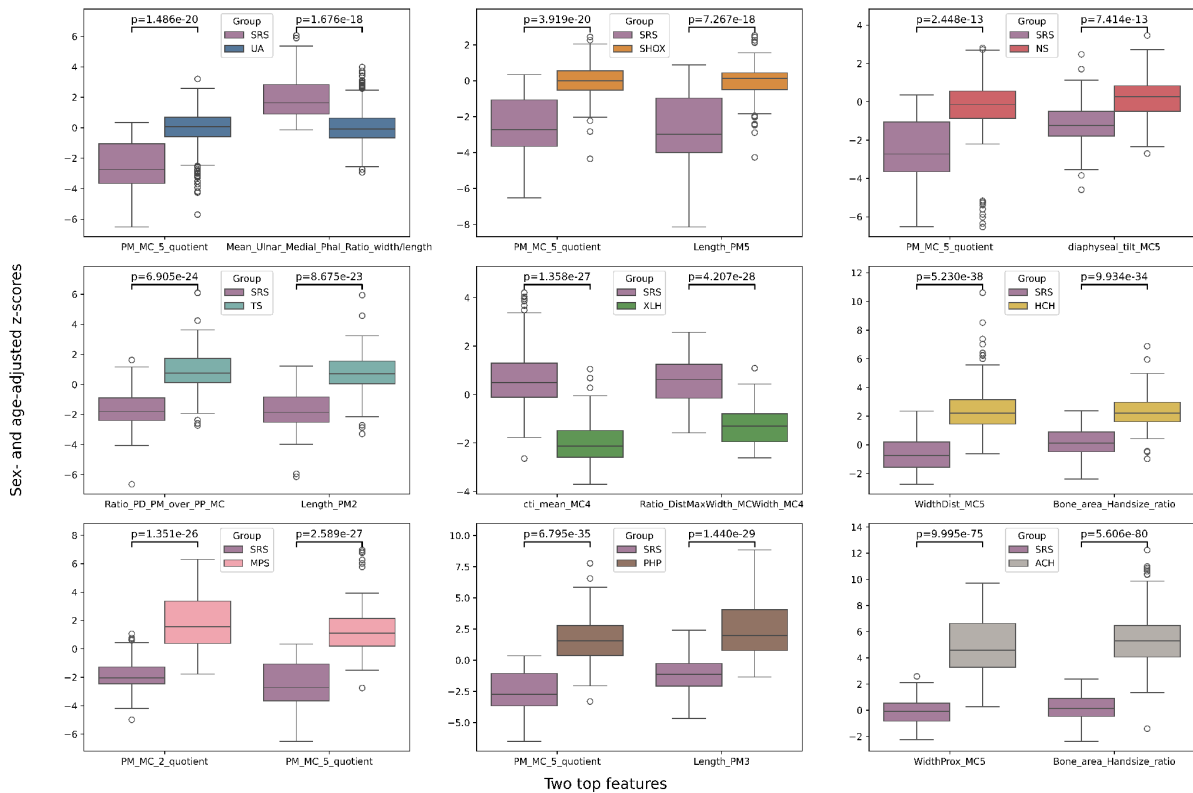
**Supplementary Figure 8 Boxplots of the top-ranked features in the nine “NS vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare NS images to each condition (UA, SHOX, TS, XLH, SRS, HCH, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



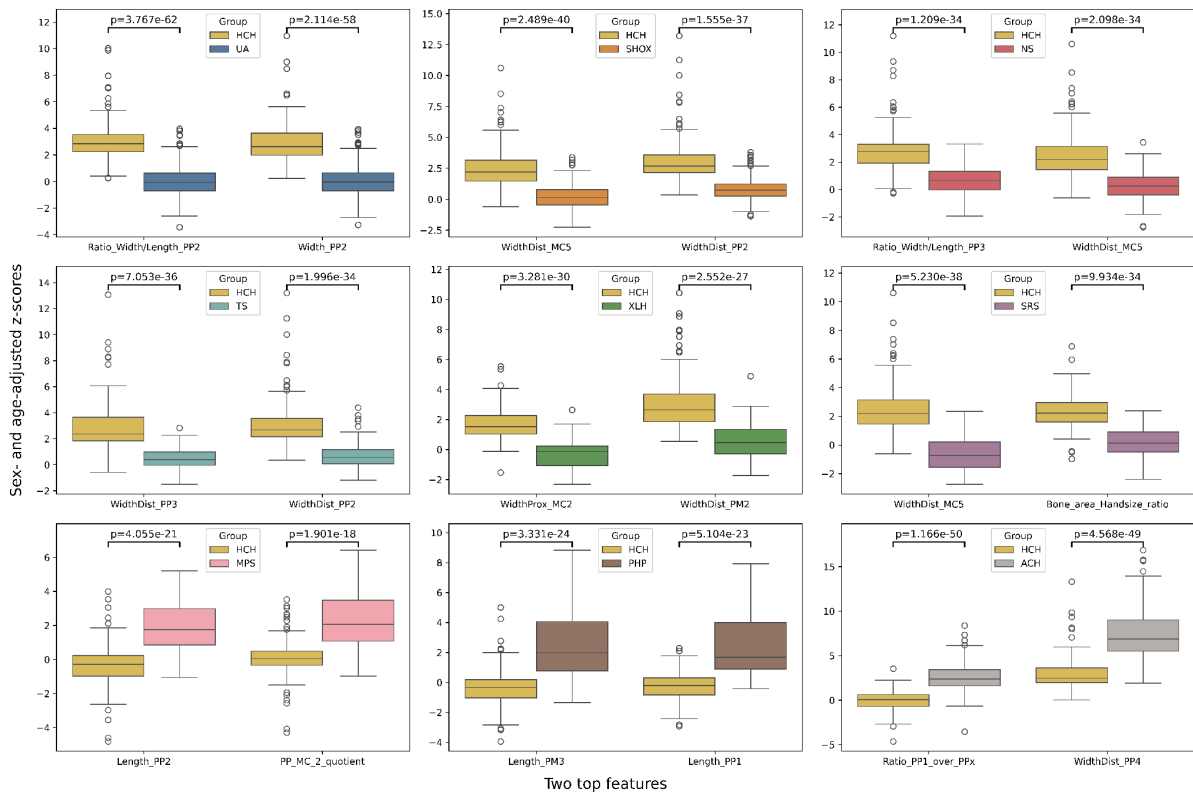
**Supplementary Figure 9 Boxplots of the top-ranked features in the nine “TS vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare TS images to each condition (UA, SHOX, NS, XLH, SRS, HCH, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



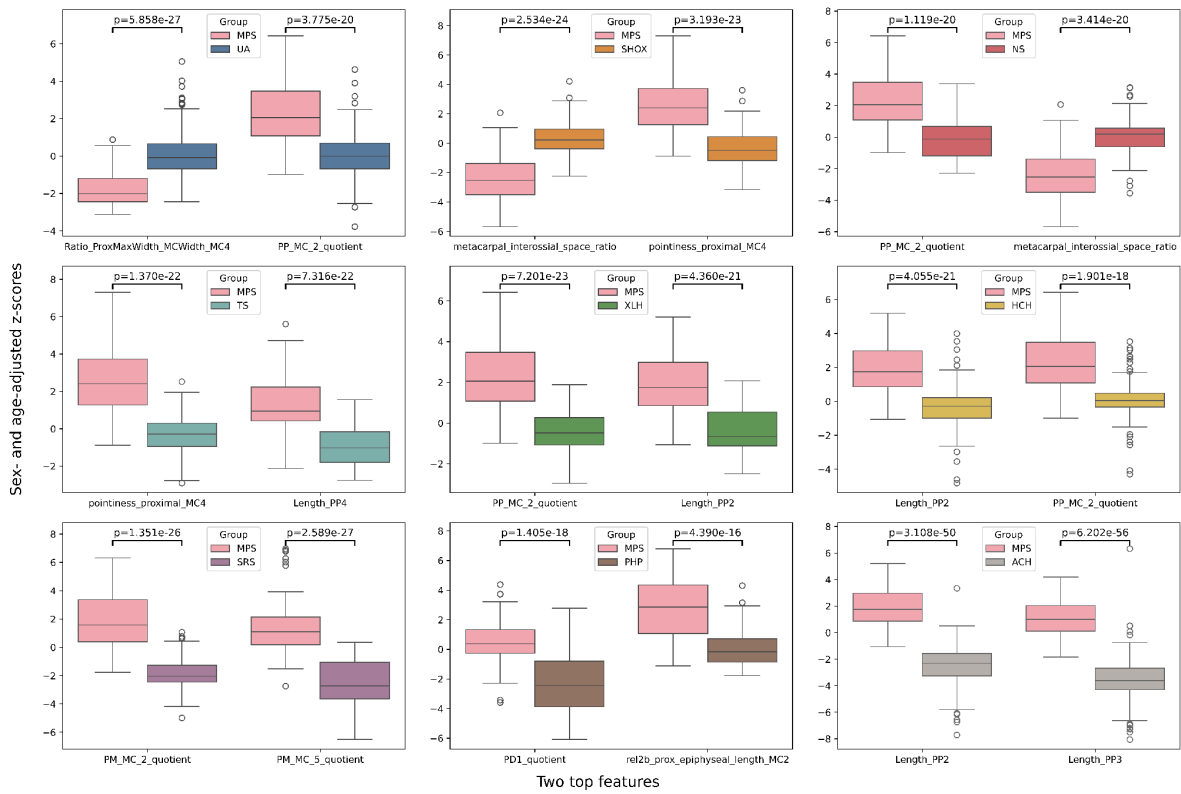
**Supplementary Figure 10** Boxplots of the top-ranked features in the nine “XLH vs One” scenarios. Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare XLH images to each condition (UA, SHOX, NS, TS, SRS, HCH, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



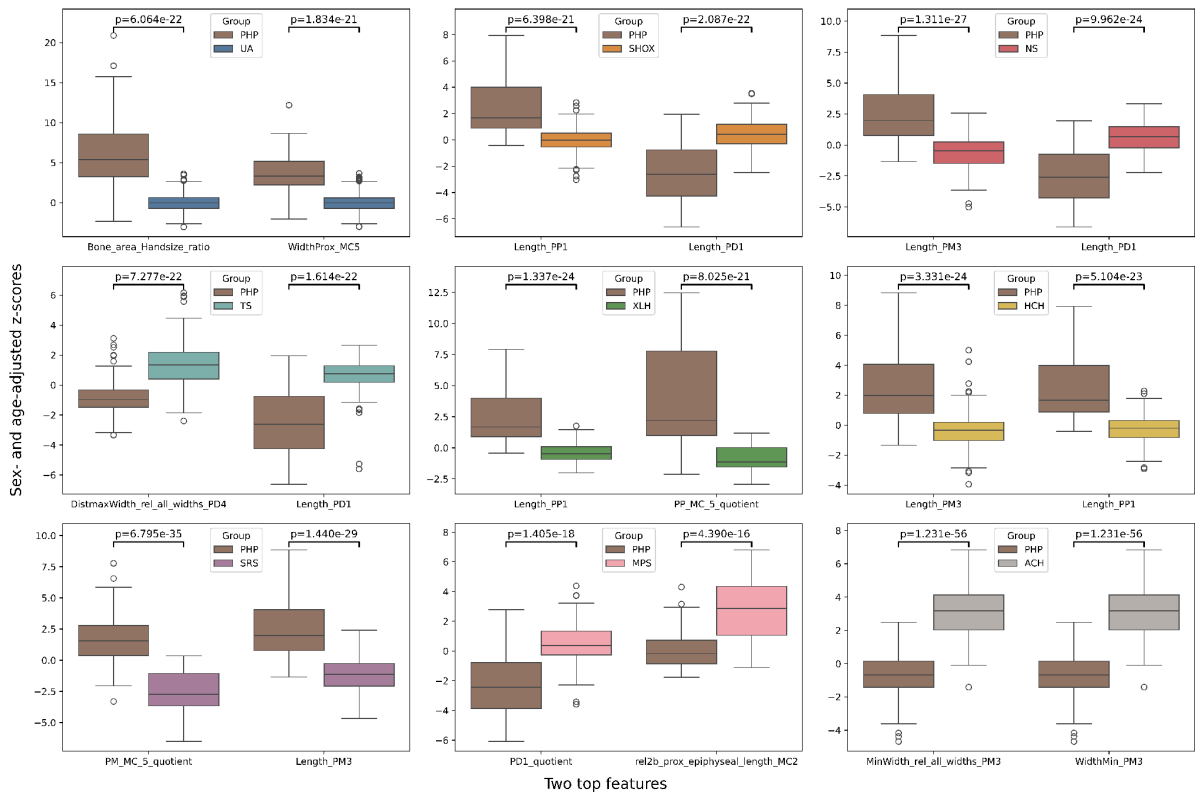
**Supplementary Figure 11 Boxplots of the top-ranked features in the nine “SRS vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare SRS images to each condition (UA, SHOX, NS, TS, XLH, HCH, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



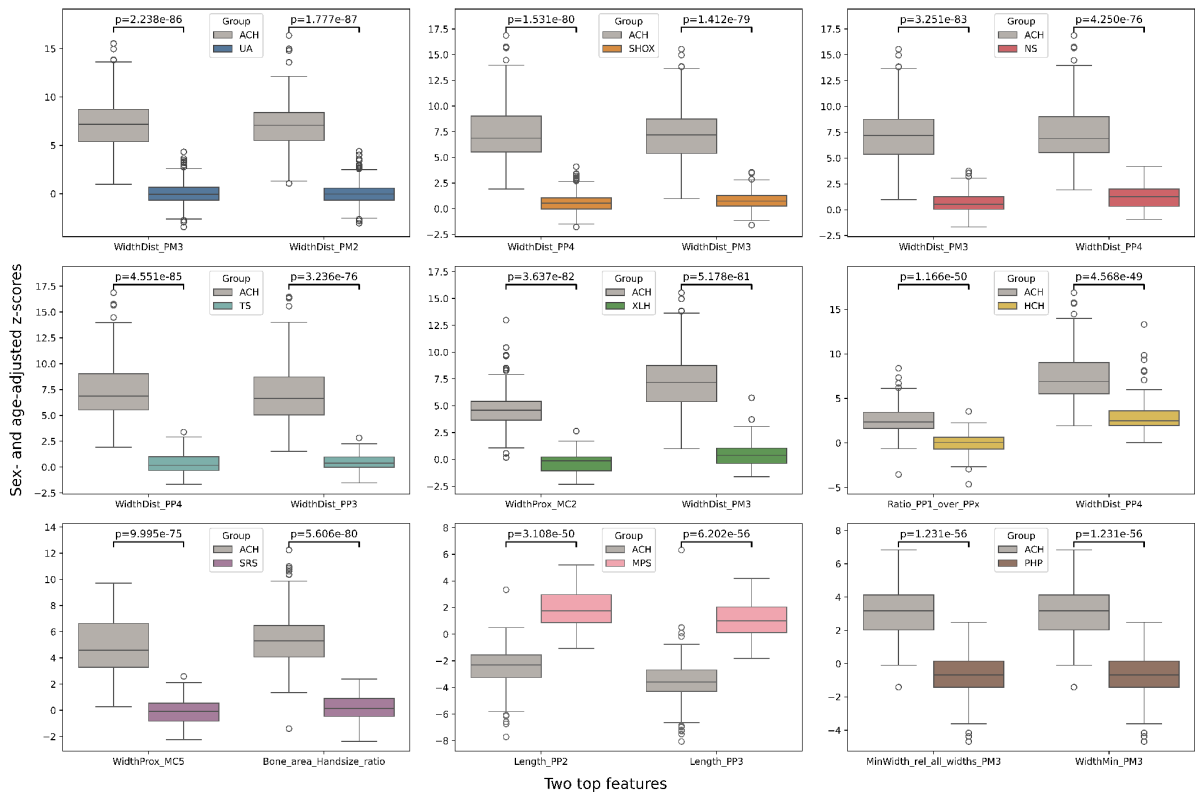
**Supplementary Figure 12 Boxplots of the top-ranked features in the nine “HCH vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare HCH images to each condition (UA, SHOX, NS, TS, XLH, SRS, MPS, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



**Supplementary Figure 13 Boxplots of the top-ranked features in the nine “MPS vs One” scenarios.** Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare MPS images to each condition (UA, SHOX, NS, TS, XLH, SRS, HCH, PHP, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



**Supplementary Figure 14** Boxplots of the top-ranked features in the nine “PHP vs One” scenarios. Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare PHP images to each condition (UA, SHOX, NS, TS, XLH, SRS, HCH, MPS, and ACH). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (teal), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.



**Supplementary Figure 15** Boxplots of the top-ranked features in the nine “ACH vs One” scenarios. Each y-axis shows the sex- and age-adjusted z-score relative to the UA reference set. The nine scenarios compare ACH images to each condition (UA, SHOX, NS, TS, XLH, SRS, HCH, MPS, and PHP). Feature ranking was derived by summing the ROC-based rank and the t-test-based rank. Box colors indicate diagnostic groups: UA (blue), SHOX (orange), NS (red), TS (yellow), XLH (green), SRS (red), HCH (purple), MPS (pink), PHP (brown), and ACH (grey). Benjamini-Hochberg-adjusted p-values for each pairwise comparison are shown in brackets above the box pairs.

<b>Cohort</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Median</b>	<b>Q1</b>	<b>Q3</b>	<b>Min</b>	<b>Max</b>
UA	1353	23.15	5.00	22.59	20.52	25.05	15.15	145.59
SHOX	317	27.82	6.99	26.60	23.90	29.59	18.64	89.25
NS	134	33.17	11.46	30.72	26.30	37.13	21.65	107.87
TS	111	33.68	10.03	30.92	27.66	36.12	16.59	67.72
XLH	87	32.27	6.30	31.36	27.62	37.44	20.96	57.58
HCH	170	36.17	21.39	31.59	27.84	36.66	21.74	273.67
SRS	86	36.26	14.83	33.49	29.80	39.05	21.99	142.20
MPS	85	128.39	230.79	46.77	35.70	68.24	20.45	1384.07
PHP	104	55.14	28.78	52.10	38.46	66.79	20.12	228.28
ACH	189	63.93	26.67	58.02	50.99	71.03	25.89	256.33
additional conditions	18	35.60	11.99	33.25	26.03	41.58	22.65	63.69

**Supplementary Table 1:** Euclidean radii of hand radiographs in the 550-dimensional feature space.

Descriptive statistics (mean, standard deviation, median, first and third quartiles, minimum, and maximum) of the Euclidean radius for each cohort or condition. The radius reflects the distance of each sample from the UA train/reference in the standardized mean vector high-dimensional phenotypic space. The set of additional conditions consists of 2 radiographs for each of the following conditions: ACAN-related short stature, Digorge syndrome, Down syndrome, Hypophosphatasia, KBG syndrome, Léri-Weill dyschondrosteosis, Maffucci syndrome, Osteogenesis imperfecta, type I, Pseudoachondroplasia.

Cohort	Feature	Number of scenarios	mean combined rank	
UA	Width_PP2	2	4.5	HCH_Hea, Hea_SHO
UA	WidthDist_PP2	2	6	HCH_Hea, Hea_Noo
UA	WidthDist_PM2	2	7.5	ACH_Hea, Hea_SHO
SHOX	pointiness_proximal_MC4	2	4	MPS_SHO, Noo_SHO
SHOX	Length_PP1	2	4	PHP_SHO, SHO_Tur
SHOX	metacarpal_interossial_space_ratio	2	4	MPS_SHO, PHP_SHO
SRS	PM_MC_5_quotient	5	2.4	Hea_SRS, MPS_SRS, Noo_SRS, PHP_SRS, SHO_SRS
SRS	PM_MC_2_quotient	2	4	Hea_SRS, MPS_SRS
SRS	Ratio_PD_PM_over_PP_MC	1	4	SHO_SRS, SRS_Tur
NS	metacarpal_interossial_space_ratio	2	6	MPS_Noo, Noo_XLH
NS	cti_mean_MC2	1	2	Noo_SHO
NS	PM_MC_5_quotient	1	2	Noo_SRS
XLH	Ratio_ProxMaxWidth_MCWidth_MC2	4	3.75	Hea_XLH, Noo_XLH, SHO_XLH, Tur_XLH
XLH	cti_mean_MC4	3	5	Hea_XLH, SHO_XLH, SRS_XLH
XLH	cti_mean_MC3	2	2	Hea_XLH, SHO_XLH
TS	Ratio_PP1_over_PPx	2	2	Hea_Tur, SHO_Tur
TS	DistmaxWidth_rel_all_widths_PD4	2	2.5	Noo_Tur, PHP_Tur
TS	WidthDist_PP3	2	3	ACH_Tur, HCH_Tur
HCH	WidthDist_MC5	3	3.666666666666667	HCH_Noo, HCH_SHO, HCH_SRS
HCH	WidthDist_PP2	3	6.333333333333333	HCH_Hea, HCH_SHO, HCH_Tur
HCH	WidthProx_MC2	2	4	ACH_HCH, HCH_XLH
ACH	WidthDist_PP4	6	4.666666666666667	ACH_HCH, ACH_Hea, ACH_Noo, ACH_SHO, ACH_Tur, ACH_XLH
ACH	WidthDist_PM3	5	5.4	ACH_Hea, ACH_Noo, ACH_SHO, ACH_SRS, ACH_XLH
ACH	WidthDist_PM2	4	7	ACH_Hea, ACH_Noo, ACH_SHO, ACH_Tur
PHP	Length_PP1	4	4.25	HCH_PHP, Hea_PHP, PHP_SHO, PHP_XLH
PHP	Length_PD1	4	5.5	MPS_PHP, Noo_PHP, PHP_SHO, PHP_Tur
PHP	Length_PM3	3	3.666666666666667	HCH_PHP, Noo_PHP, PHP_SRS
MPS	PP_MC_2_quotient	5	4.6	HCH_MPS, Hea_MPS, MPS_Noo, MPS_SRS, MPS_XLH
MPS	Length_PP2	3	3.666666666666667	ACH_MPS, HCH_MPS, MPS_XLH
MPS	metacarpal_interossial_space_ratio	3	5.333333333333333	Hea_MPS, MPS_Noo, MPS_SHO

**Supplementary Table 2: Top 3 discriminative features per affected cohort derived from its 9 pairwise one-vs-one comparisons with other cohorts.** The final ranking per disorder reflects how frequently a feature appeared among the top three features across the relevant OvO scenarios.

Scenario	Feature name	n (radiographs) Group1/ Group2	Mean(SD) score Group1/Group2	Mean(SD) Group1/Group2 (Z-score)	Absolute Hedges' g	Absolute T-score	adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
UA vs SHOX	Width_PP2	1353 / 317	0.014 (0.002) / 0.016 (0.002)	0.004 (1.001) / 1.018 (0.906)	1.061	17.6	1.079e-51	1	0.778	1	1
UA vs SHOX	Ratio_Width/ Length_PP4	1353 / 317	0.213 (0.034) / 0.24 (0.026)	0.006 (0.994) / 0.939 (0.938)	0.966	15.8	1.916e-43	2	0.759	4	3
UA vs SHOX	WidthDist_PM2	1353 / 317	0.013 (0.001) / 0.014 (0.001)	0.003 (0.998) / 0.898 (0.901)	0.942	15.6	3.705e-43	4	0.755	5	4.5
UA vs NS	Width_PM2	1353 / 134	0.012 (0.002) / 0.014 (0.002)	0.005 (1.003) / 1.495 (1.215)	1.337	13.7	3.776e-26	2	0.835	2	2
UA vs NS	WidthDist_PP2	1353 / 134	0.016 (0.002) / 0.018 (0.001)	0.005 (1.005) / 1.381 (1.045)	1.342	14.6	2.277e-28	1	0.834	3	2
UA vs NS	Width_PM4	1353 / 134	0.013 (0.002) / 0.014 (0.002)	0.009 (1.000) / 1.276 (1.029)	1.248	13.6	3.776e-26	3	0.818	5	4
UA vs TS	Ratio_PP1_ over_PPx	1353 / 111	0.769 (0.044) / 0.821 (0.038)	0.006 (0.997) / 1.702 (1.157)	1.569	15	7.402e-27	1	0.87	1	1
UA vs TS	WidthDist_PD4	1353 / 111	0.01 (0.001) / 0.011 (0.002)	0.007 (0.995) / 1.701 (1.464)	1.352	12	6.498e-20	3	0.842	2	2.5
UA vs TS	Ratio_DistMaxWidth_M CWidth_PD4	1353 / 111	1.28 (0.117) / 1.48 (0.196)	0.012 (0.992) / 1.937 (1.734)	1.362	11.5	4.341e-19	5	0.835	3	4
UA vs XLH	cti_mean_MC3	1353 / 87	0.5 (0.092) / 0.362 (0.067)	-0.003 (0.993) / -2.147 (0.904)	2.256	21.3	3.531e-36	1	0.942	1	1
UA vs XLH	Ratio_ProxMaxWidth_M CWidth_MC2	1353 / 87	1.95 (0.257) / 1.64 (0.217)	-0.001 (0.995) / -1.961 (0.869)	2.097	20.2	5.278e-35	2	0.933	2	2
UA vs XLH	cti_mean_MC4	1353 / 87	0.501 (0.091) / 0.372 (0.067)	-0.003 (0.998) / -2.020 (0.923)	2.098	19.7	5.372e-34	4	0.929	3	3.5
UA vs HCH	Ratio_Width/ Length_PP2	1353 / 170	0.233 (0.035) / 0.305 (0.055)	0.005 (1.000) / 3.032 (1.470)	2.406	26.1	3.767e-62	2	0.974	2	2
UA vs HCH	Width_PP2	1353 / 170	0.014 (0.002) / 0.018 (0.004)	0.004 (1.001) / 2.894 (1.492)	2.273	24.6	2.114e-58	3	0.967	4	3.5
UA vs HCH	WidthDist_PP2	1353 / 170	0.016 (0.002) / 0.02 (0.003)	0.005 (1.005) / 3.137 (1.749)	2.195	22.9	9.072e-54	7	0.977	1	4
UA vs SRS	PM_MC_5_ quotient	1353 / 86	0.362 (0.035) / 0.272 (0.06)	0.010 (0.991) / -2.636 (1.813)	1.809	13.4	1.486e-20	2	0.901	1	1.5
UA vs SRS	PM_MC_2_ quotient	1353 / 86	0.347 (0.022) / 0.313 (0.024)	0.001 (1.006) / -1.722 (1.161)	1.585	13.4	8.325e-21	1	0.862	4	2.5
UA vs SRS	Mean_Ulnar_Medial_Ph al_Ratio_wi dth/length	1353 / 86	0.337 (0.06) / 0.424 (0.07)	0.003 (0.997) / 1.974 (1.477)	1.563	12.2	1.676e-18	3	0.882	2	2.5
UA vs MPS	Ratio_ProxMaxWidth_M CWidth_MC4	1353 / 85	1.81 (0.303) / 1.27 (0.295)	-0.008 (0.997) / -1.766 (0.953)	1.803	16.5	5.858e-27	1	0.894	3	2
UA vs MPS	PP_MC_2_ quotient	1353 / 85	0.609 (0.031) / 0.682 (0.052)	-0.003 (0.995) / 2.348 (1.671)	1.709	12.8	3.775e-20	5	0.897	2	3.5
UA vs MPS	metacarpal_interossial_ space_ratio	1353 / 85	0.89 (0.125) / 0.59 (0.205)	-0.011 (0.993) / -2.368 (1.618)	1.755	13.3	1.099e-20	4	0.885	6	5
UA vs PHP	Bone_area_Handsize_ratio	1353 / 104	0.033 (0.002) / 0.044 (0.008)	0.000 (0.992) / 5.672 (4.262)	1.832	13.5	6.064e-22	1	0.89	1	1

<b>UA vs PHP</b>	WidthProx_MC5	1353 / 104	0.019 (0.002) / 0.024 (0.004)	-0.002 (0.999) / 3.449 (2.666)	1.713	13.1	1.834e-21	2	0.869	4	3
<b>UA vs PHP</b>	Length_PP1	1353 / 104	0.047 (0.002) / 0.051 (0.004)	0.003 (0.996) / 2.445 (1.981)	1.557	12.5	1.378e-20	6	0.881	2	4
<b>UA vs ACH</b>	WidthDist_PM3	1353 / 189	0.014 (0.002) / 0.021 (0.003)	0.008 (0.994) / 7.438 (2.800)	3.535	36.2	2.238e-86	2	0.999	3	2.5
<b>UA vs ACH</b>	WidthDist_PP4	1353 / 189	0.016 (0.002) / 0.024 (0.003)	0.004 (0.998) / 7.374 (2.840)	3.46	35.4	8.110e-85	5	0.999	1	3
<b>UA vs ACH</b>	WidthDist_PM2	1353 / 189	0.013 (0.001) / 0.019 (0.003)	0.003 (0.998) / 7.109 (2.637)	3.563	36.7	1.777e-87	1	0.998	5	3

**Supplementary Table 3.**

**Statistics of the highest-ranked features for differentiating between UA and each affected class.**

The table lists the three highest-ranked features for each “UA vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/ Group2	Mean(SD) Group1/Group2	Mean(SD) Z-score Group1/Group2	Absolute Hedg es' g	Absolute T-score	Benjamin i-Hochber g adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combine d Rank
<b>SHOX vs UA</b>	Width_PP2	317 / 1350	0.016 (0.002) / 0.014 (0.002)	1.018 (0.906) / 0.004 (1.001)	1.061	17.6	1.079e-51	1	0.778	1	1
<b>SHOX vs UA</b>	Ratio_Width/L ength_PP4	317 / 1350	0.24 (0.026) / 0.213 (0.034)	0.939 (0.938) / 0.006 (0.994)	0.966	15.8	1.916e-43	2	0.759	4	3
<b>SHOX vs UA</b>	WidthDist_PM 2	317 / 1350	0.014 (0.001) / 0.013 (0.001)	0.898 (0.901) / 0.003 (0.998)	0.942	15.6	3.705e-43	4	0.755	5	4.5
<b>SHOX vs NS</b>	cti_mean_MC2	317 / 134	0.514 (0.08) / 0.462 (0.082)	0.109 (1.320) / -1.083 (1.309)	0.905	8.8	1.084e-13	1	0.731	1	1
<b>SHOX vs NS</b>	pointiness_pro ximal_MC4	317 / 134	0.795 (0.068) / 0.829 (0.065)	-0.377 (1.102) / 0.391 (0.931)	0.752	7.6	1.328e-10	2	0.703	2	2
<b>SHOX vs NS</b>	Ratio_DistMax Width_MCWidt h_PD1	317 / 134	0.924 (0.086) / 0.877 (0.077)	0.004 (1.147) / -0.764 (0.933)	0.734	7.4	1.778e-10	3	0.69	3	3
<b>SHOX vs TS</b>	Ratio_PP1_ov er_PPx	317 / 111	0.763 (0.051) / 0.821 (0.038)	0.073 (1.236) / 1.702 (1.157)	1.358	12.5	2.350e-24	1	0.887	1	1
<b>SHOX vs TS</b>	Length_PP1	317 / 111	0.046 (0.002) / 0.049 (0.002)	-0.033 (0.886) / 1.353 (1.204)	1.31	11.1	3.280e-19	2	0.824	2	2
<b>SHOX vs TS</b>	Ratio_DistMax Width_MCWidt h_PD4	317 / 111	1.25 (0.146) / 1.48 (0.196)	-0.074 (1.391) / 1.937 (1.734)	1.277	11	3.280e-19	3	0.823	3	3
<b>SHOX vs XLH</b>	cti_mean_MC3	317 / 87	0.482 (0.08) / 0.362 (0.067)	0.214 (1.200) / -2.147 (0.904)	2.217	20	1.258e-44	1	0.946	1	1

SHOX vs XLH	Ratio_ProxMaxWidth_MCWidth_MC2	317 / 87	1.92 (0.266) / 1.64 (0.217)	0.058 (1.072) / -1.961 (0.869)	2.065	18.2	7.338e-39	2	0.938	2	2
SHOX vs XLH	cti_mean_MC4	317 / 87	0.471 (0.072) / 0.372 (0.067)	0.033 (1.105) / -2.020 (0.923)	2.013	17.6	5.584e-37	3	0.926	3	3
SHOX vs HCH	WidthDist_MC5	317 / 170	0.017 (0.002) / 0.02 (0.003)	0.181 (0.979) / 2.503 (1.638)	1.718	16.9	2.489e-40	1	0.92	4	2.5
SHOX vs HCH	WidthDist_PP2	317 / 170	0.017 (0.001) / 0.02 (0.003)	0.816 (0.870) / 3.137 (1.749)	1.678	16.3	1.555e-37	5	0.936	1	3
SHOX vs HCH	WidthDist_MC4	317 / 170	0.018 (0.002) / 0.021 (0.003)	0.157 (0.977) / 2.407 (1.585)	1.706	16.9	2.489e-40	2	0.911	6	4
SHOX vs SRS	PM_MC_5_quotient	317 / 86	0.358 (0.03) / 0.272 (0.06)	-0.016 (0.875) / -2.636 (1.813)	1.837	13	3.919e-20	1	0.904	1	1
SHOX vs SRS	Length_PM5	317 / 86	0.028 (0.002) / 0.022 (0.005)	-0.013 (0.833) / -2.839 (2.192)	1.701	11.7	7.267e-18	2	0.879	2	2
SHOX vs SRS	Ratio_PD_PM_over_PP_MC	317 / 86	0.417 (0.019) / 0.385 (0.024)	0.125 (1.079) / -1.711 (1.341)	1.506	11.7	5.636e-19	3	0.862	3	3
SHOX vs MPS	metacarpal_interosial_space_ratio	317 / 85	0.922 (0.132) / 0.59 (0.205)	0.310 (1.013) / -2.368 (1.618)	1.98	14.5	2.534e-24	1	0.914	1	1
SHOX vs MPS	pointiness_proximal_MC4	317 / 85	0.795 (0.068) / 0.968 (0.12)	-0.377 (1.102) / 2.454 (1.782)	1.907	13.9	3.193e-23	2	0.908	2	2
SHOX vs MPS	proximal_radial_area/ellips_area/prox_MC4	317 / 85	1.69 (0.172) / 1.38 (0.221)	0.277 (1.069) / -1.683 (1.191)	1.728	13.8	2.534e-24	3	0.889	3	3
SHOX vs PHP	Length_PP1	317 / 104	0.046 (0.002) / 0.051 (0.004)	-0.033 (0.886) / 2.445 (1.981)	1.613	12.4	6.398e-21	3	0.902	1	2
SHOX vs PHP	Length_PD1	317 / 104	0.035 (0.002) / 0.031 (0.004)	0.474 (1.036) / -2.494 (2.225)	1.707	13.1	2.087e-22	2	0.868	3	2.5
SHOX vs PHP	metacarpal_interosial_space_ratio	317 / 104	0.922 (0.132) / 0.7 (0.167)	0.310 (1.013) / -1.479 (1.255)	1.565	13.2	4.210e-24	1	0.862	5	3
SHOX vs ACH	WidthDist_PP4	317 / 189	0.017 (0.002) / 0.024 (0.003)	0.584 (0.923) / 7.374 (2.840)	3.211	31.9	1.531e-80	1	0.998	1	1
SHOX vs ACH	WidthDist_PM3	317 / 189	0.015 (0.001) / 0.021 (0.003)	0.803 (0.807) / 7.438 (2.800)	3.216	31.8	1.412e-79	2	0.997	3	2.5
SHOX vs ACH	WidthDist_PM2	317 / 189	0.014 (0.001) / 0.019 (0.003)	0.898 (0.901) / 7.109 (2.637)	3.147	31.3	8.634e-80	3	0.993	5	4

**Supplementary Table 4.**

**Statistics of the highest-ranked features for differentiating between SHOX and each other class.**

The table lists the three highest-ranked features for each “SHOX vs One” scenario. *n* denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/Group2	Mean(SD) Group1/Group2	Mean(SD) Z-score Group1/Group2	absolut Hedges' g	Absolute T-score	Benjamin i-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combine d Rank
NS vs UA	Width_PM2	134 / 1350	0.014 (0.002) / 0.012 (0.002)	1.49 (1.21) / 0.005 (1.0)	1.337	13.7	3.776e-26	2	0.835	2	2
NS vs UA	WidthDist_PP2	134 / 1350	0.018 (0.001) / 0.016 (0.002)	1.38 (1.05) / 0.005 (1.01)	1.342	14.6	2.277e-28	1	0.834	3	2
NS vs UA	Width_PM4	134 / 1350	0.014 (0.002) / 0.013 (0.002)	1.28 (1.03) / 0.009 (1.0)	1.248	13.6	3.776e-26	3	0.818	5	4
NS vs SHOX	cti_mean_MC2	134 / 317	0.462 (0.082) / 0.514 (0.08)	-1.08 (1.31) / 0.109 (1.32)	0.905	8.8	1.084e-13	1	0.731	1	1
NS vs SHOX	pointiness_proximal_MC4	134 / 317	0.829 (0.065) / 0.795 (0.068)	0.391 (0.931) / -0.377 (1.1)	0.752	7.6	1.328e-10	2	0.703	2	2
NS vs SHOX	Ratio_DistMaxWidth_MCWidth_PD1	134 / 317	0.877 (0.077) / 0.924 (0.086)	-0.764 (0.933) / 0.004 (1.15)	0.734	7.4	1.778e-10	3	0.69	3	3
NS vs TS	DistmaxWidth_rel_all_widths_PD4	134 / 111	0.044 (0.004) / 0.052 (0.007)	-0.49 (0.879) / 1.39 (1.53)	1.506	11.5	3.273e-20	1	0.874	1	1
NS vs TS	DistmaxWidth_rel_all_widths_PD3	134 / 111	0.043 (0.004) / 0.051 (0.007)	-0.723 (0.871) / 1.16 (1.61)	1.449	11	4.601e-19	2	0.867	2	2
NS vs TS	DistmaxWidth_rel_all_widths_PD2	134 / 111	0.037 (0.004) / 0.044 (0.007)	-0.65 (0.931) / 1.0 (1.55)	1.287	9.8	1.589e-16	4	0.841	3	3.5
NS vs XLH	Ratio_ProxMaxWidth_MCWidth_MC2	134 / 87	1.88 (0.286) / 1.64 (0.217)	-0.355 (1.11) / -1.96 (0.869)	1.607	12	5.811e-23	1	0.886	1	1
NS vs XLH	pointiness_proximal_MC3	134 / 87	0.82 (0.061) / 0.896 (0.045)	-0.231 (1.16) / 1.43 (0.912)	1.586	11.9	8.880e-23	2	0.874	2	2
NS vs XLH	metacarpal_interossial_space_ratio	134 / 87	0.893 (0.139) / 0.69 (0.14)	-0.001 (1.09) / -1.71 (1.15)	1.525	11	6.007e-20	5	0.871	3	4
NS vs HCH	Ratio_Width/Length_PP3	134 / 170	0.228 (0.023) / 0.28 (0.054)	0.592 (1.04) / 2.86 (1.62)	1.665	14.8	1.209e-34	1	0.916	1	1
NS vs HCH	WidthDist_MC5	134 / 170	0.017 (0.002) / 0.02 (0.003)	0.257 (1.01) / 2.5 (1.64)	1.648	14.7	2.098e-34	2	0.912	2	2
NS vs HCH	Ratio_Width/Length_PP2	134 / 170	0.253 (0.023) / 0.305 (0.055)	0.985 (1.0) / 3.03 (1.47)	1.622	14.4	1.062e-33	3	0.9	3	3
NS vs SRS	PM_MC_5_quotient	134 / 86	0.346 (0.058) / 0.272 (0.06)	-0.387 (1.84) / -2.64 (1.81)	1.228	8.9	2.448e-13	1	0.83	1	1
NS vs SRS	diaphyseal_tilt_MC5	134 / 86	1.02 (0.035) / 0.973 (0.036)	0.198 (1.1) / -1.18 (1.18)	1.206	8.7	7.414e-13	2	0.811	3	2.5
NS vs SRS	Length_PM5	134 / 86	0.027 (0.004) / 0.022 (0.005)	-0.466 (1.95) / -2.84 (2.19)	1.139	8.2	6.742e-12	6	0.815	2	4
NS vs MPS	PP_MC_2_quotient	134 / 85	0.605 (0.036) / 0.682 (0.052)	-0.173 (1.19) / 2.35 (1.67)	1.734	12.1	1.119e-20	1	0.897	1	1
NS vs MPS	metacarpal_interossial_space_ratio	134 / 85	0.893 (0.139) / 0.59 (0.205)	-0.001 (1.09) / -2.37 (1.62)	1.712	11.9	3.414e-20	2	0.886	2	2
NS vs MPS	Length_MC2	134 / 85	0.102 (0.004) / 0.096 (0.005)	0.54 (1.35) / -1.7 (1.59)	1.512	10.8	2.535e-18	3	0.861	4	3.5
NS vs PHP	Length_PM3	134 / 104	0.041 (0.002) / 0.046 (0.003)	-0.774 (1.43) / 2.41 (1.96)	1.844	13.9	1.311e-27	1	0.921	1	1
NS vs PHP	Length_PD1	134 / 104	0.035 (0.002) / 0.031 (0.004)	0.625 (1.13) / -2.49 (2.23)	1.762	13	9.962e-24	2	0.876	3	2.5
NS vs PHP	Bone_area_Handsize_ratio	134 / 104	0.034 (0.002) / 0.044 (0.008)	0.776 (0.945) / 5.67 (4.26)	1.581	11.5	1.307e-18	3	0.872	4	3.5
NS vs ACH	WidthDist_PM3	134 / 189	0.015 (0.001) / 0.021 (0.003)	0.713 (0.992) / 7.44 (2.8)	3.195	30.4	3.251e-83	1	0.996	2	1.5

NS vs ACH	WidthDist_PP4	134 / 189	0.017 (0.002) / 0.024 (0.003)	1.18 (1.08) / 7.37 (2.84)	2.875	27.3	4.250e-76	4	0.996	1	2.5
NS vs ACH	WidthDist_PM2	134 / 189	0.014 (0.001) / 0.019 (0.003)	1.23 (1.04) / 7.11 (2.64)	2.924	27.7	7.279e-78	2	0.987	5	3.5

**Supplementary Table 5.**

**Statistics of the highest-ranked features for differentiating between NS and each other class.**

The table lists the three highest-ranked features for each “NS vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1 /Group 2	Mean(SD) Group1/Group 2	Mean(SD) Z-score Group1/Group 2	Absolute Hedges 'g	Absolute T-score	Benjamini-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
TS vs UA	Ratio_PP1_over_PPx	111 / 1350	0.821 (0.038) / 0.769 (0.044)	1.7 (1.16) / 0.006 (0.997)	1.569	15	7.402e-27	1	0.87	1	1
TS vs UA	WidthDist_PD4	111 / 1350	0.011 (0.002) / 0.01 (0.001)	1.7 (1.46) / 0.007 (0.995)	1.352	12	6.498e-20	3	0.842	2	2.5
TS vs UA	Ratio_DistMaxWidth_MCWidth_PD4	111 / 1350	1.48 (0.196) / 1.28 (0.117)	1.94 (1.73) / 0.012 (0.992)	1.362	11.5	4.341e-19	5	0.835	3	4
TS vs SHOX	Ratio_PP1_over_PPx	111 / 317	0.821 (0.038) / 0.763 (0.051)	1.7 (1.16) / 0.073 (1.24)	1.358	12.5	2.350e-24	1	0.887	1	1
TS vs SHOX	Length_PP1	111 / 317	0.049 (0.002) / 0.046 (0.002)	1.35 (1.2) / -0.033 (0.886)	1.31	11.1	3.280e-19	2	0.824	2	2
TS vs SHOX	Ratio_DistMaxWidth_MCWidth_PD4	111 / 317	1.48 (0.196) / 1.25 (0.146)	1.94 (1.73) / -0.074 (1.39)	1.277	11	3.280e-19	3	0.823	3	3
TS vs NS	DistmaxWidth_rel_all_widths_PD4	111 / 134	0.052 (0.007) / 0.044 (0.004)	1.39 (1.53) / -0.49 (0.879)	1.506	11.5	3.273e-20	1	0.874	1	1
TS vs NS	DistmaxWidth_rel_all_widths_PD3	111 / 134	0.051 (0.007) / 0.043 (0.004)	1.16 (1.61) / -0.723 (0.871)	1.449	11	4.601e-19	2	0.867	2	2
TS vs NS	DistmaxWidth_rel_all_widths_PD2	111 / 134	0.044 (0.007) / 0.037 (0.004)	1.0 (1.55) / -0.65 (0.931)	1.287	9.8	1.589e-16	4	0.841	3	3.5
TS vs XLH	pointiness_mean_MC2	111 / 87	0.733 (0.048) / 0.834 (0.043)	-0.72 (1.17) / 1.86 (1.21)	2.164	15.1	1.485e-31	1	0.951	1	1
TS vs XLH	pointiness_mean_MC3	111 / 87	0.761 (0.05) / 0.861 (0.048)	-0.739 (1.26) / 1.8 (1.15)	2.09	14.7	4.648e-31	3	0.947	2	2.5
TS vs XLH	Ratio_ProxMaxWidth_MCWidth_MC2	111 / 87	2.04 (0.267) / 1.64 (0.217)	0.347 (1.3) / -1.96 (0.869)	2.082	14.9	1.485e-31	2	0.944	3	2.5
TS vs HCH	WidthDist_PP3	111 / 170	0.017 (0.001) / 0.021 (0.004)	0.456 (0.841) / 2.89 (1.78)	1.742	15.4	7.053e-36	1	0.941	1	1
TS vs HCH	WidthDist_PP4	111 / 170	0.016 (0.001) / 0.019 (0.003)	0.394 (0.995) / 2.91 (1.74)	1.765	15.3	4.461e-36	2	0.934	3	2.5

<b>TS vs HCH</b>	WidthDist_PP2	111 / 170	0.016 (0.001) / 0.02 (0.003)	0.711 (1.0) / 3.14 (1.75)	1.698	14.8	1.996e-34	3	0.936	2	2.5
<b>TS vs SRS</b>	Ratio_PD_PM_over_PP_MC	111 / 86	0.425 (0.024) / 0.385 (0.024)	0.832 (1.51) / -1.71 (1.34)	1.777	12.5	6.905e-24	1	0.901	1	1
<b>TS vs SRS</b>	Length_PM2	111 / 86	0.036 (0.002) / 0.033 (0.002)	0.706 (1.46) / -1.7 (1.35)	1.71	12	8.675e-23	3	0.891	3	3
<b>TS vs SRS</b>	PD_MC_5_quotient	111 / 86	0.337 (0.031) / 0.288 (0.03)	1.37 (1.47) / -0.976 (1.33)	1.742	12.3	9.090e-24	2	0.885	4	3
<b>TS vs MPS</b>	pointiness_proximal_MC4	111 / 85	0.779 (0.056) / 0.968 (0.12)	-0.326 (0.964) / 2.45 (1.78)	1.933	13	1.370e-22	1	0.907	2	1.5
<b>TS vs MPS</b>	Length_PP4	111 / 85	0.062 (0.002) / 0.067 (0.003)	-0.957 (1.04) / 1.37 (1.51)	1.784	12.1	7.316e-22	6	0.909	1	3.5
<b>TS vs MPS</b>	proximal_rad_area/ellips_approx_MC4	111 / 85	1.77 (0.168) / 1.38 (0.221)	0.481 (1.17) / -1.68 (1.19)	1.822	12.7	5.520e-24	2	0.899	5	3.5
<b>TS vs PHP</b>	DistmaxWidth_rel_all_widths_PD4	111 / 104	0.052 (0.007) / 0.042 (0.006)	1.39 (1.53) / -0.813 (1.26)	1.57	11.6	7.277e-22	2	0.882	1	1.5
<b>TS vs PHP</b>	Length_PD1	111 / 104	0.035 (0.002) / 0.031 (0.004)	0.582 (1.2) / -2.49 (2.23)	1.713	12.5	1.614e-22	1	0.872	3	2
<b>TS vs PHP</b>	Bone_area_Handsize_ratio	111 / 104	0.034 (0.002) / 0.044 (0.008)	1.03 (0.901) / 5.67 (4.26)	1.502	10.9	1.841e-17	4	0.861	5	4.5
<b>TS vs ACH</b>	WidthDist_PP4	111 / 189	0.016 (0.001) / 0.024 (0.003)	0.394 (0.995) / 7.37 (2.84)	3.271	30.7	4.551e-85	1	0.999	1	1
<b>TS vs ACH</b>	WidthDist_PP3	111 / 189	0.017 (0.001) / 0.025 (0.004)	0.456 (0.841) / 7.18 (3.04)	3.011	28.6	3.236e-76	2	0.998	2	2
<b>TS vs ACH</b>	WidthDist_PM2	111 / 189	0.014 (0.001) / 0.019 (0.003)	1.07 (1.06) / 7.11 (2.64)	2.996	27.9	2.839e-79	3	0.99	4	3.5

### Supplementary Table 6.

#### Statistics of the highest-ranked features for differentiating between TS and each other class.

The table lists the three highest-ranked features for each “TS vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 - ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/Group2	Mean(SD) Group1/Group2	Mean(SD) Z-score Group1/Group2	Absolute Hedges' g	Absolute T-score	Benjamini-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
<b>XLH vs UA</b>	cti_mean_MC3	87 / 1350	0.362 (0.067) / 0.5 (0.092)	-2.15 (0.904) / -0.003 (0.993)	2.256	21.3	3.531e-36	1	0.942	1	1.0
<b>XLH vs UA</b>	Ratio_ProxMaxWidth_MCWidth_MC2	87 / 1350	1.64 (0.217) / 1.95 (0.257)	-1.96 (0.869) / -0.001 (0.995)	2.097	20.2	5.278e-35	2	0.933	2	2.0
<b>XLH vs UA</b>	cti_mean_MC4	87 / 1350	0.372 (0.067) / 0.501 (0.091)	-2.02 (0.923) / -0.003 (0.998)	2.098	19.7	5.372e-34	4	0.929	3	3.5
<b>XLH vs SHOX</b>	cti_mean_MC3	87 / 317	0.362 (0.067) / 0.482 (0.08)	-2.15 (0.904) / 0.214 (1.2)	2.217	20.0	1.258e-44	1	0.946	1	1.0

<b>XLH vs SHOX</b>	Ratio_ProxMaxWidth_MCWidth_MC2	87 / 317	1.64 (0.217) / 1.92 (0.266)	-1.96 (0.869) / 0.058 (1.07)	2.065	18.2	7.338e-39	2	0.938	2	2.0
<b>XLH vs SHOX</b>	cti_mean_MC4	87 / 317	0.372 (0.067) / 0.471 (0.072)	-2.02 (0.923) / 0.033 (1.11)	2.013	17.6	5.584e-37	3	0.926	3	3.0
<b>XLH vs NS</b>	Ratio_ProxMaxWidth_MCWidth_MC2	87 / 134	1.64 (0.217) / 1.88 (0.286)	-1.96 (0.869) / -0.355 (1.11)	1.607	12.0	5.811e-23	1	0.886	1	1.0
<b>XLH vs NS</b>	pointiness_proximal_MC3	87 / 134	0.896 (0.045) / 0.82 (0.061)	1.43 (0.912) / -0.231 (1.16)	1.586	11.9	8.88e-23	2	0.874	2	2.0
<b>XLH vs NS</b>	metacarpal_interossial_space_ratio	87 / 134	0.69 (0.14) / 0.893 (0.139)	-1.71 (1.15) / -0.001 (1.09)	1.525	11.0	6.007e-20	5	0.871	3	4.0
<b>XLH vs TS</b>	pointiness_mean_MC2	87 / 111	0.834 (0.043) / 0.733 (0.048)	1.86 (1.21) / -0.72 (1.17)	2.164	15.1	1.485e-31	1	0.951	1	1.0
<b>XLH vs TS</b>	pointiness_mean_MC3	87 / 111	0.861 (0.048) / 0.761 (0.05)	1.8 (1.15) / -0.739 (1.26)	2.09	14.7	4.648e-31	3	0.947	2	2.5
<b>XLH vs TS</b>	Ratio_ProxMaxWidth_MCWidth_MC2	87 / 111	1.64 (0.217) / 2.04 (0.267)	-1.96 (0.869) / 0.347 (1.3)	2.082	14.9	1.485e-31	2	0.944	3	2.5
<b>XLH vs HCH</b>	WidthProx_MC2	87 / 170	0.023 (0.002) / 0.026 (0.002)	-0.269 (0.988) / 1.71 (1.09)	1.893	14.6	3.281e-30	1	0.921	1	1.0
<b>XLH vs HCH</b>	WidthDist_PM2	87 / 170	0.013 (0.001) / 0.016 (0.003)	0.563 (1.22) / 2.99 (1.72)	1.627	13.1	2.552e-27	3	0.902	3	3.0
<b>XLH vs HCH</b>	WidthDist_PP1	87 / 170	0.016 (0.001) / 0.018 (0.002)	0.113 (0.812) / 2.06 (1.51)	1.608	13.5	3.241e-29	2	0.899	5	3.5
<b>XLH vs SRS</b>	cti_mean_MC4	87 / 86	0.372 (0.067) / 0.515 (0.117)	-2.02 (0.923) / 0.759 (1.51)	2.208	14.6	1.358e-27	1	0.951	1	1.0
<b>XLH vs SRS</b>	Ratio_DistMaxWidth_MCWidth_MC4	87 / 86	1.5 (0.166) / 1.72 (0.187)	-1.3 (0.804) / 0.558 (0.917)	2.15	14.2	4.207e-28	2	0.934	2	2.0
<b>XLH vs SRS</b>	ProxmaxWidth_rel_all_widths_PP2	87 / 86	0.095 (0.008) / 0.103 (0.01)	-1.68 (0.847) / 0.224 (0.914)	2.147	14.2	4.207e-28	3	0.933	3	3.0
<b>XLH vs MPS</b>	PP_MC_2_quotient	87 / 85	0.596 (0.026) / 0.682 (0.052)	-0.393 (1.02) / 2.35 (1.67)	1.97	12.9	7.201e-23	1	0.933	1	1.0
<b>XLH vs MPS</b>	Length_PP2	87 / 85	0.06 (0.002) / 0.065 (0.003)	-0.418 (1.09) / 1.94 (1.48)	1.807	11.9	4.36e-21	3	0.897	3	3.0
<b>XLH vs MPS</b>	Length_PP5	87 / 85	0.049 (0.002) / 0.053 (0.003)	-0.705 (0.986) / 1.66 (1.65)	1.732	11.4	2.269e-19	4	0.895	5	4.5
<b>XLH vs PHP</b>	Length_PP1	87 / 104	0.046 (0.002) / 0.051 (0.004)	-0.418 (0.75) / 2.45 (1.98)	1.904	13.6	1.337e-24	1	0.953	1	1.0
<b>XLH vs PHP</b>	PP_MC_5_quotient	87 / 104	0.614 (0.032) / 0.754 (0.106)	-0.88 (1.01) / 4.01 (3.92)	1.705	12.3	8.025e-21	3	0.921	2	2.5
<b>XLH vs PHP</b>	Ratio_DistMaxWidth_MCWidth_MC2	87 / 104	1.48 (0.115) / 1.76 (0.213)	-1.57 (0.973) / 0.369 (1.15)	1.821	12.7	1.337e-24	2	0.92	3	2.5
<b>XLH vs ACH</b>	WidthProx_MC2	87 / 189	0.023 (0.002) / 0.031 (0.003)	-0.269 (0.988) / 4.66 (1.81)	3.372	29.2	3.637e-82	1	0.995	1	1.0
<b>XLH vs ACH</b>	WidthDist_PM3	87 / 189	0.014 (0.002) / 0.021 (0.003)	0.521 (1.25) / 7.44 (2.8)	3.181	28.4	5.178e-81	2	0.993	4	3.0
<b>XLH vs ACH</b>	WidthDist_PP4	87 / 189	0.016 (0.002) / 0.024 (0.003)	0.743 (1.27) / 7.37 (2.84)	3.007	26.8	2.04e-76	4	0.994	3	3.5

**Supplementary Table 7.**

**Statistics of the highest-ranked features for differentiating between XLH and each other class.**

The table lists the three highest-ranked features for each “XLH vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to

generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/Group 2	Mean(SD) Group1/Group 2	Mean(SD) Z-score Group1/Group 2	Absolut Hedges' g	Absolute T-score	Benjamin i-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combine d Rank
HCH vs UA	Ratio_Width/Lengt h_PP2	170 / 1350	0.305 (0.055) / 0.233 (0.035)	3.03 (1.47) / 0.005 (1.0)	2.406	26.1	3.767e-62	2	0.974	2	2.0
HCH vs UA	Width_PP2	170 / 1350	0.018 (0.004) / 0.014 (0.002)	2.89 (1.49) / 0.004 (1.0)	2.273	24.6	2.114e-58	3	0.967	4	3.5
HCH vs UA	WidthDist_PP2	170 / 1350	0.02 (0.003) / 0.016 (0.002)	3.14 (1.75) / 0.005 (1.01)	2.195	22.9	9.072e-54	7	0.977	1	4.0
HCH vs SHOX	WidthDist_MC5	170 / 317	0.02 (0.003) / 0.017 (0.002)	2.5 (1.64) / 0.181 (0.979)	1.718	16.9	2.489e-40	1	0.92	4	2.5
HCH vs SHOX	WidthDist_PP2	170 / 317	0.02 (0.003) / 0.017 (0.001)	3.14 (1.75) / 0.816 (0.87)	1.678	16.3	1.555e-37	5	0.936	1	3.0
HCH vs SHOX	WidthDist_MC4	170 / 317	0.021 (0.003) / 0.018 (0.002)	2.41 (1.58) / 0.157 (0.977)	1.706	16.9	2.489e-40	2	0.911	6	4.0
HCH vs NS	Ratio_Width/Lengt h_PP3	170 / 134	0.28 (0.054) / 0.228 (0.023)	2.86 (1.62) / 0.592 (1.04)	1.665	14.8	1.209e-34	1	0.916	1	1.0
HCH vs NS	WidthDist_MC5	170 / 134	0.02 (0.003) / 0.017 (0.002)	2.5 (1.64) / 0.257 (1.01)	1.648	14.7	2.098e-34	2	0.912	2	2.0
HCH vs NS	Ratio_Width/Lengt h_PP2	170 / 134	0.305 (0.055) / 0.253 (0.023)	3.03 (1.47) / 0.985 (1.0)	1.622	14.4	1.062e-33	3	0.9	3	3.0
HCH vs TS	WidthDist_PP3	170 / 111	0.021 (0.004) / 0.017 (0.001)	2.89 (1.78) / 0.456 (0.841)	1.742	15.4	7.053e-36	1	0.941	1	1.0
HCH vs TS	WidthDist_PP4	170 / 111	0.019 (0.003) / 0.016 (0.001)	2.91 (1.74) / 0.394 (0.995)	1.765	15.3	4.461e-36	2	0.934	3	2.5
HCH vs TS	WidthDist_PP2	170 / 111	0.02 (0.003) / 0.016 (0.001)	3.14 (1.75) / 0.711 (1.0)	1.698	14.8	1.996e-34	3	0.936	2	2.5
HCH vs XLH	WidthProx_MC2	170 / 87	0.026 (0.002) / 0.023 (0.002)	1.71 (1.09) / -0.269 (0.988)	1.893	14.6	3.281e-30	1	0.921	1	1.0
HCH vs XLH	WidthDist_PM2	170 / 87	0.016 (0.003) / 0.013 (0.001)	2.99 (1.72) / 0.563 (1.22)	1.627	13.1	2.552e-27	3	0.902	3	3.0
HCH vs XLH	WidthDist_PP1	170 / 87	0.018 (0.002) / 0.016 (0.001)	2.06 (1.51) / 0.113 (0.812)	1.608	13.5	3.241e-29	2	0.899	5	3.5
HCH vs SRS	WidthDist_MC5	170 / 86	0.02 (0.003) / 0.016 (0.002)	2.5 (1.64) / -0.548 (1.23)	2.098	16.7	5.23e-38	1	0.946	1	1.0
HCH vs SRS	Bone_area_Handsi ze_ratio	170 / 86	0.037 (0.002) / 0.033 (0.002)	2.39 (1.14) / 0.186 (1.02)	2.033	15.7	9.934e-34	2	0.934	3	2.5
HCH vs SRS	Width_PP5	170 / 86	0.014 (0.003) / 0.011 (0.002)	2.3 (1.53) / -0.54 (1.34)	1.963	15.2	1.254e-32	3	0.935	2	2.5
HCH vs MPS	Length_PP2	170 / 85	0.061 (0.002) / 0.065 (0.003)	-0.311 (1.14) / 1.94 (1.48)	1.698	12.3	4.055e-21	1	0.901	1	1.0
HCH vs MPS	PP_MC_2_quotient	170 / 85	0.609 (0.03) / 0.682 (0.052)	0.077 (1.04) / 2.35 (1.67)	1.626	11.5	1.901e-18	2	0.896	2	2.0
HCH vs MPS	Length_MC5	170 / 85	0.08 (0.003) / 0.074 (0.005)	0.973 (1.27) / -1.41 (1.86)	1.492	10.6	2.794e-17	6	0.865	3	4.5
HCH vs PHP	Length_PM3	170 / 104	0.042 (0.002) / 0.046 (0.003)	-0.427 (1.3) / 2.41 (1.96)	1.697	13.1	3.331e-24	1	0.903	2	1.5
HCH vs PHP	Length_PP1	170 / 104	0.046 (0.002) / 0.051 (0.004)	-0.227 (0.902) / 2.45 (1.98)	1.732	13.0	5.104e-23	2	0.922	1	1.5

HCH vs PHP	Length_PM4	170 / 104	0.04 (0.002) / 0.044 (0.003)	-0.364 (1.26) / 2.07 (1.87)	1.526	11.8	1.999e-21	3	0.86	6	4.5
HCH vs ACH	Ratio_PP1_over_PPx	170 / 189	0.764 (0.048) / 0.851 (0.058)	-0.029 (1.1) / 2.59 (1.58)	1.922	18.4	1.166e-50	3	0.932	3	3.0
HCH vs ACH	WidthProx_MC2	170 / 189	0.026 (0.002) / 0.031 (0.003)	1.71 (1.09) / 4.66 (1.81)	1.973	18.9	2.021e-51	2	0.931	4	3.0
HCH vs ACH	WidthDist_PP4	170 / 189	0.019 (0.003) / 0.024 (0.003)	2.91 (1.74) / 7.37 (2.84)	1.891	18.1	4.568e-49	5	0.936	1	3.0

### Supplementary Table 8.

#### Statistics of the highest-ranked features for differentiating between HCH and each other class.

The table lists the three highest-ranked features for each “HCH vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/ Group2	Mean(SD) Group1/Group 2	Mean(SD) Z-score Group1/Group 2	Absolute Hedges' g	Absolute T-score	Benjamin i-Hochbe rg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combine d Rank
SRS vs UA	PM_MC_5_quotient	86 / 1350	0.272 (0.06) / 0.362 (0.035)	-2.64 (1.81) / 0.01 (0.991)	1.809	13.4	1.486e-20	2	0.901	1	1.5
SRS vs UA	PM_MC_2_quotient	86 / 1350	0.313 (0.024) / 0.347 (0.022)	-1.72 (1.16) / 0.001 (1.01)	1.585	13.4	8.325e-21	1	0.862	4	2.5
SRS vs UA	Mean_Ulnar_Medial_Phal_Ratio_width/length	86 / 1350	0.424 (0.07) / 0.337 (0.06)	1.97 (1.48) / 0.003 (0.997)	1.563	12.2	1.676e-18	3	0.882	2	2.5
SRS vs SHOX	PM_MC_5_quotient	86 / 317	0.272 (0.06) / 0.358 (0.03)	-2.64 (1.81) / -0.016 (0.875)	1.837	13.0	3.919e-20	1	0.904	1	1.0
SRS vs SHOX	Length_PM5	86 / 317	0.022 (0.005) / 0.028 (0.002)	-2.84 (2.19) / -0.013 (0.833)	1.701	11.7	7.267e-18	2	0.879	2	2.0
SRS vs SHOX	Ratio_PD_PM_over_PP_MC	86 / 317	0.385 (0.024) / 0.417 (0.019)	-1.71 (1.34) / 0.125 (1.08)	1.506	11.7	5.636e-19	3	0.862	3	3.0
SRS vs NS	PM_MC_5_quotient	86 / 134	0.272 (0.06) / 0.346 (0.058)	-2.64 (1.81) / -0.387 (1.84)	1.228	8.93	2.448e-13	1	0.83	1	1.0
SRS vs NS	diaphyseal_tilt_MC5	86 / 134	0.973 (0.036) / 1.02 (0.035)	-1.18 (1.18) / 0.198 (1.1)	1.206	8.69	7.414e-13	2	0.811	3	2.5
SRS vs NS	Length_PM5	86 / 134	0.022 (0.005) / 0.027 (0.004)	-2.84 (2.19) / -0.466 (1.95)	1.139	8.17	6.742e-12	6	0.815	2	4.0
SRS vs TS	Ratio_PD_PM_over_PP_MC	86 / 111	0.385 (0.024) / 0.425 (0.024)	-1.71 (1.34) / 0.832 (1.51)	1.777	12.5	6.905e-24	1	0.901	1	1.0
SRS vs TS	Length_PM2	86 / 111	0.033 (0.002) / 0.036 (0.002)	-1.7 (1.35) / 0.706 (1.46)	1.710	12.0	8.675e-23	3	0.891	3	3.0
SRS vs TS	PD_MC_5_quotient	86 / 111	0.288 (0.03) / 0.337 (0.031)	-0.976 (1.33) / 1.37 (1.47)	1.663	11.7	4.95e-22	4	0.893	2	3.0
SRS vs XLH	cti_mean_MC4	86 / 87	0.515 (0.117) / 0.372 (0.067)	0.759 (1.51) / -2.02 (0.923)	2.208	14.6	1.358e-27	1	0.951	1	1.0

SRS vs XLH	Ratio_DistMaxWidth_MCWidth_MC4	86 / 87	1.72 (0.187) / 1.5 (0.166)	0.558 (0.917) / -1.3 (0.804)	2.15	14.2	4.207e-28	2	0.934	2	2.0
SRS vs XLH	ProxmaxWidth_rel_al_l_widths_PP2	86 / 87	0.103 (0.01) / 0.095 (0.008)	0.224 (0.914) / -1.68 (0.847)	2.147	14.2	4.207e-28	3	0.933	3	3.0
SRS vs HCH	WidthDist_MC5	86 / 170	0.016 (0.002) / 0.02 (0.003)	-0.548 (1.23) / 2.5 (1.64)	2.098	16.7	5.23e-38	1	0.946	1	1.0
SRS vs HCH	Bone_area_Handsize_ratio	86 / 170	0.033 (0.002) / 0.037 (0.002)	0.186 (1.02) / 2.39 (1.14)	2.033	15.7	9.934e-34	2	0.934	3	2.5
SRS vs HCH	Width_PP5	86 / 170	0.011 (0.002) / 0.014 (0.003)	-0.54 (1.34) / 2.3 (1.53)	1.963	15.2	1.254e-32	3	0.935	2	2.5
SRS vs MPS	PM_MC_2_quotient	86 / 85	0.313 (0.024) / 0.389 (0.044)	-1.72 (1.16) / 1.97 (2.05)	2.205	14.5	1.351e-26	1	0.954	2	1.5
SRS vs MPS	PM_MC_5_quotient	86 / 85	0.272 (0.06) / 0.408 (0.066)	-2.64 (1.81) / 1.36 (1.91)	2.134	14.0	2.589e-27	2	0.958	1	1.5
SRS vs MPS	PP_MC_2_quotient	86 / 85	0.602 (0.031) / 0.682 (0.052)	-0.44 (1.03) / 2.35 (1.67)	2	13.1	3.785e-24	5	0.938	3	4.0
SRS vs PHP	PM_MC_5_quotient	86 / 104	0.272 (0.06) / 0.416 (0.058)	-2.64 (1.81) / 1.77 (1.89)	2.366	16.3	6.795e-35	1	0.972	1	1.0
SRS vs PHP	Length_PM3	86 / 104	0.041 (0.002) / 0.046 (0.003)	-1.11 (1.41) / 2.41 (1.96)	2.05	14.3	1.44e-29	3	0.939	3	3.0
SRS vs PHP	PM_MC_4_quotient	86 / 104	0.446 (0.039) / 0.598 (0.105)	-1.29 (1.17) / 3.93 (3.63)	1.926	13.8	4.422e-25	4	0.95	2	3.0
SRS vs ACH	WidthProx_MC5	86 / 189	0.019 (0.002) / 0.026 (0.003)	-0.137 (0.984) / 4.86 (2.15)	2.977	26.4	9.995e-75	2	0.994	1	1.5
SRS vs ACH	Bone_area_Handsize_ratio	86 / 189	0.033 (0.002) / 0.043 (0.004)	0.186 (1.02) / 5.45 (2.06)	3.22	28.2	5.606e-80	1	0.992	5	3.0
SRS vs ACH	WidthDist_PM3	86 / 189	0.015 (0.002) / 0.021 (0.003)	1.05 (1.26) / 7.44 (2.8)	2.936	26.1	4.942e-74	4	0.992	4	4.0

**Supplementary Table 9.**

**Statistics of the highest-ranked features for differentiating between SRS and each other class.**

The table lists the three highest-ranked features for each “SRS vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radio graphs) Group1/Group2	Mean(SD) Group1/Group2	Mean(SD) Z-score Group1/Group2	Absolute Hedges' g	Absolute T-score	Benjamin-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
MPS vs UA	Ratio_ProxMaxWidth_MCWidth_MC4	85 / 1350	1.27 (0.295) / 1.81 (0.303)	-1.77 (0.953) / -0.008 (0.997)	1.803	16.5	5.858e-24	1	0.894	3	2.0
MPS vs UA	PP_MC_2_quotient	85 / 1350	0.682 (0.052) / 0.609 (0.031)	2.35 (1.67) / -0.003 (0.995)	1.709	12.8	3.775e-17	5	0.897	2	3.5

<b>MPS vs UA</b>	metacarpal_interossial_space_ratio	85 / 1350	0.59 (0.205) / 0.89 (0.125)	-2.37 (1.62) / -0.011 (0.993)	1.755	13.3	1.099e-17	4	0.885	6	5.0
<b>MPS vs SHOX</b>	metacarpal_interossial_space_ratio	85 / 317	0.59 (0.205) / 0.922 (0.132)	-2.37 (1.62) / 0.31 (1.01)	1.98	14.5	2.534e-21	1	0.914	1	1.0
<b>MPS vs SHOX</b>	pointiness_proximal_MC4	85 / 317	0.968 (0.12) / 0.795 (0.068)	2.45 (1.78) / -0.377 (1.1)	1.907	13.9	3.193e-20	2	0.908	2	2.0
<b>MPS vs SHOX</b>	proximal_rad_area/ellips_approx_MC4	85 / 317	1.38 (0.221) / 1.69 (0.172)	-1.68 (1.19) / 0.277 (1.07)	1.728	13.8	2.534e-21	3	0.889	3	3.0
<b>MPS vs NS</b>	PP_MC_2_quotient	85 / 134	0.682 (0.052) / 0.605 (0.036)	2.35 (1.67) / -0.173 (1.19)	1.734	12.1	1.119e-17	1	0.897	1	1.0
<b>MPS vs NS</b>	metacarpal_interossial_space_ratio	85 / 134	0.59 (0.205) / 0.893 (0.139)	-2.37 (1.62) / -0.001 (1.09)	1.712	11.9	3.414e-17	2	0.886	2	2.0
<b>MPS vs NS</b>	Length_MC2	85 / 134	0.096 (0.005) / 0.102 (0.004)	-1.7 (1.59) / 0.54 (1.35)	1.512	10.8	2.535e-15	3	0.861	4	3.5
<b>MPS vs TS</b>	pointiness_proximal_MC4	85 / 111	0.968 (0.12) / 0.779 (0.056)	2.45 (1.78) / -0.326 (0.964)	1.933	13.0	1.37e-19	1	0.907	2	1.5
<b>MPS vs TS</b>	Length_PP4	85 / 111	0.067 (0.003) / 0.062 (0.002)	1.37 (1.51) / -0.957 (1.04)	1.784	12.1	7.316e-19	6	0.909	1	3.5
<b>MPS vs TS</b>	proximal_rad_area/ellips_approx_MC4	85 / 111	1.38 (0.221) / 1.77 (0.168)	-1.68 (1.19) / 0.481 (1.17)	1.822	12.7	5.52e-21	2	0.899	5	3.5
<b>MPS vs XLH</b>	PP_MC_2_quotient	85 / 87	0.682 (0.052) / 0.596 (0.026)	2.35 (1.67) / -0.393 (1.02)	1.97	12.9	7.201e-20	1	0.933	1	1.0
<b>MPS vs XLH</b>	Length_PP2	85 / 87	0.065 (0.003) / 0.06 (0.002)	1.94 (1.48) / -0.418 (1.09)	1.807	11.9	4.36e-18	3	0.897	3	3.0
<b>MPS vs XLH</b>	Length_PP5	85 / 87	0.053 (0.003) / 0.049 (0.002)	1.66 (1.65) / -0.705 (0.986)	1.732	11.4	2.269e-16	4	0.895	5	4.5
<b>MPS vs HCH</b>	Length_PP2	85 / 170	0.065 (0.003) / 0.061 (0.002)	1.94 (1.48) / -0.311 (1.14)	1.698	12.3	4.055e-18	1	0.901	1	1.0
<b>MPS vs HCH</b>	PP_MC_2_quotient	85 / 170	0.682 (0.052) / 0.609 (0.03)	2.35 (1.67) / 0.077 (1.04)	1.626	11.5	1.901e-15	2	0.896	2	2.0
<b>MPS vs HCH</b>	Length_MC5	85 / 170	0.074 (0.005) / 0.08 (0.003)	-1.41 (1.86) / 0.973 (1.27)	1.492	10.6	2.794e-14	6	0.865	3	4.5
<b>MPS vs SRS</b>	PM_MC_2_quotient	85 / 86	0.389 (0.044) / 0.313 (0.024)	1.97 (2.05) / -1.72 (1.16)	2.205	14.5	1.351e-23	1	0.954	2	1.5
<b>MPS vs SRS</b>	PM_MC_5_quotient	85 / 86	0.408 (0.066) / 0.272 (0.06)	1.36 (1.91) / -2.64 (1.81)	2.134	14.0	2.589e-24	2	0.958	1	1.5
<b>MPS vs SRS</b>	PP_MC_2_quotient	85 / 86	0.682 (0.052) / 0.602 (0.031)	2.35 (1.67) / -0.44 (1.03)	2.000	13.1	3.785e-21	5	0.938	3	4.0
<b>MPS vs PHP</b>	PD1_quotient	85 / 104	0.316 (0.034) / 0.265 (0.047)	0.518 (1.48) / -2.2 (1.99)	1.546	10.8	1.405e-15	1	0.856	1	1.0
<b>MPS vs PHP</b>	rel2b_prox_epiphyseal_length_MC2	85 / 104	0.181 (0.074) / 0.089 (0.043)	2.83 (2.21) / 0.06 (1.24)	1.534	10.3	4.39e-13	2	0.852	2	2.0
<b>MPS vs PHP</b>	Length_PD1	85 / 104	0.035 (0.003) / 0.031 (0.004)	0.335 (1.56) / -2.49 (2.23)	1.466	10.2	2.606e-14	3	0.841	5	4.0

<b>MPS vs ACH</b>	Length_PP2	85 / 189	0.065 (0.003) / 0.057 (0.002)	1.94 (1.48) / -2.46 (1.5)	2.941	22.7	3.108e-47	2	0.989	1	1.5
<b>MPS vs ACH</b>	Length_PP4	85 / 189	0.067 (0.003) / 0.059 (0.002)	1.37 (1.51) / -2.88 (1.35)	3.052	22.2	7.959e-44	3	0.988	2	2.5
<b>MPS vs ACH</b>	Length_PP3	85 / 189	0.071 (0.003) / 0.062 (0.003)	1.07 (1.41) / -3.58 (1.62)	2.954	24.1	6.202e-53	1	0.986	3	2.0

**Supplementary Table 10.**

**Statistics of the highest-ranked features for differentiating between MPS and each affected class.**

The table lists the three highest-ranked features for each “MPS vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/ Group2	Mean(SD) Group1/Group 2	Mean(SD) Z-score Group1/Group 2	Absolute Hedge s' g	Absolute T-score	Benjamini-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
PHP vs UA	Bone_area_Handsize_ratio	104 / 1350	0.044 (0.008) / 0.033 (0.002)	5.67 (4.26) / 0.0 (0.992)	1.832	13.5	6.064e-22	1	0.89	1	1.0
PHP vs UA	WidthProx_MC5	104 / 1350	0.024 (0.004) / 0.019 (0.002)	3.45 (2.67) / -0.002 (0.999)	1.713	13.1	1.834e-21	2	0.869	4	3.0
PHP vs UA	Length_PP1	104 / 1350	0.051 (0.004) / 0.047 (0.002)	2.45 (1.98) / 0.003 (0.996)	1.557	12.5	1.378e-20	6	0.881	2	4.0
PHP vs SHOX	Length_PP1	104 / 317	0.051 (0.004) / 0.046 (0.002)	2.45 (1.98) / -0.033 (0.886)	1.613	12.4	6.398e-21	3	0.902	1	2.0
PHP vs SHOX	Length_PD1	104 / 317	0.031 (0.004) / 0.035 (0.002)	-2.49 (2.23) / 0.474 (1.04)	1.707	13.1	2.087e-22	2	0.868	3	2.5
PHP vs SHOX	metacarpal_interossial_space_ratio	104 / 317	0.7 (0.167) / 0.922 (0.132)	-1.48 (1.25) / 0.31 (1.01)	1.565	13.2	4.21e-24	1	0.862	5	3.0
PHP vs NS	Length_PM3	104 / 134	0.046 (0.003) / 0.041 (0.002)	2.41 (1.96) / -0.774 (1.43)	1.844	13.9	1.311e-27	1	0.921	1	1.0
PHP vs NS	Length_PD1	104 / 134	0.031 (0.004) / 0.035 (0.002)	-2.49 (2.23) / 0.625 (1.13)	1.762	13.0	9.962e-24	2	0.876	3	2.5
PHP vs NS	Bone_area_Handsize_ratio	104 / 134	0.044 (0.008) / 0.034 (0.002)	5.67 (4.26) / 0.776 (0.945)	1.581	11.5	1.307e-18	3	0.872	4	3.5
PHP vs TS	DistmaxWidth_rel_all_widths_PD4	104 / 111	0.042 (0.006) / 0.052 (0.007)	-0.813 (1.26) / 1.39 (1.53)	1.57	11.6	7.277e-22	2	0.882	1	1.5
PHP vs TS	Length_PD1	104 / 111	0.031 (0.004) / 0.035 (0.002)	-2.49 (2.23) / 0.582 (1.2)	1.713	12.5	1.614e-22	1	0.872	3	2.0
PHP vs TS	Bone_area_Handsize_ratio	104 / 111	0.044 (0.008) / 0.034 (0.002)	5.67 (4.26) / 1.03 (0.901)	1.502	10.9	1.841e-17	4	0.861	5	4.5
PHP vs XLH	Length_PP1	104 / 87	0.051 (0.004) / 0.046 (0.002)	2.45 (1.98) / -0.418 (0.75)	1.904	13.6	1.337e-24	1	0.953	1	1.0

PHP vs XLH	PP_MC_5_quotient	104 / 87	0.754 (0.106) / 0.614 (0.032)	4.01 (3.92) / -0.88 (1.01)	1.705	12.3	8.025e-21	3	0.921	2	2.5
PHP vs XLH	Ratio_DistMaxWidth_MCWidth_MC2	104 / 87	1.76 (0.213) / 1.48 (0.115)	0.369 (1.15) / -1.57 (0.973)	1.821	12.7	1.337e-24	2	0.92	3	2.5
PHP vs HCH	Length_PM3	104 / 170	0.046 (0.003) / 0.042 (0.002)	2.41 (1.96) / -0.427 (1.3)	1.697	13.1	3.331e-24	1	0.903	2	1.5
PHP vs HCH	Length_PP1	104 / 170	0.051 (0.004) / 0.046 (0.002)	2.45 (1.98) / -0.227 (0.902)	1.732	13.0	5.104e-23	2	0.922	1	1.5
PHP vs HCH	Length_PM4	104 / 170	0.044 (0.003) / 0.04 (0.002)	2.07 (1.87) / -0.364 (1.26)	1.526	11.8	1.999e-21	3	0.86	6	4.5
PHP vs SRS	PM_MC_5_quotient	104 / 86	0.416 (0.058) / 0.272 (0.06)	1.77 (1.89) / -2.64 (1.81)	2.366	16.3	6.795e-35	1	0.972	1	1.0
PHP vs SRS	Length_PM3	104 / 86	0.046 (0.003) / 0.041 (0.002)	2.41 (1.96) / -1.11 (1.41)	2.05	14.3	1.44e-29	3	0.939	3	3.0
PHP vs SRS	PM_MC_4_quotient	104 / 86	0.598 (0.105) / 0.446 (0.039)	3.93 (3.63) / -1.29 (1.17)	1.926	13.8	4.422e-25	4	0.95	2	3.0
PHP vs MPS	PD1_quotient	104 / 85	0.265 (0.047) / 0.316 (0.034)	-2.2 (1.99) / 0.518 (1.48)	1.546	10.8	1.405e-18	1	0.856	1	1.0
PHP vs MPS	rel2b_prox_epiphyseal_length_MC2	104 / 85	0.089 (0.043) / 0.181 (0.074)	0.06 (1.24) / 2.83 (2.21)	1.534	10.3	4.39e-16	2	0.852	2	2.0
PHP vs MPS	Length_PD1	104 / 85	0.031 (0.004) / 0.035 (0.003)	-2.49 (2.23) / 0.335 (1.56)	1.466	10.2	2.606e-17	3	0.841	5	4.0
PHP vs ACH	WidthMin_PM3	104 / 189	0.054 (0.003) / 0.063 (0.004)	-0.674 (1.34) / 3.09 (1.48)	2.656	22.1	1.231e-56	1	0.972	2	1.5
PHP vs ACH	MinWidth_rel_all_widths_PM3	104 / 189	0.054 (0.003) / 0.063 (0.004)	-0.674 (1.34) / 3.09 (1.48)	2.656	22.1	1.231e-56	1	0.972	2	1.5
PHP vs ACH	Length_PP3	104 / 189	0.072 (0.005) / 0.062 (0.003)	2.32 (2.76) / -3.58 (1.62)	2.596	20.0	2.39e-41	3	0.986	1	2.0

**Supplementary Table 11.**

**Statistics of the highest-ranked features for differentiating between PHP and each affected class.**

The table lists the three highest-ranked features for each “UA vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Scenario	Feature name	n (radiographs) Group1/Group2	Mean(SD) Group1/Group2	Mean(SD) Z-score Group1/Group2	Absolute Hedges' g	Absolute T-score	Benjamini-Hochberg adjusted p-value	Rank Absolute T-score	ROC AUC Adjusted	Rank ROC AUC Adjusted	Combined Rank
ACH vs UA	WidthDist_PM3	189 / 1350	0.021 (0.003) / 0.014 (0.002)	7.44 (2.8) / 0.008 (0.994)	3.535	36.2	2.238e-83	2	0.999	3	2.5
ACH vs UA	WidthDist_PM2	189 / 1350	0.019 (0.003) / 0.013 (0.001)	7.11 (2.64) / 0.003 (0.998)	3.46	36.7	1.777e-84	1	0.998	5	3.0
ACH vs UA	WidthDist_PP4	189 / 1350	0.024 (0.003) / 0.016 (0.002)	7.37 (2.84) / 0.004 (0.998)	3.563	35.4	8.11e-82	5	0.999	1	3.0

<b>ACH vs SHOX</b>	WidthDist_PP4	189 / 317	0.024 (0.003) / 0.017 (0.002)	7.37 (2.84) / 0.584 (0.923)	3.211	31.9	0.998	1	0.998	1	1.0
<b>ACH vs SHOX</b>	WidthDist_PM3	189 / 317	0.021 (0.003) / 0.015 (0.001)	7.44 (2.8) / 0.803 (0.807)	3.216	31.8	0.997	2	0.997	3	2.5
<b>ACH vs SHOX</b>	WidthDist_PM2	189 / 317	0.019 (0.003) / 0.014 (0.001)	7.11 (2.64) / 0.898 (0.901)	3.147	31.3	0.993	3	0.993	5	4.0
<b>ACH vs NS</b>	WidthDist_PM3	189 / 134	0.021 (0.003) / 0.015 (0.001)	7.44 (2.8) / 0.713 (0.992)	3.195	30.4	3.251e-80	1	0.996	2	1.5
<b>ACH vs NS</b>	WidthDist_PP4	189 / 134	0.024 (0.003) / 0.017 (0.002)	7.37 (2.84) / 1.18 (1.08)	2.875	27.3	4.25e-73	4	0.996	1	2.5
<b>ACH vs NS</b>	WidthDist_PM2	189 / 134	0.019 (0.003) / 0.014 (0.001)	7.11 (2.64) / 1.23 (1.04)	2.924	27.7	7.279e-75	2	0.987	5	3.5
<b>ACH vs TS</b>	WidthDist_PP4	189 / 111	0.024 (0.003) / 0.016 (0.001)	7.37 (2.84) / 0.394 (0.995)	3.271	30.7	4.551e-82	1	0.999	1	1.0
<b>ACH vs TS</b>	WidthDist_PP3	189 / 111	0.025 (0.004) / 0.017 (0.001)	7.18 (3.04) / 0.456 (0.841)	3.011	28.6	3.236e-73	2	0.998	2	2.0
<b>ACH vs TS</b>	WidthDist_PM2	189 / 111	0.019 (0.003) / 0.014 (0.001)	7.11 (2.64) / 1.07 (1.06)	2.996	27.9	2.839e-76	3	0.99	4	3.5
<b>ACH vs XLH</b>	WidthProx_MC2	189 / 87	0.031 (0.003) / 0.023 (0.002)	4.66 (1.81) / -0.269 (0.988)	3.372	29.2	3.637e-79	1	0.995	1	1.0
<b>ACH vs XLH</b>	WidthDist_PM3	189 / 87	0.021 (0.003) / 0.014 (0.002)	7.44 (2.8) / 0.521 (1.25)	3.181	28.4	5.178e-78	2	0.993	4	3.0
<b>ACH vs XLH</b>	WidthDist_PP4	189 / 87	0.024 (0.003) / 0.016 (0.002)	7.37 (2.84) / 0.743 (1.27)	3.007	26.8	2.04e-73	4	0.994	3	3.5
<b>ACH vs HCH</b>	Ratio_PP1_over_PPx	189 / 170	0.851 (0.058) / 0.764 (0.048)	2.59 (1.58) / -0.029 (1.1)	1.922	18.4	1.166e-47	3	0.932	3	3.0
<b>ACH vs HCH</b>	WidthProx_MC2	189 / 170	0.031 (0.003) / 0.026 (0.002)	4.66 (1.81) / 1.71 (1.09)	1.973	18.9	2.021e-48	2	0.931	4	3.0
<b>ACH vs HCH</b>	WidthDist_PP4	189 / 170	0.024 (0.003) / 0.019 (0.003)	7.37 (2.84) / 2.91 (1.74)	1.891	18.1	4.568e-46	5	0.936	1	3.0
<b>ACH vs SRS</b>	WidthProx_MC5	189 / 86	0.026 (0.003) / 0.019 (0.002)	4.86 (2.15) / -0.137 (0.984)	2.977	26.4	9.995e-72	2	0.994	1	1.5
<b>ACH vs SRS</b>	Bone_area_Handsize_ratio	189 / 86	0.043 (0.004) / 0.033 (0.002)	5.45 (2.06) / 0.186 (1.02)	3.22	28.2	5.606e-77	1	0.992	5	3.0
<b>ACH vs SRS</b>	WidthDist_PM3	189 / 86	0.021 (0.003) / 0.015 (0.002)	7.44 (2.8) / 1.05 (1.26)	2.936	26.1	4.942e-71	4	0.992	4	4.0
<b>ACH vs MPS</b>	Length_PP2	189 / 85	0.057 (0.002) / 0.065 (0.003)	-2.46 (1.5) / 1.94 (1.48)	2.941	22.7	3.108e-47	2	0.989	1	1.5
<b>ACH vs MPS</b>	Length_PP3	189 / 85	0.062 (0.003) / 0.071 (0.003)	-3.58 (1.62) / 1.07 (1.41)	3.052	24.1	6.202e-53	1	0.986	3	2.0
<b>ACH vs MPS</b>	Length_PP4	189 / 85	0.059 (0.002) / 0.067 (0.003)	-2.88 (1.35) / 1.37 (1.51)	2.954	22.2	7.959e-44	3	0.988	2	2.5
<b>ACH vs PHP</b>	WidthMin_PM3	189 / 104	0.063 (0.004) / 0.054 (0.003)	3.09 (1.48) / -0.674 (1.34)	2.656	22.1	1.231e-53	1	0.972	2	1.5
<b>ACH vs PHP</b>	MinWidth_rel_all_widths_PM3	189 / 104	0.063 (0.004) / 0.054 (0.003)	3.09 (1.48) / -0.674 (1.34)	2.656	22.1	1.231e-53	1	0.972	2	1.5
<b>ACH vs PHP</b>	Length_PP3	189 / 104	0.062 (0.003) / 0.072 (0.005)	-3.58 (1.62) / 2.32 (2.76)	2.596	20.0	2.39e-38	3	0.986	1	2.0

**Supplementary Table 12.**

**Statistics of the highest-ranked features for differentiating between ACH and each other class.**

The table lists the three highest-ranked features for each “ACH vs One” scenario. n denotes the number of images in the affected class to which the UA group is compared. The reported means and standard deviations represent the sex- and age-adjusted z-scores of the affected group relative to the UA training/reference set. The t-value and p-value are computed from

the z-score distributions of the two groups. The absolute t-value was used to rank all 550 features within each scenario, yielding the t-test rank. The adjusted ROC AUC, defined as the maximum of ROC and (1 – ROC), calculated from the same z-scores, was used to generate a second ranking, the ROC-AUC rank. The sum of the t-test rank and the ROC-AUC rank provided the final combined score used to identify the top three features per scenario.

Acquisition source institution	N hand radiographs	N patients
Children's Hospital of Los Angeles, Los Angeles, USA	1277	1277
University Hospital Magdeburg, Magdeburg, Germany	659	302
Kinderzentrum Am Johannisplatz, Leipzig, Germany	416	75
BioMarin	145	43
Hospital Universitario La Paz, Madrid, Spain	60	25
Publications	47	40
University Medical Center Hamburg-Eppendorf, Hamburg, Germany	25	18
University Hospital of Giessen, Giessen, Germany	13	7
University of Pavia, Pavia, Italy	12	3
Total:	2654	1790

**Supplementary Table 13:** Sources or acquisitions institutions of all radiographs and data used in this study in declining order. Patients who were represented in more than one institution are counted multiple times in this table. Note that one patient appeared in two source institutions; therefore, the total number of patients in this table is one higher than in Table 14.

Cohort or Conditions	N radiographs in training set	N unique patients in trainings set	N radiographs in test set	N unique patients in test set	N radiographs total	N unique patients total
UA	1303	1303	50	50	1353	1353
ACH	174	64	15	6	189	70
HCH	155	48	15	5	170	53
MPS type 1*	28	21	3	3	31	24
MPS type 2*	17	10	2	2	19	12
MPS type 4*	21	12	4	3	25	15
MPS type 6*	9	9	1	1	10	10
PHP	89	34	15	8	104	42
NS	119	31	15	7	134	38
SHOX	302	59	15	4	317	63
SRS	76	16	10	5	86	21



<b>KBG syndrome</b>	0 (0.0%)	1 (50.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
<b>Léri-Weill dyschondrosteosis</b>	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)	0 (0.0%)	0 (0.0%)
<b>Maffucci syndrome</b>	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)
<b>Osteogenesis imperfecta, type I</b>	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)
<b>Pseudoachondroplasia</b>	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)
<b>Total additional conditions:</b>	4 (22.2%)	2 (11.1%)	1 (5.6%)	2 (11.1%)	3 (16.7%)	4 (22.2%)	2 (11.1%)

\* If no chronological age at image acquisition was available, automatically derived bone age was used as default.

\*\* The conditions MPS type I, II, IV and VI were merged into one cohort MPS in our study

### Supplementary Table 15. Age distribution of hand radiographs across cohorts.

Number and percentage of radiographs per age group (0–3 to ≥18 years and age unknown) for each cohort and condition. Percentages are given relative to the total number of radiographs within each cohort. Mucopolysaccharidosis (MPS) types I, II, IV, and VI were combined into a single MPS cohort for all analyses. In cases where the chronological age was not available at the time of the study we use the automated bone age derived from Deepiasia as default, but only for this table. This was the case for 7.7%, 205 of 2654 radiographs.

chronological age group	Number of radiographs per age group in training set	Relative portion in training set	Number of radiographs per age group in test set	Relative portion in test set
<b>0-3</b>	114	0.046	13	0.076
<b>3-6</b>	292	0.118	20	0.118
<b>6-9</b>	479	0.194	25	0.147
<b>9-12</b>	562	0.228	34	0.2
<b>12-15</b>	510	0.207	34	0.2
<b>15-18</b>	254	0.103	18	0.106
<b>18+</b>	75	0.03	7	0.041
<b>Age unknown</b>	180	0.073	19	0.112

### Supplementary Table 16. Age distribution of hand radiographs in the training and test sets.

Absolute numbers and relative proportions of radiographs per age group in the training and test sets (UA, SHOX, NS, TS, HCH, ACH, MPS, XLH, PHP, SRS). Relative portions are given as fractions of the respective dataset totals. Age groups are defined as for creation of the z-scores in 3-year intervals, with an additional category for unknown age. Note that in this table