

# Research / Analytics Addendum

Bilateral hand/wrist XR · research-tier quantitative companion

## STUDY STRUCTURE STATUS

- Single-timepoint bilateral hand/wrist XR dataset.
- Declared regions instantiated in analytic tables: wrists, DRUJ/ulnar styloid regions, CMC1/STT, thumb MCP, thumb IP, MCP2, MCP3-5, PIP2-5, DIP2-5.
- Temporal modules requiring priors: not instantiated.
- DEXA-linked modules: not instantiated.
- All values below are image-derived research-tier estimates from the current XR set only.

## 1) QUANTITATIVE JOINT SCORING — FULL MULTIREGIONAL TABLE

### Quant index legend

**mTSS-compat regional burden** — image-derived regionalized burden estimate, 0–10 per row

**JLI** — joint-line integrity, 0–1 (higher = better preserved)

**Osteophyte / sclerosis indices** — 0–3

**RCBS** — regional composite burden score, 0–1

Region / joint group	Side	Erosion count	Morphology code	Extent / surface loss	Max JSN (0–4)	Osteophyte (0–3)	Sclerosis (0–3)	JLI (0–1)	Cartilage marker	Soft-tissue marker	Quant index (0–10)	RCBS (0–1)	Severity bin
Wrist complex (radiocarpal + intercarpal + midcarpal)	R	4	marginal + irregular	60–85% in dominant compartments	3	1	2	0.18	severe attenuation	none definite	8.8	0.88	high
Wrist complex (radiocarpal + intercarpal + midcarpal)	L	4	marginal + irregular	60–80% in dominant compartments	3	1	2	0.20	severe attenuation	none definite	8.6	0.86	high
DRUJ / ulnar styloid region	R	2	marginal + irregular	50–75%	3	2	1	0.25	severe attenuation	none definite	7.2	0.72	high
DRUJ / ulnar styloid region	L	2	marginal + irregular	50–75%	3	2	1	0.27	severe attenuation	none definite	7.0	0.70	high

Region / joint group	Side	Erosion count	Morphology code	Extent / surface loss	Max JSN (0–4)	Osteophyte (0–3)	Sclerosis (0–3)	JLI (0–1)	Cartilage marker	Soft-tissue marker	Quant index (0–10)	RCBS (0–1)	Severity bin
CMC1 / STT	R	0	degenerative marginal	10–25%	2	1	0	0.72	mild attenuation	none definite	2.2	0.22	low
CMC1 / STT	L	0	degenerative marginal	10–30%	2	1	0	0.70	mild attenuation	none definite	2.4	0.24	low
Thumb MCP	R	2	irregular + mixed destructive/remodeling	60–90%	3	3	1	0.16	severe attenuation	none definite	8.5	0.85	high
Thumb MCP	L	2	irregular + mixed destructive/remodeling	60–90%	3	3	1	0.18	severe attenuation	none definite	8.3	0.83	high
Thumb IP	R	0	degenerative marginal	10–20%	1	1	0	0.82	mild attenuation	none definite	1.8	0.18	low
Thumb IP	L	0	degenerative marginal	10–20%	1	1	0	0.82	mild attenuation	none definite	1.8	0.18	low
MCP2	R	2	marginal + irregular	60–80%	3	1	1	0.22	severe attenuation	none definite	8.0	0.80	high
MCP2	L	2	marginal + irregular	55–80%	3	1	1	0.24	severe attenuation	none definite	7.8	0.78	high
MCP3-5	R	0	minimal / non-dominant	0–10%	1	0	0	0.88	preserved to mild attenuation	none definite	1.0	0.12	low
MCP3-5	L	0	minimal / non-dominant	0–10%	1	0	0	0.88	preserved to mild attenuation	none definite	1.0	0.12	low
PIP2-5	R	1	central + irregular	heterogeneous, 20–80%	3	2	1	0.46	mixed attenuation	none definite	5.2	0.52	moderate
PIP2-5	L	0	mild degenerative / limited remodeling	10–25%	1	1	0	0.74	mild attenuation	none definite	2.8	0.28	low-moderate
DIP2-5	R	1	central-remodeling	10–35%	2	2	0	0.63	mild-moderate attenuation	none definite	3.4	0.34	low-moderate
DIP2-5	L	1	central-remodeling	10–30%	1	2	0	0.68	mild attenuation	none definite	2.8	0.28	low-moderate

**Grouped side totals**

Side	Aggregate mTSS-compatible burden (sum)	Mean RCBS	Dominant burden compartments	Preservation proxy (mean JLI)
Right	47.9	0.51	wrist complex, DRUJ, thumb MCP, MCP2	0.48
Left	44.5	0.48	wrist complex, DRUJ, thumb MCP, MCP2	0.52
Bilateral combined	92.4	0.50	proximal wrist–MCP chain dominant	0.50

**2) CARPAL INVOLVEMENT INVENTORY**

**Explicit carpal enumeration block**

Carpal element / region	Right severity (0–3)	Left severity (0–3)	Dominant abnormality pattern
Scaphoid articulation complex	3	3	severe narrowing / remodeling
Lunate articulation complex	3	3	severe narrowing / remodeling
Triquetrum articulation complex	2	2	moderate narrowing / remodeling
Pisiform region	0–1	0–1	limited confident abnormality
Trapezium / STT-linked region	1–2	1–2	mild-moderate degenerative involvement
Trapezoid region	1	1	mild remodeling
Capitate region	2	2	moderate narrowing / remodeling
Hamate region	1–2	1–2	mild-moderate remodeling

**3) FULL SYMMETRY ANALYTICS**

**3A) Hand symmetry matrix (HSM+)**

Joint group	JSN_L	JSN_R	Erosion_L	Erosion_R	Sclerosis_L	Sclerosis_R	Δ_sym	AN-SYM	Drift flag	CSP
Thumb MCP	3.0	3.0	2	2	1	1	0.00	0.00	no	0.00
Thumb IP	1.0	1.0	0	0	0	0	0.00	0.00	no	0.00

Joint group	JSN_L	JSN_R	Erosion_L	Erosion_R	Sclerosis_L	Sclerosis_R	$\Delta_{sym}$	AN-SYM	Drift flag	CSP
MCP2	3.0	3.0	2	2	1	1	0.00	0.00	no	0.00
MCP3-5	0.3	0.3	0	0	0	0	0.00	0.00	no	0.00
PIP2-5	0.75	1.75	0	1	0	1	1.00	1.20	yes	0.40
DIP2-5	1.0	1.5	1	1	0	0	0.50	0.60	no	0.00

## Global HSM+ summary

Metric	Value
Hand symmetry index	0.90
Dominant asymmetry vector	right-predominant interphalangeal burden
Bilateral proximal-chain parity	high
Bilateral distal-chain parity	moderate-high

## 3B) Wrist symmetry matrix (WSM+)

Wrist row / compartment	JSN_L	JSN_R	Erosion_L	Erosion_R	Sclerosis_L	Sclerosis_R	Trabecular marker_L	Trabecular marker_R	$\Delta_{sym}$	AN-SYM	Drift flag
Proximal row	3.0	3.0	2	2	2	2	1	1	0.00	0.00	no
Distal row	2.5	2.5	1	1	1	1	1	1	0.00	0.00	no
DRUJ / ulnar side	3.0	3.0	2	2	1	1	0	0	0.00	0.00	no

## Global WSM+ summary

Metric	Value
Wrist symmetry index	0.96
Radial-column parity	0.97
Ulnar-side parity	0.94
Wrist-row drift penalty	0.00

## 4) COMPOSITE METRICS — EXPANDED SET

Temporal input note: formal interval-dependent stability metrics are not computable in a baseline-only study; where shown below, values are current-state structural proxy metrics, not longitudinal deltas.

Metric	Right	Left	Bilateral / global	Status
RCBS — regional composite burden score	0.62	0.58	0.60	high burden
CMS — composite morphology score	0.79	0.75	0.77	elevated
CTDM — traction/degeneration composite matrix	0.72	0.69	0.70	elevated mixed remodeling load
RSI (formal)	N/A	N/A	N/A	baseline-only; prior-dependent
RSI-lite (cross-sectional preservation proxy)	0.33	0.37	0.35	low preservation reserve
RSI-S — stability subindex (cross-sectional proxy)	0.29	0.32	0.31	low
CDTI baseline proxy	0.69	0.65	0.67	Class III
QCR — composite region quality	0.94	0.95	0.95	high
CMC — cross-modal concordance metric	N/A	N/A	N/A	no DEXA input

### Discrepancy engine status

Parameter	Value
Discrepancy class	not instantiated
Cross-modal alert	suppressed
Structural vs densitometric reconciliation	unavailable
Dominant-source selection	XR-only current study

## 5) AGE-ADJUSTED REFERENCE VALUES — FULL AN TIER

Age context used: 57 years, female

Late-life acceleration adjustment: inactive

Modality noise factor: XR pathway only

Region / group	Primary AN metric(s)	$\Delta$ _norm estimate	Window	Percentile equivalent	Envelope status
<b>Wrist complex</b>	AN-JSN / AN-ER / AN-SCL	+3.1 / +2.6 / +1.8	>1.0	>99th structural burden	age-exceeding abnormality
<b>DRUJ / ulnar styloid</b>	AN-JSN / AN-ER / AN-SCL	+2.8 / +2.2 / +1.4	>1.0	>99th	age-exceeding abnormality
<b>Thumb MCP</b>	AN-JSN / AN-ER	+2.7 / +2.1	>1.0	>99th	age-exceeding abnormality
<b>MCP2</b>	AN-JSN / AN-ER	+2.6 / +2.0	>1.0	>99th	age-exceeding abnormality
<b>PIP2-5 right</b>	AN-JSN / AN-SYM	+1.3 / +1.2	>1.0	91st–95th	age-exceeding abnormality
<b>PIP2-5 left</b>	AN-JSN	+0.4	<0.5	~60th	age-expected to borderline
<b>DIP2-5 right</b>	AN-JSN / AN-SYM	+0.8 / +0.6	0.5–1.0	~80th	borderline deviation
<b>DIP2-5 left</b>	AN-JSN	+0.6	0.5–1.0	~75th	borderline deviation
<b>CMC1 / STT</b>	AN-JSN	+0.4 to +0.5	<0.5 to 0.5	~60th–70th	age-expected / borderline
<b>Global periarticular bone quality</b>	BQE-AN	-0.7 z-equivalent	0.5–1.0 below expected	~31st	mildly below age-expected

**AN-family summary**

Metric	Value
<b>Dominant age-exceeding compartments</b>	bilateral wrists, DRUJ regions, bilateral thumb MCP, bilateral MCP2
<b>Borderline age-deviation compartments</b>	bilateral DIP groups, mild basal thumb compartments
<b>AN-SYM highest value</b>	PIP chain = 1.20
<b>BQE-AN status</b>	mildly reduced periarticular bone quality signal

## 6) DEXA-RADIOGRAPH LINKAGE

Module	Status	Note
BADA	N/A	no DEXA attached
$\Delta$ BMDnorm	N/A	no prior densitometry
DRI	N/A	no XR-DEXA pair available
DEXA provenance table	suppressed	no densitometric input
Cross-modal coherence estimate	suppressed	XR-only dataset

Quantitative missingness logged for densitometric path: yes

## 7) LONGITUDINAL / STABILITY / TRAJECTORY STATUS

Module	Status	Note
Longitudinal delta table	N/A	no prior study
$\Delta$ erosions / $\Delta$ JSN / $\Delta$ osteophytes / $\Delta$ sclerosis / $\Delta$ JLI	N/A	baseline-only
TSS / temporal stability score	N/A	prior-dependent
CDC / confidence decay curve	N/A	prior-dependent
STAB-T / MTV / trajectory zone metrics	N/A	prior-dependent
Bimanual temporal divergence markers	N/A	prior-dependent
Longitudinal AN deltas	N/A	prior-dependent

Temporal module flag: baseline-suppressed, non-error

Longitudinal gap warning: not applicable

## 8) REGIONAL CLUSTERING AND SEVERITY MAP

Cluster	Included regions	Mean burden	Symmetry profile	Cluster confidence
<b>Cluster 1</b>	bilateral wrist complexes + bilateral DRUJ/ulnar styloid + bilateral MCP2 + bilateral thumb MCP	0.80	high bilateral parity	0.95
<b>Cluster 2</b>	right PIP chain (PIP3-dominant)	0.52	asymmetric / right-dominant	0.88
<b>Cluster 3</b>	bilateral DIP chains	0.31	moderate parity	0.82
<b>Cluster 4</b>	bilateral CMC1/STT + thumb IP	0.20	high parity	0.79

**Region severity map**

Region set	Severity code
<b>Bilateral wrist–MCP proximal chain</b>	H
<b>Right IP overlay</b>	M
<b>Left IP overlay</b>	L–M
<b>Basal thumb degenerative compartments</b>	L

**9) ADJACENCY-BASED CROSS-REGION CONSISTENCY METRICS**

Adjacency pair	Consistency index (0–1)	Harmonization status
<b>Wrist complex ↔ MCP2</b>	0.91	high
<b>MCP2 ↔ PIP2-5</b>	0.55	mixed
<b>PIP2-5 ↔ DIP2-5</b>	0.81	high
<b>CMC1/STT ↔ Thumb MCP</b>	0.72	moderate
<b>Thumb MCP ↔ Thumb IP</b>	0.44	low

Global ACRC: 0.69

Adjacency profile: proximal-chain dominant with superimposed distal overlay

## 10) MAPR / CSW / QCL / RELIABILITY / PROVENANCE

### 10A) Confidence provenance

Parameter	Right	Left	Global
MAPR	0.95	0.95	0.95
CSW	0.93	0.94	0.94
Laterality confidence	1.00	1.00	1.00
Projection adequacy pass	yes	yes	yes
Morphologic richness pass	yes	yes	yes

### 10B) Concordance and reliability

Metric	Value	Status
QCL index (final)	0.95	high
ARI — analytic reliability index	0.93	high
DSS — drift-safety sentinel	0.09	low signal
MS-SCS — multi-study stability consistency score	N/A	single study
Validator pattern-consistency	pass	no internal contradiction after physician correction

### 10C) Provenance / registry-facing items

Field	Value
ai_fallback_mode	false
external_ai_source	none
external_ai_confidence	N/A
human override present	yes
override source	Physician

Field	Value
override reason	pattern hierarchy correction / dominant-process reweighting
override region	bilateral hands and wrists
quantitative_missing_fields logged	yes
experimental_mode	true

## 11) QUANTITATIVE MISSINGNESS / DATA INTEGRITY EXTENSIONS

Missing or suppressed module	Reason
Formal longitudinal deltas	no prior study
R31 temporal stability outputs	no prior study
Longitudinal AN deltas	no prior study
DEXA linkage metrics (BADA / $\Delta$ BMDnorm / DRI)	no DEXA input
Cross-modal discrepancy class	no densitometric input
External AI provenance fields	no external model attached
Multi-study reliability alignment metrics	single study only

## 12) EXPERIMENTAL EXTENSIONS — ACTIVE / INACTIVE STATUS

Experimental block	Status	Note
High-granularity symmetry overlay	text-mode derived, no graphic	proximal bilateral parity with right-sided IP asymmetry
Extended QCL beta parameters	not externally displayed	registry-only suppression
AEIT	inactive	no medication adverse-effect imaging trigger in current XR set
ONC / INF overlays	inactive	no trigger features instantiated
Genetic / developmental modulation	inactive	no dedicated input; adult study
Neuro-functional concordance	inactive	no EMG/NCS input

### 13) COMPACT SUMMARY GRID

Domain	Result
<b>Highest-burden compartments</b>	bilateral wrists, DRUJ/ulnar styloid, bilateral thumb MCP, bilateral MCP2
<b>Highest asymmetry</b>	right PIP chain
<b>Best bilateral symmetry</b>	wrist complexes and MCP2 / thumb MCP
<b>Age-exceeding burden</b>	proximal wrist–MCP chain dominant
<b>DEXA path</b>	unavailable
<b>Temporal path</b>	unavailable
<b>Reliability tier</b>	high
<b>Final registry state</b>	complete current-study XR addendum; temporal and densitometric modules suppressed as not applicable