Biomechanical comparative study of the JuggerKnot™ soft anchor technique with other common mallet finger fracture fixation techniques

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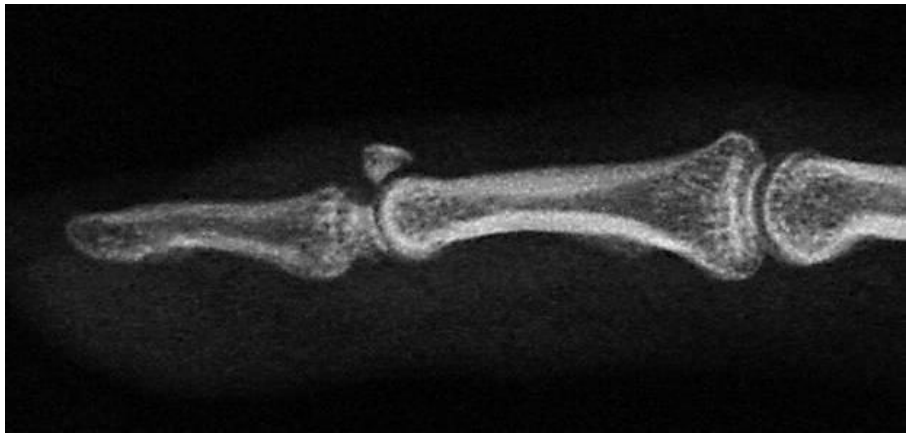
Study Disclosures

- I have no financial disclosures to report

Mallet Finger Deformity



Splinting

- Cumbersome
- Compliance issue

Operative

- Open injury
- Cannot tolerate splinting
- Large avulsion fracture
  - >30% of articulation

Fixation Methods

- Kirschner wire extension
- Hemicerclage
- Pull-out sutures
- Tension band wiring
- Umbrella handle

All Methods Require Immobilization!

Study Aims

- A biomechanically sound device
  - Early mobilization without protection
    - DIPJ mobilization has force of 5.6N (Husain JHSA 2008)
- Less soft tissue complications

- Biomechanical study
  - Peak load resistance to flexion of DIPJ
  - How do suture anchors compare?

Methods

- 32 specimens (8 fresh frozen cadaveric human hands)
  - 8 of each finger
  - No thumbs

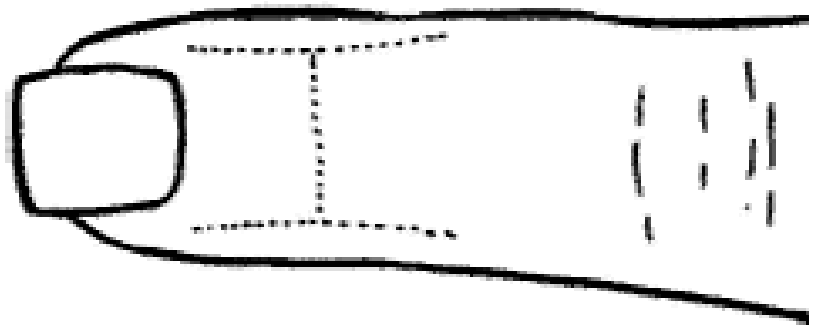
- 8 specimens for trial of procedure
- 24 specimens for analysis

Preparation

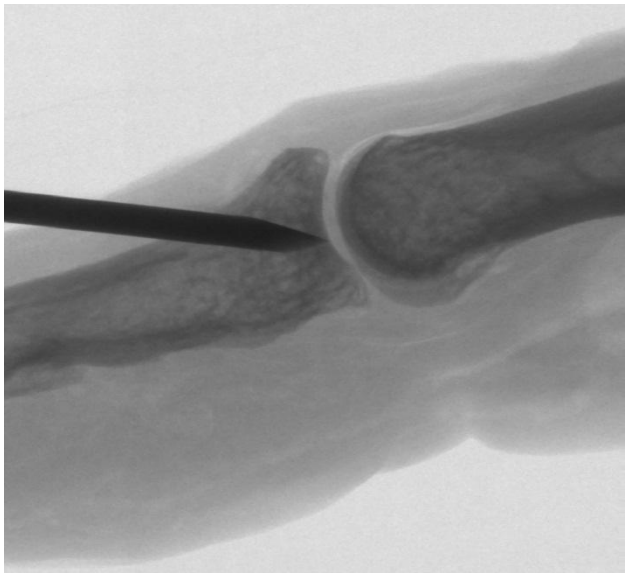
- Thawed to room temperature (24°C)
- Amputated at PIPJ
- Sparing of extensor tendon to wrist level
- Nails intact
- None had OA joints and bone defects

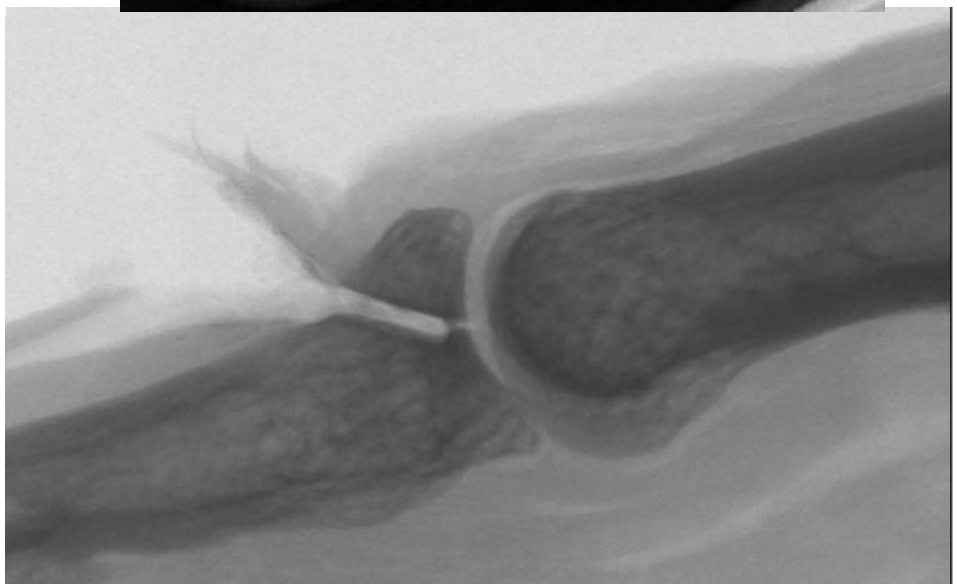
Preparation

- H-shaped skin incision at dorsal of DIPJ
  - Osteotomy
  - Fixation
- Fluoroscopic guidance



Fragment Sizing





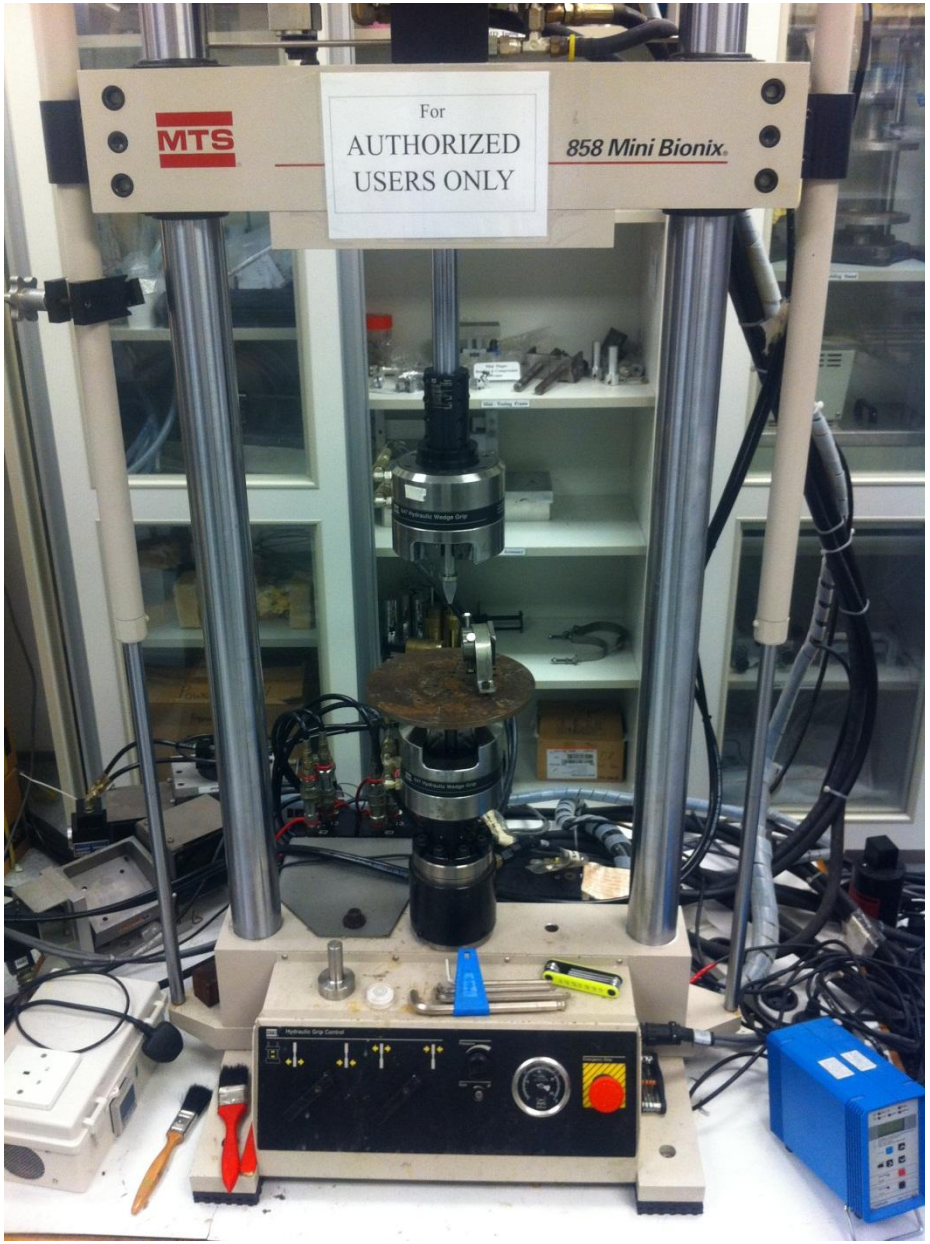
Fixation Methods

- Kirschner wire
- Pull-out wire
- Tension-band wiring
- Suture Anchor
  - JuggerKnot™

- Randomized block pattern distribution

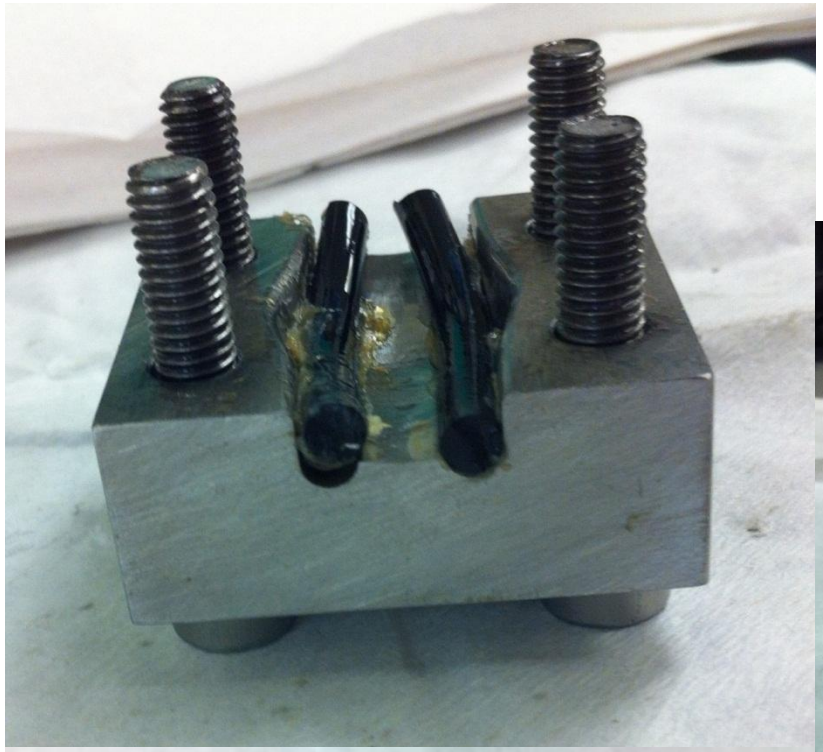
Biomechanical Testing

- MTS 858 Mini Bionix servo-hydraulic load frame



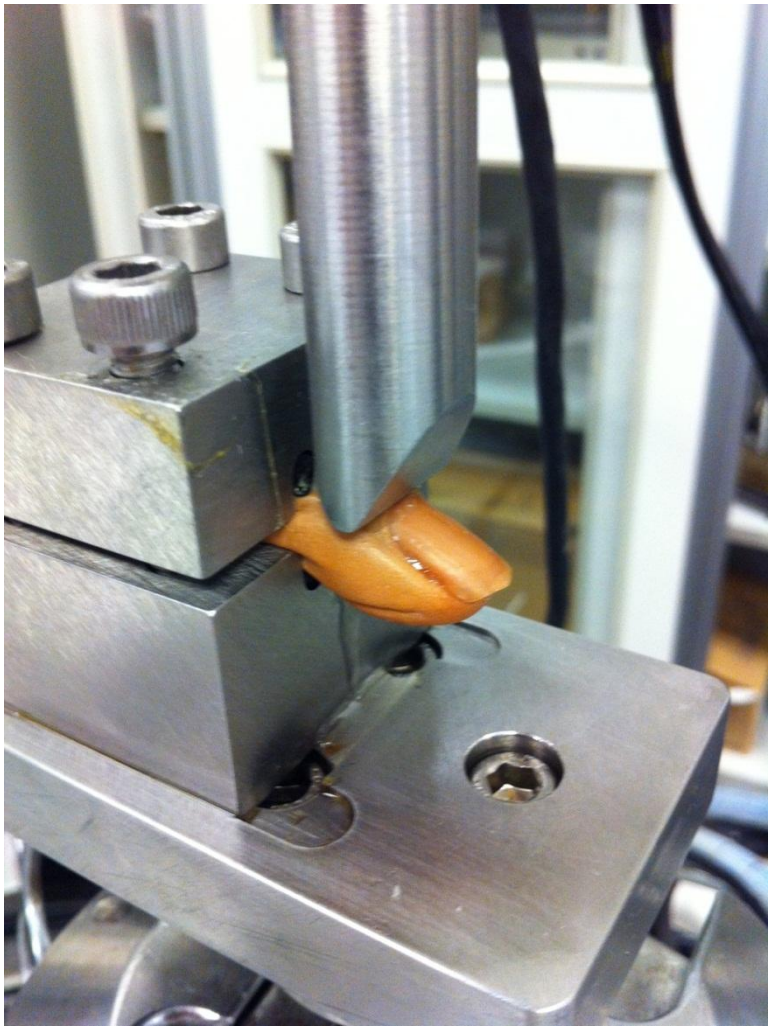
Mounting Device

- 4N torque screws
- 10N preloaded extensor tendon
- Testing apparatus with clamping device



Biomechanical Testing

- Peak load resistance
- Load testing at DIPJ flexion
  - 30 degrees
  - 45 degrees
  - 60 degrees
- Speed: 10cm/s
- Load distance: Tan Θ of mount to nail fold



Biomechanical Testing

- Complications
  - Implant failure
    - Loosening of knot, pull-out of implant, implant fracture
  - Fixation failure
    - >1mm widening of fracture site

Comparability between Digits

Average Peak Load

No differences between Digits

		Mean (N)	Range (N)	Standard Deviation	p-value
Before osteotomy	30°	16.45	8.45-31.25	1.14	0.370
	45°	31.32	16.39-52.50	8.79	0.342
	60°	57.01	24.26-88.47	19.52	0.450
After fixation	30°	18.88	7.10-50.18	11.03	0.549
	45°	30.48	11.70-80.80	17.66	0.505
	60°	44.27	17.50-98.80	21.25	0.515

Comparison between Fixation Methods

Peak Load Analysis

TBW Strongest Fixation
Suture Anchor Strong Enough to Resist Normal DIPJ forces

Fixation method	Before osteotomy: N (±SD)			After fixation: N (±SD)		
	30°	45°	60°	30°	45°	60°
Kirschner wire	12.37 (±2.67)	23.73 (±6.67)	45.75 (±22.14)	11.86 (±3.07)	21.13 (±5.41)	39.42 (±16.60)
Pull-out wire	19.01 (±6.27)	34.80 (±9.20)	58.41 (±19.29)	18.40 (±7.91)	25.60 (±7.73)	36.92 (±9.07)
Tension-band wire	17.51 (±4.41)	33.75 (±6.71)	62.71 (±19.23)	31.91 (±12.81)	52.69 (±21.52)	67.80 (±25.00)
Suture Anchor	16.93 (±6.11)	32.99 (±9.35)	61.17 (±17.52)	13.35 (±4.91)	22.51 (±4.91)	32.96 (±13.55)
p-value	0.161	0.099	0.446	0.001	0.001	0.008

Complications

- Dorsal skin impingement with TBW in 3 digits
- No implant failure
- No fixation failure

Discussion

- Only biomechanical study using suture anchors for mallet injuries
- Randomization
- Standardized biomechanical testing
- All fixation methods can withstand normal DIPJ movement in terms of peak load resistance

Future Studies

- Information on fatigue failure?
- Animal studies for healing potential
- Clinical trials for applicability in clinical setting

Thank You