Reattachment of Flexor Digitorum Profundus Avulsion: Biomechanical Performance of 3 Techniques

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Purpose To investigate whether inclusion of the volar plate in repair of flexor digitorum profundus avulsions increases the strength of the repair and resists gapping.

Methods Cadaveric fingers (n = 18) were divided into 3 equal groups. The first technique involved 2 micro-suture anchors only (A). The second used only volar plate repair (VP). The third group was a hybrid, combining a micro-suture anchor with volar plate augmentation (AVP). Specimens were loaded cyclically to simulate passive motion rehabilitation before being loaded to failure. Clinical failure was defined as 3 mm of gapping, and physical failure as the highest load associated with hardware failure, suture breakage, anchor pullout, or volar plate avulsion.

Results Gapping throughout cycling was significantly greater for the A group than VP and AVP with no difference detected between VP and AVP groups. Gapping exceeded 3 mm during cycling of 3 A specimens, but in none of the VP or AVP specimens. Load at clinical and physical failure for A was significantly lower than for VP and AVP, whereas no difference was detected between VP and AVP.

Conclusions In this cadaveric model, incorporating the volar plate conferred a significant advantage in strength, increasing the mean load to physical failure by approximately 100 N.

Clinical relevance According to previous biomechanical studies, current reconstructive strategies for flexor digitorum profundus zone I avulsions are not strong enough to withstand active motion rehabilitation. We demonstrated the potential use of volar plate augmentation and the prospective advantageous increase in strength in this cadaveric model. *In vivo* performance and effects on digital motion are not known. *(J Hand Surg Am. 2014;39(11):2214–2219. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Cadaver, biomechanics, flexor digitorum profundus, hand, tendon.

Zone I flexor digitorum profundus (FDP) avulsion injuries require surgical fixation to reapproximate the tendon to the volar base of the distal phalanx.[1] Although many surgical options exist for repair, there is no consensus as to the best repair method because each has its own advantages and complications. The ideal repair would withstand functional loads and early postoperative active mobilization. The 2 widely accepted fixation techniques use either a dorsal button or suture anchors.[1]

The traditional dorsal button technique, described by Bunnell[2] in the 1940s and since modified by several others, involves an external pullout suture that

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is secured to a button over the nail plate.[3] Potential complications include nail plate deformity, nailfold necrosis, and infection.[1] In addition, repair gapping has been associated with the monofilament suture material essential for suture removal after healing.[4–6]

Internal fixation techniques avoid problems associated with pullout sutures. Suture anchors can be different sizes and preloaded with different suture materials. If the anchor is inserted retrograde at a 45° angle, it resists pullout.[7] Previous testing demonstrated that failure typically occurs by suture rupture at the anchor attachment or by anchor pullout.[8] Potential advantages of this technique include decreased risk of infection, ability to use a locked suture technique, and permanent tendon-to-bone fixation. However, dorsal skin irritation, joint penetration, and nailbed problems have been reported. Osteoporotic bone offers less resistance to pullout and is a relative contraindication.[8] The suture anchors also add expense.

Distal interphalangeal (DIP) joint stiffness and loss of motion are frequent complications of FDP avulsion repairs. Other complications include re-rupture, loss of fixation, and quadrigia.[1] Some authors report as high as 75% fair to poor clinical outcomes in FDP avulsion injuries with current repair strategies.[9] The strength of the repair dictates the aggressiveness of postoperative rehabilitation aimed at preventing adhesions and contractures, while avoiding re-rupture or gapping. Repair site gapping greater than 3 mm has been associated with poorer results for tendon repairs.[10]

Previous biomechanical studies showed that repair with 2 micro-suture anchors is stronger than the modified Bunnell dorsal button technique.[8] However, neither technique is strong enough to withstand active range of motion rehabilitation.[11] In an attempt to improve repair strength to a level that would allow more aggressive postoperative therapy, we investigated the possibility of augmenting the repair by incorporating the volar plate (VP) at the level of the DIP joint. Outcome measures are overall repair strength and resistance to gapping. Cyclical tests performed mimicked passive range of motion protocols and tested gapping, whereas one-time load to failure testing measured the ultimate strength of the repair.

MATERIALS AND METHODS

The index, middle, and ring fingers were harvested from 10 human fresh-frozen cadaveric hands (average age, 60 y; range, 44–75 y). The thumb and little fingers were not used because of differences in size. Each hand was thawed to room temperature overnight. We excluded specimens with evidence of previous trauma. The FDP tendons were released at the musculotendinous junction proximally (minimum length, 15 cm) and exposed at the DIP joint by removing overlying skin and subcutaneous tissue. The A5 pulley was excised and the DIP joint VP was identified before harvesting each digit at the level of the proximal interphalangeal joint. The FDP was released sharply from its insertion on the distal phalanx. All soft tissue structures and the flexor digitorum superficialis tendon were removed to avoid tethering.

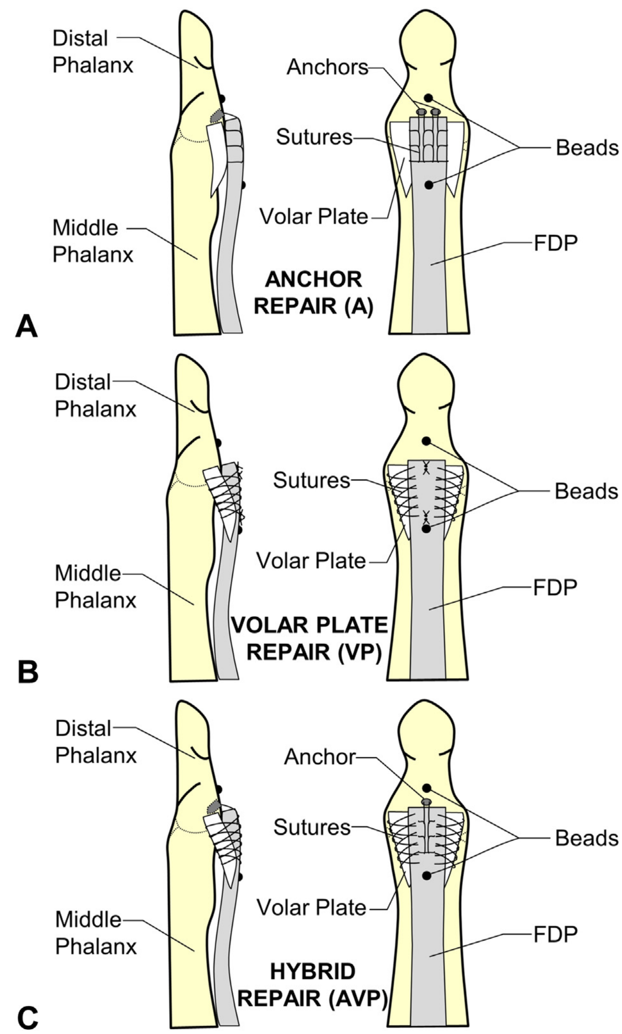

FIGURE 1: Repair techniques for **A** double suture anchor repair group, **B** volar plate repair group (VP), and **C** hybrid repair group (AVP) involving one anchor and the volar plate.

We performed each of the 3 techniques on each hand, alternating which technique was done on which finger (Fig. 1). Technique practice and refinement achieved consistent and standardized repairs using the first 4 hands. For the remaining 6 hands, 18 repairs