

Fixation Constructs for Thumb Metacarpophalangeal Joint Ulnar Collateral Ligament Avulsion Fractures: A Biomechanical Study

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Thumb MCP joint UCL avulsion fractures

Thumb ulnar collateral ligament fracture avulsions are often treated operatively in the active population. Fixation of thumb metacarpal UCL fracture avulsions or reconstituting the UCL in such injuries has been shown to have more predictable results than nonoperative treatment¹. Several biomechanical studies of the strength of the native UCL and demonstrating acceptable means of treatment for UCL tears have been published²⁻⁵. One commonly used and validated method of treating UCL tears and fracture avulsions is the suture anchor construct (Figure 1b). To this date there are no construct comparisons published.

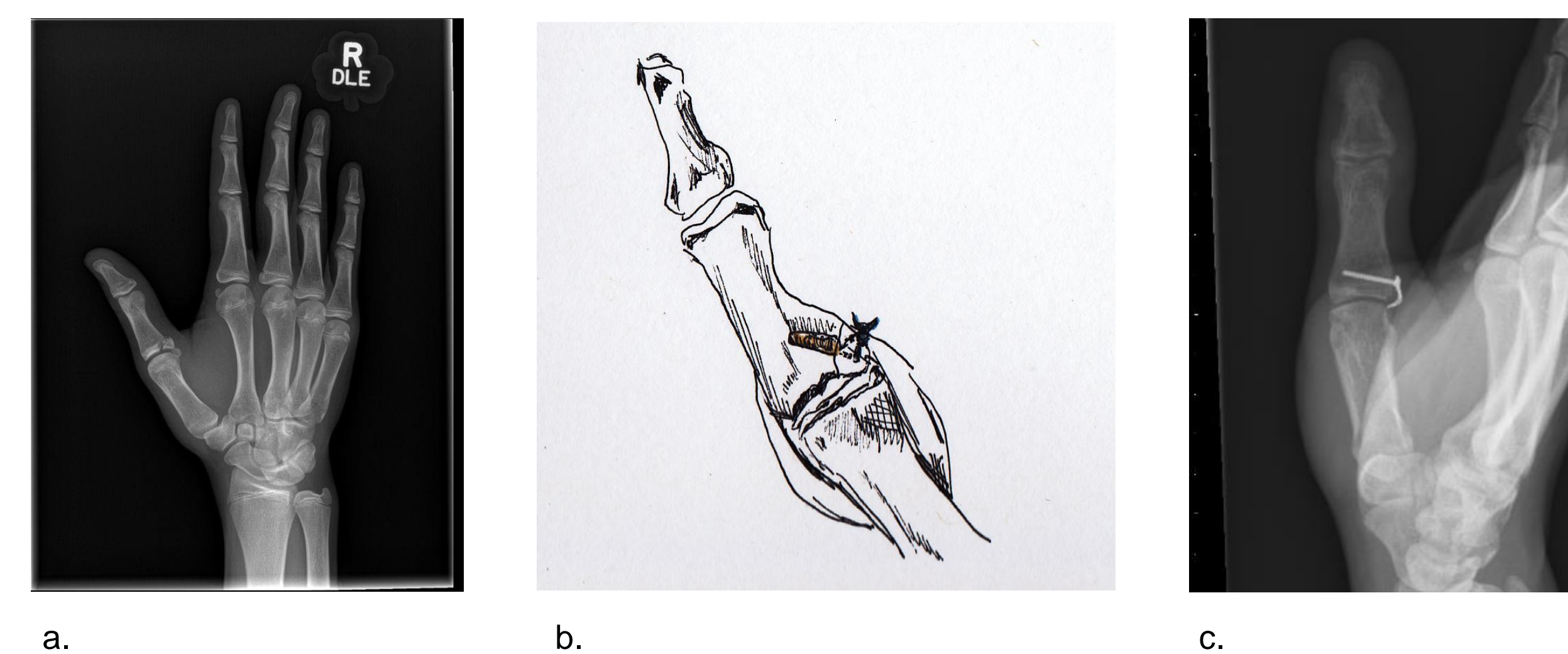


Figure 1:
a. Thumb UCL avulsion fracture
b. Suture anchor fixation
c. Hook plate fixation

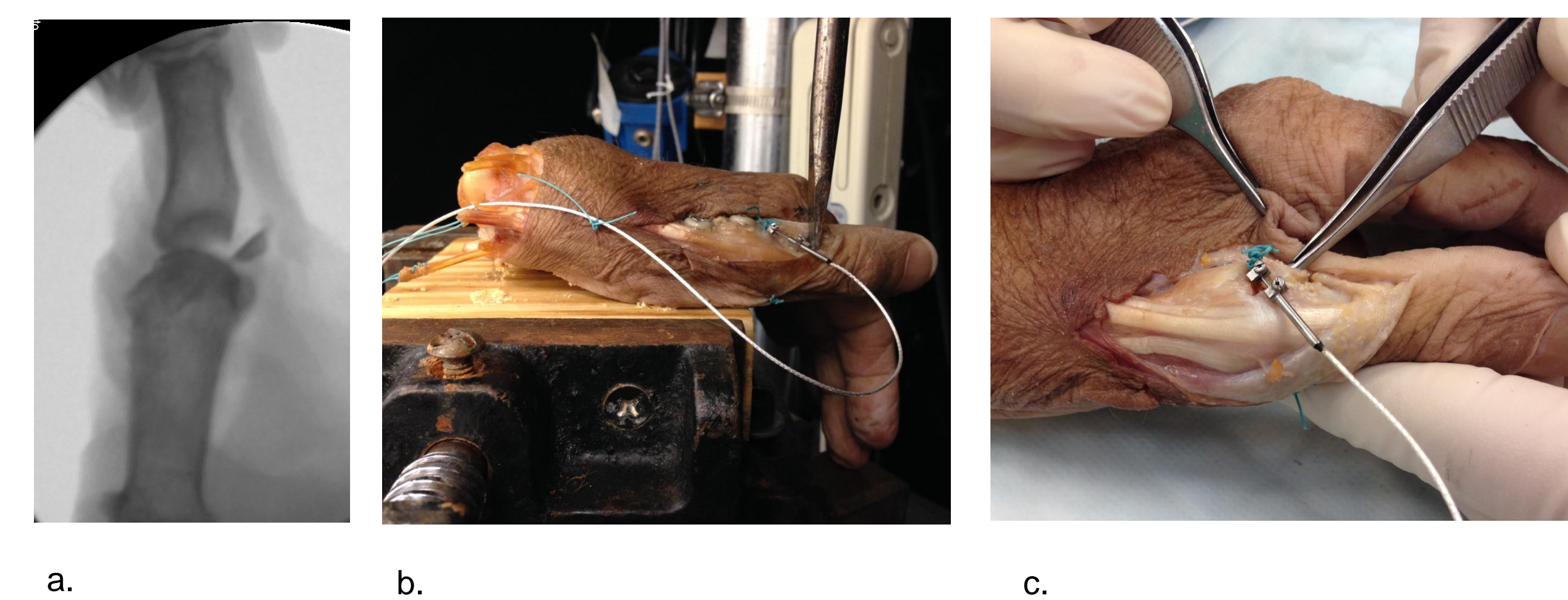
We hypothesized that the hook plate construct described by Kang et al² for fixation of small articular fracture avulsion fragments (Figure 1c) is biomechanically equivalent to a suture anchor construct tied over bone tunnels.

Methods

The thumb metacarpophalangeal joint UCL was exposed via a standard approach in 7 matched pairs of cadaver hands. An osteotomy was made parallel to the shaft of the proximal phalanx along the entire insertion of the UCL (Figure 2a). The osteotomy was fixed with either suture anchor (Mini Biocomposite SutureTak with 2-0 FiberWire, Arthrex) through two drill holes in the avulsion fragment and tied, or hook plate (1.5 mm titanium plate/screws, Synthes) construct.

Specimens were mounted on an MTS device and loaded to failure (Figure 2b). Motion perpendicular to the osteotomy was measured using an implanted 3 mm differential variable reluctance transducer device (Figure 2c). Differences in load to failure and construct stiffness were compared and analyzed using a t-test.

Figure 2:
a. An osteotomy was made parallel to the shaft of the proximal phalanx along the entire insertion of the UCL.
b. Mounted specimen onto the MTS device, with the abduction stress being applied 15 mm away from the metacarpophalangeal joint, as described in the model by Harley et al.³
c. Photograph of suture anchor fixation construct with DVRT applied.



Results

The hook plate construct failed at significantly higher loads than suture fixation. Load to failure in the hook plate construct 57.9 N (± 20.2 N) compared to 27 N (± 18.6 N) in the suture anchor construct ($P \leq 0.006$) (Figure 3a). The difference in construct stiffness was 48.8 N/mm (± 17.3 N/mm) compared to 6.6 N/mm (± 12.7 N/mm) ($P \leq 0.000$) (Figure 3b).

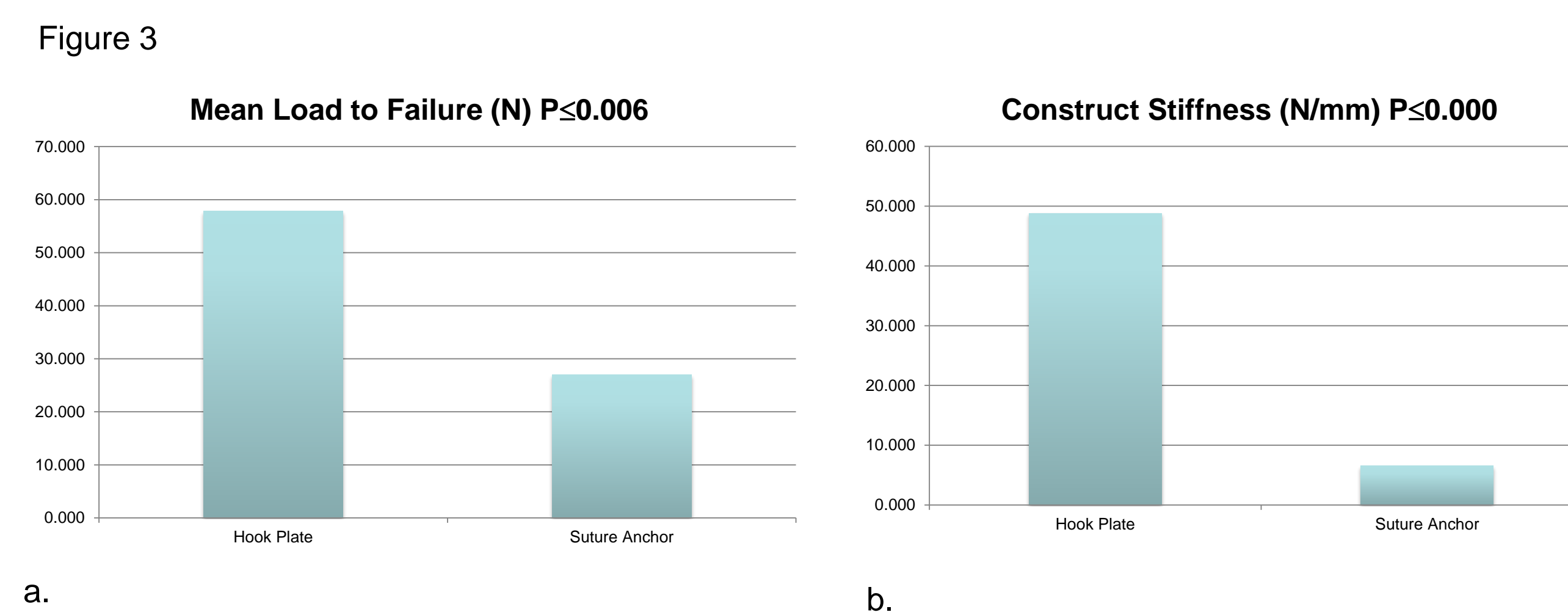
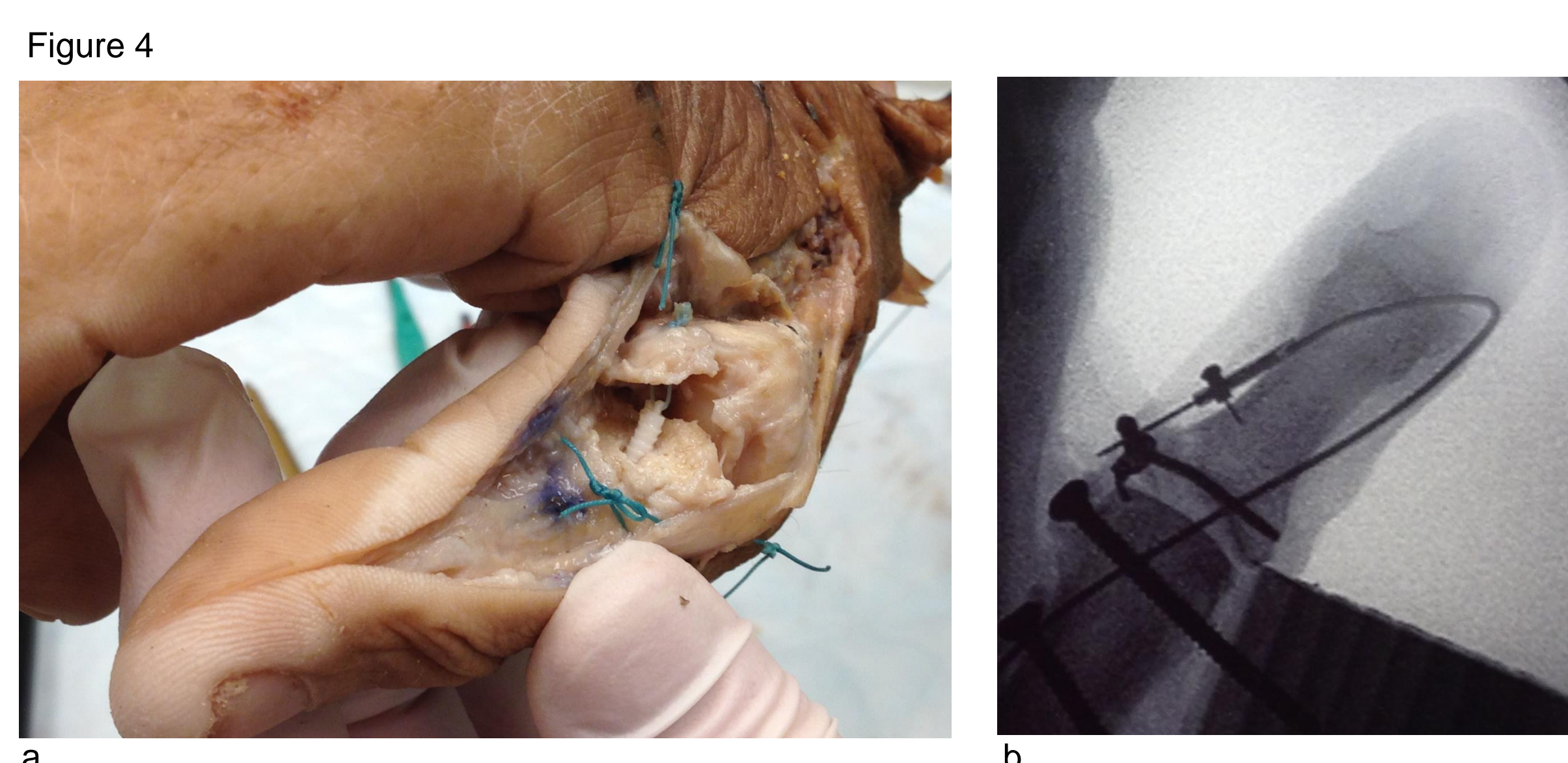


Figure 3:
a. The main mechanism of failure for the suture anchor construct was suture anchor pullout (Figure 4a). The main mechanism of failure for the hook plate construct was screw pullout or bending (Figure 4b).



Discussion

The hook plate construct appears to be biomechanically superior to suture anchor fixation for these avulsion fractures. The method of failure for suture anchor fixation was most commonly suture anchor pullout. This is likely secondary to the lack of a cortical buttress and the soft quality of the metaphyseal bone into which the anchor is placed. This was even more pronounced in the matched cadaver thumbs with poor bone quality.

Limitations/Next Steps

This was an in vitro cadaver study, which can simulate the effects of the constructs in vivo, but has limitations. For example, incorporation of the surrounding soft tissue envelope and surrounding dynamic structures was not included. In addition, the average age of our specimens was higher than that of the typical patient who presents with this injury. This presents a few discrepancies; first, the mode of failure of UCL injuries may be different for softer, more osteopenic bone, and second, that in the clinical situation, a patient with stronger bone stock may not have such an insufficient amount of bone in which to seat the anchor.

Conclusions

- Based on this model, the hook plate construct for fixation of thumb metacarpophalangeal joint ulnar collateral ligament fracture avulsions is biomechanically superior to the suture anchor construct.

-The lack of cortical apposition for the suture anchor as well as its placement into softer metaphyseal bone appears to contribute to suture anchor pullout and this construct should be used with caution when applied to this clinical situation.

References

1. Dinowitz M, Trumble T, Hanel D, Vedder NB, Gilbert M. Failure of cast immobilization for thumb ulnar collateral ligament avulsion fractures. *YJHSU*. 1997;22(6):1057-1063. doi:10.1016/S0363-5023(97)80049-4.
2. Carlson MG, Warner KK, Meyers KN, Hearn KA, Kok PL. Mechanics of an Anatomical Reconstruction for the Thumb Metacarpophalangeal Collateral Ligaments. *YJHSU*. 2013;38(1):117-123. doi:10.1016/j.jhsa.2012.09.015.
3. Harley BJ, Werner FW, Green JK. A biomechanical modeling of injury, repair, and rehabilitation of ulnar collateral ligament injuries of the thumb. *The Journal of Hand Surgery*. 2004;29(5):915-920. doi:10.1016/j.jhsa.2004.04.017.
4. Kataoka T. Changes in Shape and Length of the Collateral and Accessory Collateral Ligaments of the Metacarpophalangeal Joint During Flexion. *J Bone Joint Surg Am*. 2011;93(14):1318. doi:10.2106/JBJS.J.00733.
5. Tang P. Collateral ligament injuries of the thumb metacarpophalangeal joint. *J Am Acad Orthop Surg*. 2011;19(5):287-296.
6. Kang GC-W, Yam A, Phoon ES, Yi-Liang Lee J, Teoh L-C. The Hook Plate Technique for Fixation of Phalangeal Avulsion Fractures. *J Bone Joint Surg Am*. 2012;94(11). doi:10.2106/JBJS.K.00601.

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