Volar Plate Repair for Posttraumatic Hyperextension Deformity of the Proximal Interphalangeal Joint

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Abstract

Traditionally, flexor digitorum superficialis tenodesis has been recommended for surgical correction of posttraumatic proximal interphalangeal (PIP) joint hyperextension deformity resulting from recurrent volar plate (VP) disruption. In contrast, VP repair has been used sparingly to restore joint stability, because of concerns regarding excessive scarring, insufficient substance, and the often long time between injury and repair.

In the study reported here, we critically evaluated the long-term functional outcome of isolated VP repairs for chronic dorsal instability of the PIP joint performed over an 18-year period. Twenty-five patients underwent surgery for hyperextension deformity of the PIP joint. Mean time from injury to repair was 8.2 years. All patients complained of painful locking of the PIP joint in extension. Precise repair of the VP was performed by meticulous scar lysis and advancement to the anatomical site of insertion while avoiding the adjacent nutrient vessels. Follow-up evaluation included completion of the DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire and digital mobility, strength, and radiographic assessment.

At a mean follow-up of 8 years, we found consistent alleviation of pain, restoration of joint stability, mean arc of motion ranging from 6° to 92° of flexion, and grip strength returned to within 90% of the contralateral side. All patients returned to unrestricted activities.

Traumatic disruption of the volar plate (VP) is being recognized with increasing frequency as the cause of disabling hyperextension deformity of the proximal interphalangeal (PIP) joint.[1-7] Although encountered in all sectors of the population, VP injury is particularly prevalent among athletes whose fingers are continually exposed to violent forces. Unfortunately, the initial trauma is usually dismissed as trivial, as mild hyperextension deformities are often well tolerated. Over time, increasing instability develops with dorsal subluxation. This often undergoes a predictable sequence of events. Initially, the VP detaches from its most distal insertion on the volar base of the middle phalanx. The proximal check rein ligaments are quite strong and seldom the site of detachment. This distally based avulsion is the result of a combination of a hyperextension force combined with varying amounts of either radial or ulnar deviation. The ensuing PIP joint imbalance results in a progressive swan-neck deformity (Figure 1) or "volar boutonniere." Patients soon complain of painful snapping as the lateral bands slide over the head of the proximal phalanx with attempted flexion. As time passes, there is loss of strength, locking in extension, and the inability to initiate flexion. Ultimately, posttraumatic arthritis may develop, after which surgical management becomes more complex. There is considerable variability, however, in the time it takes for these late degenerative changes to occur. VP repair can successfully be used to restore stability of the PIP joint with favorable results in all but the final stages of the disorder.

VP arthroplasty of the PIP joint has been performed since the 1960s.[8] Despite a consensus that surgery is necessary to correct the PIP joint hyperextension deformity, the best method of restraining excessive extension has been debated. Tendon graft reconstruction,[1,7] superficialis tenodesis,[9-12] lateral band tenodesis,[13-16] and collateral ligament advancement[1,4] have all been used. The superiority of one method over another has not been determined because of the paucity of studies evaluating this injury pattern.

The surgical goals for correction of posttraumatic chronic hyperextension deformities of the PIP joint include restoration of joint stability, functional improvement, alleviation of pain, and return to full sports or work. As digital imbalance results solely from VP disruption, precise repair of the VP with advancement to the anatomical site of insertion while avoiding adjacent flexor tendons seems logical.

In the study reported here, we critically assessed our long-term clinical and radiographic outcomes after isolated VP advancement secondary to chronic traumatic hyperextension deformities.

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Figure 1. (A) Patient's severe proximal interphalangeal joint hyperextension or swan-neck deformity in small finger, before surgery. (B) Preoperative lateral radiograph of same patient.

Figure 2. (A) Preoperative lateral radiograph taken in extension shows dorsal subluxation. (B) Same patient's preoperative lateral radiograph taken in flexion shows congruous joint. Note absence of significant degenerative changes.

Material and Methods

Twenty-five patients who underwent isolated VP advancement for hyperextension deformity of the PIP joint were reviewed retrospectively. Mean age was 42.7 years (range, 18-65 years). Mean time from injury to repair was 8.2 years (range, 2 months–23 years). The little finger was the foremost involved digit (13 cases), followed by the ring finger (7 cases), the long finger (3 cases), and the index finger (2 cases). Thirteen cases occurred in the dominant hand. Most (16) patients stated that the initial injury was sports related. All patients complained of pain and locking of the PIP joint in extension. Preoperative radiographs taken in extension showed dorsal subluxation (mean, 24.3°), whereas those taken in flexion showed a congruous joint (Figure 2) with a preserved joint space. No patients had severe degenerative changes seen on plain radiographs taken in flexion before intervention; however, remodeling of the proximal and middle phalangeal articular surfaces was seen in patients with long-standing injuries (Figure 1) and did not preclude VP repair. VP repair and advancement were performed in each patient by meticulous scar lysis and advancement to the anatomical site of insertion while avoiding the adjacent nutrient vessels. In no cases were additional procedures (ie, superficialis tenodesis) required to substitute or augment an incompetent or scarred VP. In addition, no modifications were performed when an extensor lag at the distal interphalangeal joint (ie, pseudo-mallet deformity) existed; however, full passive motion at this joint is recommended.

Mean follow-up was 8 years (range, 1-22 years). Follow-up evaluation included completion of the DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire and digital mobility, strength, and radiographic assessment. Results were classified as *excellent, good, fair,* or *poor*.[9] An excellent result was defined as complete correction of the hyperextension deformity, achievement of ROM equal to the contralateral finger, and a stable, painless PIP joint with no functional disability. The operative result was good when hyperextension of the PIP joint was fully corrected but there existed a 5° to 15° asymptomatic flexion contracture. A fair result was defined as a flexion contracture of more than 15° with some mild pain of functional disability. No improvement after surgery was considered a poor result. This study was approved by the institutional review boards at our institution.

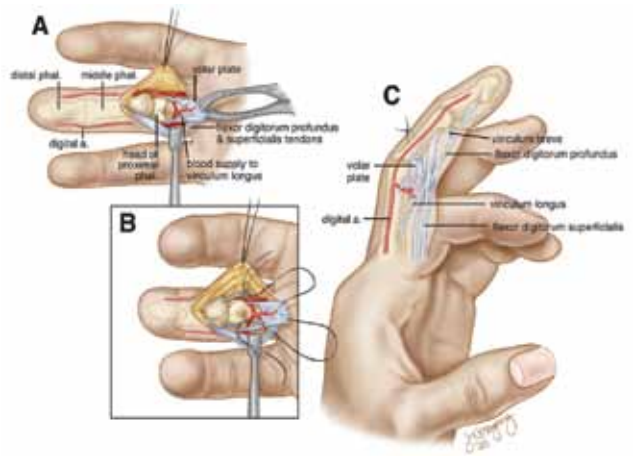

Figure 3. (A) Volar plate (VP) is exposed by gently retracting profundus and superficialis tendon. Meticulous lysis of scar is performed, being careful not to disrupt check rein ligaments or important nutrient vessels. (B) Shallow trough is created at base of middle phalanx using a small rongeur. Absorbable traction sutures are then secured to widest margins of VP. Keith needles are used to advance sutures through base of middle phalanx, making sure to maintain its width. (C) Sutures should exit dorsal aspect of middle phalanx in area of triangular ligament. Joint is transfixed at 15° to 25° with a 0.35-mm Kirschner wire. Under maximal tension, VP is advanced and tied securely on dorsal surface with cotton pledget. Abbreviations: a., artery; phal., phalanx. Illustration by Jill Gregory, Medical Illustrator, Beth Israel Medical Center, New York, New York. Copyright 2005, Continuum Health Partners.

Technique for Volar Plate Advancement

A Bruner zigzag incision was made over the volar aspect of the PIP joint. A skin flap was developed, with care taken to identify, isolate, and protect both neurovascular bundles. A "window" was carefully made in the flexor sheath between the A2 and A4 pulleys. The profundus and superficialis tendons were gently retracted, and the VP was identified and freed of all adhesions. The degree of scar tissue was usually related to the chronicity of the injury.[8] Meticulous lysis of scar was performed, with care taken not to disrupt the check rein ligaments or the important nutrient vessels (Figure 3A). This permitted successful mobilization of the VP. A shallow trough was then created at the base of the middle phalanx using a small rongeur. The articular surface was not routinely exposed unless there was concern about the degree of degenerative changes. Softening or mild discoloration of the articular cartilage as well as partial-thickness ulcerations were not considered a contraindication to proceed with VP repair. Absorbable traction sutures were then secured to the widest margins of the VP. With use of Keith needles, the sutures were advanced through the base of the middle phalanx, with care taken to maintain its width (Figure 3B). The suture exited the dorsal aspect of the middle phalanx in the area of the triangular ligament (Figure 3C). The joint was then transfixed at approximately 15° to 25° of flexion with a 0.35-mm Kirschner wire. Under maximal tension, the VP was advanced and tied securely on the dorsal surface with a cotton pledget, thus creating a check rein to hyperextension. The plate was also sutured to the accessory collateral ligaments on both sides of the joint, thus restoring the integrity of the critical collateral ligament–palmar plate complex. Occasionally, the check rein ligaments had to be incised when the VP could not be primarily advanced; however, this was done judiciously. The PIP joint was immobilized for 3 weeks, at which point the Kirschner wire was removed and dorsal block splinting was begun. The splint was discontinued after 6 weeks.

Results

At a mean follow-up of 8 years (range, 1-22 years), we found consistent alleviation of pain and restoration of joint stability. Mean range of motion (ROM) improved from 24° to 93° before surgery to 6° to 92° after surgery. Mean distal interphalangeal joint ROM was 6° to 84° before surgery and 2° to 84° after surgery. Metacarpophalangeal joint ROM did not change from its preoperative values (0°-90°). Grip strength returned to within 90% of the contralateral side. Postoperative radiographs showed mild degenerative changes in 7 patients. Mean DASH score at final follow-up was 5.6, indicative of minimal disability. Twenty-three cases were rated satisfactory (excellent/good) and 2 fair.

The 2 patients with fair results complained of mild pain and more than 15° of flexion contracture with mild loss of function. All patients in the study had stable PIP joints and returned to their previous occupations, including full sporting activity. To date, no patients had a recurrence of their deformity. No correlation was seen between the increased time between injury and surgical repair or final outcome.

Discussion

VP disruption is a very common injury. The vast majority of these injuries are appropriately treated with extension block splinting, buddy strapping, or even careful neglect. Sometimes these injuries, especially those exposed to recurrent trauma, progress to chronic hyperextension deformities, which require surgical intervention secondary to pain, instability, loss of motion, and function. The key to preventing these late-appearing sequelae is to recognize the acute disruption. Although the obvious clinical and radiographic deformity of an overt dislocation is absent, careful inspection of the injured digit demonstrates the subtle but diagnostic features: swelling, ecchymosis, and tenderness along the palmar aspect of the PIP joint. Lateral radiographs can show a small avulsion fracture at the base of the middle phalanx, though findings are usually nonspecific. In such cases, conservative treatment—extension block splinting followed by protective splinting that permits full but guarded joint ROM—should be started promptly. This should be followed by a program of increasingly resistive exercises, which will consistently result in uncomplicated healing of the VP.[17,18] It should be noted that PIP joint swelling may persist for several months. Using these techniques, we have yet to encounter

a VP injury that resulted in PIP joint instability with dorsal subluxation. Unlike most digital deformities caused by chronic regional or systemic disorders, hyperextension deformities due to VP injury can be prevented by prompt, precise primary care.[19]

In contrast to the acute injury, the chronic VP disruption with an established hyperextension deformity requires surgical stabilization for preservation of joint function. Attempts at splinting and therapy serve little purpose; without operative intervention, the chronic injury is prone to a predictable sequence of persistent instability, increasing deformity, and, ultimately, articular destruction of the PIP joint. Ideally, surgical correction should restore the 2 principal functions of the disrupted VP—namely, its passive restraint to extension and its dynamic assistance to flexion.[20] In its normal position, the palmar plate increases the moment arm of the superficialis flexors. Clearly, the most physiologic method of achieving these goals is repair of the damaged fibrocartilagenous plate per se.

"Lysis of scar with mobilization and advancement of a viable VP offers the best opportunity for precise restoration of joint stability and digital balance."

Lysis of scar with mobilization and advancement of a viable VP offers the best opportunity for precise restoration of joint stability and digital balance. With this method of repair, the crucial palmar stabilizer is repaired in an anatomical position with a precise measure of tension; consequently, accurate repair of the basic pathology is effected, and the inexactness of tenodesis or tendon grafting is eliminated. In addition, no donor tissue is required, and interference with the adjacent normal tissues is avoided.

Clearly, successful VP advancement is contingent on the quality of the injured VP after mobilization. Intraoperative inspection of the VP in all cases revealed it to be in excellent condition, with minimal evidence of fibrosis after mobilization. This finding can be attributed to the well-preserved vascularity of the proximal VP (Figure 3A).[21,22] The distal portion of the VP is less vascular and therefore may contribute to delayed plate healing or lack of plate healing.[21] The main vascular supply to the VP is from the proximal transverse palmar arch (PTPA), which arises from the palmar digital arteries. The PTPA, which has a "horseshoe" pattern, supplies the proximal portion of the VP. These same vessels also contribute to the vincular system, which supplies the flexor digitorum superficialis and profundus tendons.[23]

Corroborating the experiences of McCue and colleagues,[5] Bowers,[21] and Bowers and colleagues,[23] we have successfully used VP advancement for 25 patients treated within 18 years from their initial injuries. After surgery, all 25 patients returned to full activity and demonstrated a stable joint with functional ROM. In no case did the initial deformity recur.

Intuitively, an increasing interval between injury and repair lessens the probability of viable restoration of the palmar plate. Nevertheless, successful advancement has been reported at intervals from 10 to 20 years after injury.[9,13,24] Thus, in all cases of hyperextension deformity secondary to VP injury, one should thoroughly inspect the palmar plate to determine whether it is suitable for advancement. However, caution must be advised against excessive mobilization, which can jeopardize the integrity of the check rein ligaments and/or the critical vascular network to the VP and vincular system. In addition, caution must be emphasized in repairs that require positioning of the PIP joint in severe flexion. Positioning the joint in excess of 40° to facilitate advancement is apt to result in a flexion contracture as disabling as the existing hyperextension deformity. In such cases, palmar plate advancement is not advisable, and an alternative plan is necessary for success.

In cases in which palmar plate damage has been irreparable, superficialis tenodesis has proved a successful alternative method of reconstruction.[9] However, this technique did not prove necessary in our series. Moreover, a reluctance to sacrifice a normal superficialis is well-founded for several basic reasons. First, a loss of flexion is likely affected by removing a portion of the tendon. In cases of chronic hyperextension deformity, however, the potential loss is more than counterbalanced by the restoration of joint stability with its improved sequence and force of flexion. Second, disturbance of an intact flexor mechanism (particularly within the digital flexor sheath) risks the possibility of restrictive adhesions. Third, a significant number of patients lack function of the superficialis to the ring or little finger, which are the most common digits affected by this injury pattern. In one study, 21% of patients had clinically deficient or absent superficialis function to the ring or small finger, despite cadaveric studies confirming its presence in 100% of cases.[24] This further illustrates that sacrifice of an already weak and/or insufficient superficialis tendon may lead to diminished flexion and strength.

Summary

In summary, VP repair by scar lysis and advancement has proved a consistently successful and preferred method for correcting posttraumatic hyperextension deformity of the PIP joint. Reconstructing the anatomical configuration of the PIP joint and avoiding the complex and often deficient digital flexor mechanism are distinct advantages. A minor

residual flexion contracture of the PIP joint is a surgically created check rein to dorsal instability and should not be considered a complication of the procedure.

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