Intramedullary Headless Screw Fixation of Metacarpal Fractures: A Radiographic Analysis for Optimal Screw Choice

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BACKGROUND & PURPOSE

- **Metacarpal** and phalangeal fractures are responsible for 10% of all fractures and account for 41% of hand injuries presenting to the emergency room or urgent care.[1]
- While several methods of operative treatment have been described, **intramedullary headless compression screw (IM HCS)** fixation has the advantage of zero-profile, stable fixation with minimal soft tissue violation, and allows for early motion.
- Application of this technique requires an understanding of metacarpal morphometric parameters.
- Radiographs are the primary diagnostic and intraoperative modality for treatment of metacarpal fractures, and as such, we have chosen to investigate the radiographic parameters of metacarpal anatomy as it relates to intramedullary fixation of metacarpal fractures.
- The **purpose** of this study is to investigate variations in **radiographic metacarpal anatomy** as it relates to intramedullary fixation of metacarpal fractures and to **compare this anatomy to available headless screw dimensions.**

MATERIALS & METHODS

- **Retrospective Chart and X-ray Review**
  - 30 subjects (15 men and 15 women)
  - Ages 18-60 years old
  - Posteroanterior (PA) and slightly pronated Lateral (LAT) Radiographs
- **Exclusion Criteria**:
  - Previous Metacarpal Fractures
  - Inflammatory Arthritis or evidence of hardware or soft tissue and bony abnormalities on X-ray
- **Measurements *(Figures 1)***:
  - Metacarpal Length, Isthmus Cortical Thickness, Medullary Isthmus Diameter, Retrograde Distance to Isthmus, Metacarpal Head Width, Projected Dorsal Entry Point, Cascade Angle, Metacarpal head cross-sectional area (CSA)
- **Comparison with 25 Commercially Available Screws from 7 Manufacturers**
  - Leading and Trailing Head Diameters
  - % CSA of Metacarpal Head Occupied

RESULTS & FIGURES

Table 1: All Measurements (millimeters ± standard deviation) ; *p-value ≤ 0.05

	Index			Long			Ring			Small		
	All	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
	(N = 30)	(N = 15)	(N = 15)	(N = 30)	(N = 15)	(N = 15)	(N = 30)	(N = 15)	(N = 15)	(N = 30)	(N = 15)	(N = 15)
PA Metacarpal Length	67.3 ± 4.8	69.8 ± 4.8	64.5 ± 3.0 *	64.9 ± 4.5	67 ± 4.1	62.6 ± 3.7 *	57 ± 4.2	58.9 ± 3.9	55 ± 3.4 *	52.5 ± 4.2	55 ± 3.4	49.8 ± 3.3 *
PA IM Canal Diameter	2.9 ± 1.1	3.4 ± 1.1	2.5 ± 0.8 *	2.7 ± 0.8	2.9 ± 0.9	2.5 ± 0.6	2.7 ± 0.8	2.9 ± 0.8	2.4 ± 0.7	3.7 ± 0.9	4 ± 0.8	3.6 ± 0.9
LAT IM Canal Diameter	2.8 ± 1.0	3.3 ± 1.1	2.3 ± 0.7 *	3.2 ± 0.9	3.5 ± 1.0	2.9 ± 0.8	3.1 ± 0.9	3.4 ± 1.0	2.8 ± 0.7	3.4 ± 0.8	3.9 ± 0.6	3 ± 0.7 *
PA Isthmus distance	39.2 ± 3.0	40.5 ± 2.6	37.8 ± 2.7	38.1 ± 2.7	39.3 ± 2.7	36.8 ± 2.2	32 ± 3.3	32.7 ± 2.6	31.3 ± 3.9	28.2 ± 3.0	29.6 ± 2.7	26.7 ± 2.7
PA Head Width	15.3 ± 1.7	16.4 ± 1.5	14 ± 0.8 *	15.8 ± 1.7	17.1 ± 1.3	14.5 ± 1.0 *	13.1 ± 1.5	14.1 ± 1.2	12.1 ± 1.0 *	12.4 ± 1.4	13.3 ± 1.1	11.4 ± 1.1 *
LAT Head Width	18.4 ± 2.0	19.5 ± 2.1	17.3 ± 1.1 *	17.4 ± 1.7	18.5 ± 1.4	16.2 ± 1.2 *	14.7 ± 1.6	15.8 ± 1.2	13.5 ± 1.0 *	13.2 ± 1.8	14.3 ± 1.7	11.9 ± 0.8 *
LAT Dorsal Entry Distance	6.4 ± 1.3	7 ± 1.2	5.8 ± 1.1	5.3 ± 1.4	6.3 ± 1.4	5.2 ± 1.3	4.4 ± 0.9	4.4 ± 0.8	4.4 ± 1.1	3.8 ± 0.7	3.9 ± 0.8	3.6 ± 0.6
LAT Dorsal Entry / Head Width	0.4 ± 0.05	0.4 ± 0.05	0.33 ± 0.05	0.3 ± 0.05	0.3 ± 0.07	0.32 ± 0.06	0.3 ± 0.06	0.28 ± 0.04	0.3 ± 0.06 *	0.3 ± 0.05	0.3 ± 0.04	0.3 ± 0.05
Calculated Isthmus Cortical Thickness	5.6 ± 0.67	5.8 ± 0.62	5.4 ± 0.68	5.2 ± 0.60	5.4 ± 0.65	4.9 ± 0.41 *	3.8 ± 0.49	4 ± 0.53	3.6 ± 0.31 *	3.5 ± 0.72	3.9 ± 0.65	3.2 ± 0.63 *
Head CSA	222.4 ± 45.2	252.5 ± 43.5	190.1 ± 13.6 *	218.6 ± 43.2	248.6 ± 35.1	186.4 ± 23.3 *	153.1 ± 32.2	175.8 ± 25.4	128.7 ± 17.3 *	130 ± 28.4	150.3 ± 23.1	108.4 ± 13.8 *

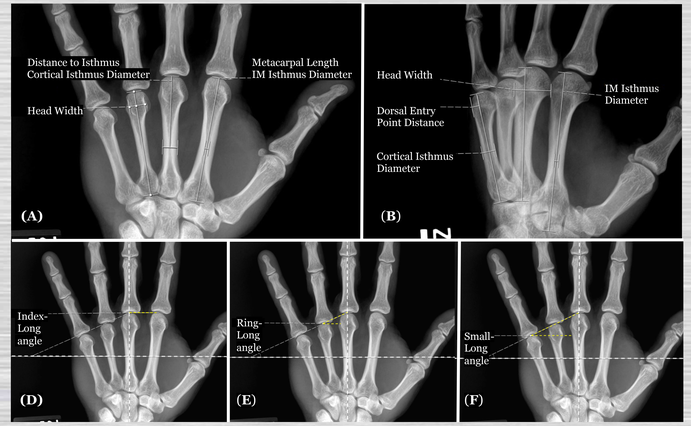
- **Isthmus Diameter**: Small Metacarpal had largest isthmus diameter (3.8mm PA, 3.4mm LAT) ($p<0.05$)

PA vs. LAT Isthmus Diameter T-test

- Long and Ring metacarpal isthmus diameters were larger on LAT than PA while Small metacarpal larger on PA ($p<0.05$)
- Index metacarpal isthmus diameter shows no statistical difference (3.0 mm PA vs. 2.8 mm LAT, $p = 0.248$).

- **Isthmus Cortical Thickness**: Index had thickest cortex 5.7mm (5.8mm men, 5.5mm women); Cortical Thickness in men was greater than women in all metacarpals except index ($p<0.05$ vs. $p=0.3$)
- **Dorsal Entry Point Range:** 25%-35% of LAT mead width
- **Cascade Angle:** Index-Middle **0°**[.95CI (-)1.1° – 1.1°], Ring-Middle **24°** [95CI 22.8° – 25.2°], and Small-Middle **27°** [.95CI 25.7° – 27.9°]
- **Retrograde distance to the Isthmus** from the metacarpal head was longest in the Index (39.2 mm followed by the Long (38.1 mm), Ring (32.0 mm), then Small metacarpal (28.2 mm)
- **Metacarpal Head CSA: I**ndex (222mm²), Middle (219mm²), Ring (153mm²), Small (130mm²)
- **25 Commercially Available Screws**
  - Leading Head Diameter: 1.7-4.5mm
  - Trailing Head Diameter: 2.1-5.8mm
  - Trailing heads occupy 2.2 – 7.1%, 3.2-7.3%, 4.6-10.4%, and 6.2-9.8% of cross-sectional area of index, middle, ring, and small metacarpal heads respectively

FIGURE 1: Diagrammatic Depiction of Measurements: (A) PA view; (B) LAT view; (D)-(F) Cascade angles referenced from Long metacarpal



CONCLUSIONS

- Metacarpal head entry point can help identify the appropriate guide pin starting point for placing in intermedullary metacarpal screw.
- The cascade angle can be used to estimate the amount of fracture shortening on injury X-rays.
- Surgeons should be mindful to choose the appropriate screw size in light of the variations between individual metacarpals and between men and women.

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