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Concomitant internal joint stabilizer augmentation with isometric lateral ulnar collateral ligament repair for unstable elbow dislocations: a surgical technique

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A R T I C L E I N F O

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Complex unstable elbow fracture dislocations can present challenges to treating surgeons. Surgeons must balance the need to confer bony stability, while also allowing for early range of motion rehabilitation protocols, to decrease post injury stiffness that can be common to this pathology.[15,17,19,21] Terrible triad injuries or coronoid fractures with associated ligamentous injury may lead to persistent ulnohumeral joint instability after fixation.[7,9,10] In these situations, surgeons have historically used prolonged immobilization in elbow flexion with or without transarticular pinning or static external fixators to maintain joint reduction, but with these techniques, patients can have difficulty regaining functional elbow range of motion. Alternatively, hinged external fixators permit stabilized elbow range of motion, thereby decreasing post injury stiffness; however, they are technically difficult to apply and are accompanied with complications including pin site infections and pin site pain.[2,4,5-10,18,20] In response to these difficulties, an internal joint stabilizer (IJS) (Skeletal Dynamics, Miami, FL, USA) was developed. With an internal hinged device, the surgeon may avoid both the increased infection risk posed by external fixation and stiffness associated with previous static techniques by permitting the patient early elbow range of motion.[11-13] Despite its benefit, the IJS system can also be technically challenging, as it requires placement of the humeral pin in the center axis of rotation of the distal humerus to confer stability and isometric motion of the elbow. This placement limits the ability to anatomically repair the lateral ulnar collateral ligament (LUCL). This article seeks to describe a surgical technique that permits the isometric placement of the IJS while allowing for a more anatomic repair of the LUCL on the lateral humeral condyle.

Anatomy

The elbow is made up of both dynamic and static stabilizers which confer stability to the joint through its range of motion. The lateral elbow dynamic stabilizers include the common extensor origin as well as small contributions of the mobile wad. The static stabilizers of the lateral elbow include contributions from the lateral collateral ligament complex and the ulnohumeral joint capsule. The lateral collateral ligament complex is made of 4 components including the accessory lateral collateral ligament, annular ligament, lateral radial collateral ligament, and the LUCL. Of these, the lateral collateral ligament acts as the primary restraint to varus and external rotation stresses. Camp et al described the origin of the LUCL 10.7 mm distal from the lateral epicondyle and 8.2 mm proximal to the capitellar articular cartilage in a cadaveric study. The humeral footprint on average covers an area of 26.0 mm^2. Distally the LUCL inserts 3.3 mm distal to the apex of the supinator crest of the ulna.[1] When torn in acute trauma, the LUCL can avulse from its humeral origin, the ulnar insertion, or tears in its midsubstance. Anatomic ligament repair or reconstruction following injury of these stabilizers is crucial for restoration of normal elbow biomechanics.

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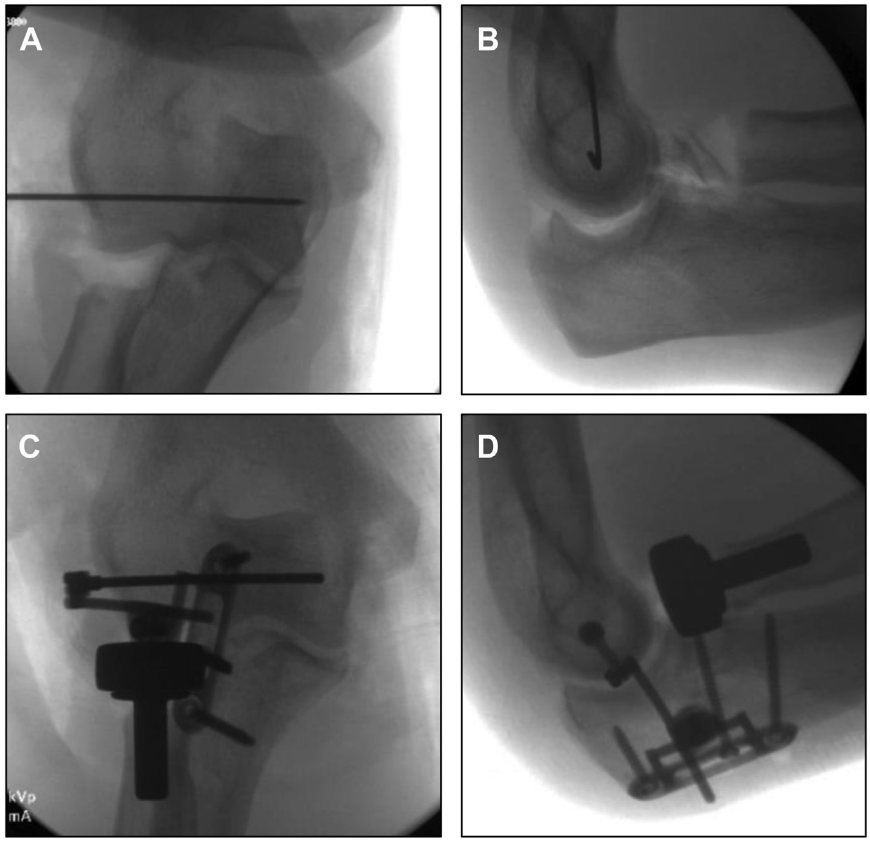

Figure 1 (**A** and **B**) demonstrate orthogonal fluoroscopic confirmation of isometric IJS guide wire placement at the center of rotation of the elbow within the distal humerus. (**C** and **D**) demonstrate AP and lateral fluoroscopic views of the elbow demonstrating final IJS construct placement of the IJS in the elbow center of rotation seated within the suture anchor. *IJS*, internal joint stabilizer; *LUCL*, lateral ulnar collateral ligament.

Indications/contraindications

Use of the IJS has been described for patients with elbow fracture dislocations injury patterns that either do not permit for traditional osteosynthesis techniques or residual instability despite appropriate fixation. The decision to proceed with IJS augmentation is determined by the intraoperative examination and assessment of elbow stability. Patients are counseled preoperatively that this augmentation may be necessary to provide adequate postoperative elbow stability. Contraindications for use are similar to other hardware constructs including cases of active infection, documented metal allergy, inadequate bone stock, or inadequate fixation or stabilization techniques.

Technique

With the patient positioned supine on a hand table, a lateral curvilinear incision is made posterior to the lateral condyle of the distal humerus extending toward the subcutaneous border of the ulna. A Kaplan or Kocher approach can be used depending on elbow pathology. The forearm is maintained in pronation to ensure protection of the posterior interosseus nerve. The lateral condyle and collateral ligament is then exposed, verifying disruption of the proximal origin. Any concomitant osseous pathology must be addressed prior to repair of the lateral ligamentous structures.

In this technique, the guide pin for the IJS system is placed as demonstrated in Figs. 1 and 2 using a combination of placement guides, direct visualization, and fluoroscopic guidance. This step must be performed prior to LUCL repair and is crucial to ensuring collinearity of the suture anchor and IJS pin and confirming appropriate construct placement. The IJS guide pin must be placed at the axis of rotation of the elbow within the distal humerus and is verified on intraoperative imaging to allow for the concentrically reduced elbow to maintain an appropriate arc of motion. The path of the IJS humeral pin is drilled using a 2.5 mm cannulated drill and the guidewire is then removed. As demonstrated in Fig. 2, the drill hole for the IJS pin now acts as the site for the suture anchor repair of the LUCL and the wire is used to maintain collinearity of the anchor when placed with the IJS pin hole path. Next attention is turned to ligament repair. The LUCL fibers are sutured with a large nonabsorbable suture in a Krackow stitch fashion leaving tails at the proximal most portion of the ligament to be incorporated into the suture anchor fixation. The guidewire for the suture anchor is placed in the existing IJS pin guide hole, and the site is then over-drilled with 4.0 mm drill to a depth of 2 cm to accommodate the anchor. The LUCL repair sutures are secured into the anchor site using a 4.5 mm SwiveLock anchor (Arthrex) (Figs. 3-5) with appropriately tensioning. The hollow center of the suture anchor is now located at the insertion point for the IJS humeral pin. The inner portion of the anchor is gently drilled with the 2.5 mm drill to allow for placement of the central axis guide from the IJS (Fig. 5). Of note, this step removes minimal material from the central portion of the suture anchor and does not interfere with the suture interface with the bone—suture anchor thread interdigitation. Optionally, this step may be performed over a guidewire with a cannulated 2.5 mm drill to ensure concentricity of the drill path within the anchor. The IJS ulnar plate is then applied and connected to the central IJS pin while holding the elbow concentrically reduced. The elbow is taken

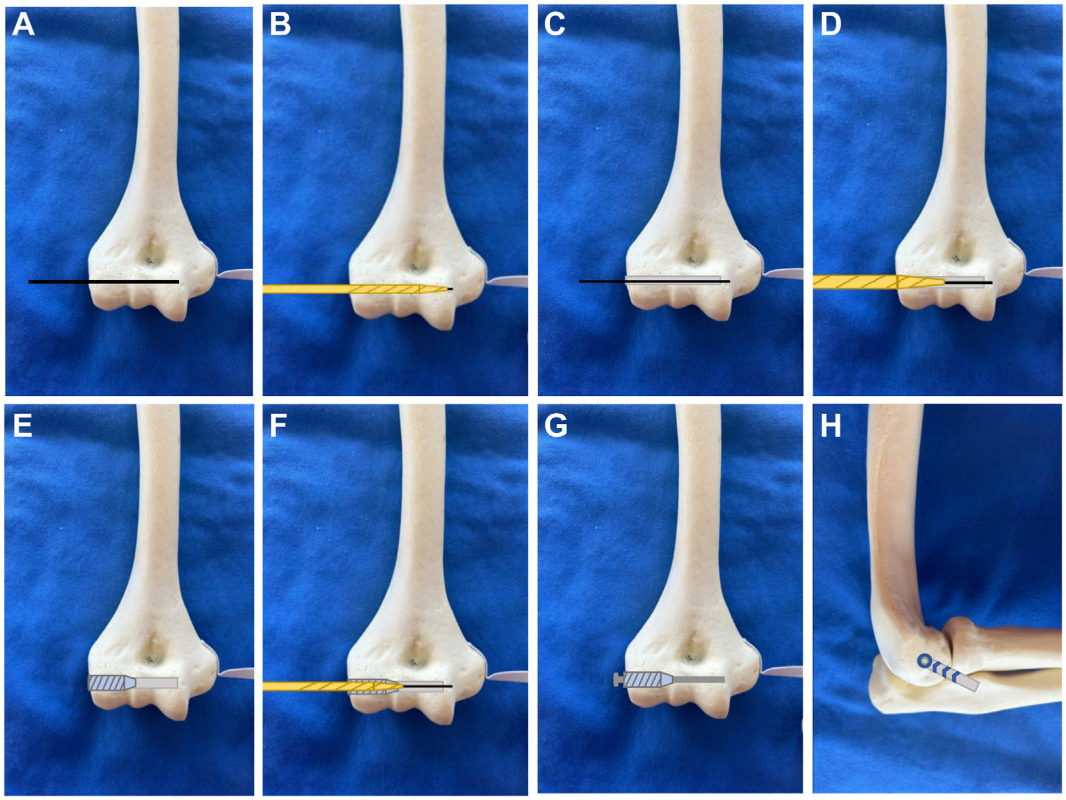

Figure 2 (**A**) The IJS guide pin is positioned at the isometric point of the distal humerus parallel to the elbow axis of rotation, taking into account use for both subsequent LUCL suture anchor repair and IJS pin placement. (**B**) A 2.5 mm cannulated drill creates initial IJS path over guide pin, ensuring that the anchor center aligns with future IJS pin trajectory. (**C**) Demonstration of IJS drill path. (**D**) IJS pin is used to guide 4.0 mm drill for suture anchor insertion. (**E**) Both the guidewire and drill are removed and LUCL suture anchor is placed. (**F**) Preparation of inner diameter of suture anchor with 2.5 mm to accept IJS pin. Note this drill diameter nearly matches existing inner diameter of the suture anchor. This step ensures easy gliding of the IJS pin within the anchor. Image showing optional use of guidewire to ensure concentric drill trajectory. (**G**) Demonstration of IJS pin slotted within suture anchor after guidewire and drill removal. (**H**) Lateral elbow view demonstrating final LUCL repair with IJS pin slotted within the suture anchor. *IJS*, internal joint stabilizer; *LUCL*, lateral ulnar collateral ligament.

through a range of motion under fluoroscopic guidance noting stability and concentric motion of the joint. The wound is thoroughly irrigated and closed in standard fashion.

Patients may be discharged on the day of surgery with the elbow positioned at 90° of flexion and neutral position of the forearm in a long arm posterior slab splint. The patient is made nonweight bearing. At 7-10 days postoperatively, the splint is discontinued and an early range of motion physical therapy regimen is initiated, including active and active-assisted range of motion of the shoulder, wrist and elbow, with avoidance of varus stresses. At 6 weeks, the patient is advanced to a 10-pound lifting restriction, which is then progressed to 15 pounds at 12 weeks with full use allowed at 18 weeks postoperatively.

Expected outcomes

Elbow fracture dislocations present unique challenges to the treating surgeon. Historical treatment algorithms have been fraught with complications, ranging from elbow stiffness, synostosis, and pin site infections.[3,17,19,21] Orbay and Mijares first described the use of an IJS system in their 2014 paper which obviates the need for external fixators or prolonged immobilization. Orbay et al demonstrated the efficacy of the IJS in patients with persistent instability after fracture dislocation of the elbow in their 2017 prospective multicenter study, which has been verified subsequently by other studies.[11,12,14,16] The author's modified technique differs from the original description in several key ways. First, our surgical technique allows for the concomitant usage of the distal humeral site for the IJS central axis humeral pin and more anatomic repair of the LUCL origin. Use of the IJS previously used LUCL repair techniques that potentially altered the joint mechanics of this important static stabilizer by working around the IJS pin. Second, by utilization of only one drill site and humeral IJS pin passage through the center of the anchor, our construct allows for maintenance of the LUCL repair to its anatomic footprint while minimizing risk for ligament injury during placement of the IJS or potential iatrogenic injury to the bone. Finally, the performance of the LUCL repair first allows the surgeon to adequately tension the soft tissues, helping to restore stability and elbow biomechanics. The modification presented in this surgical technique offers some unique benefits useful to surgeons seeking to further improve the anatomic restoration of the static stabilizers of the elbow. In the author's experience, the described surgical technique has produced equivalent results in terms of added elbow stability and allowance for early range of motion as described by Orbay while not sacrificing anatomic repair of the LUCL to its footprint.

Complications

A potential disadvantage to the described technique is the possibility for damage to the suture anchor during secondary drilling for IJS central axis pin placement. This technique has been frequently employed by the authors and this complication has not been witnessed. To ensure suture anchor integrity, the authors verify both that the correct drill bit is used for drilling the central axis of the suture anchor and that the drill passes down the central axis of the suture anchor to allow for IJS humeral pin placement.

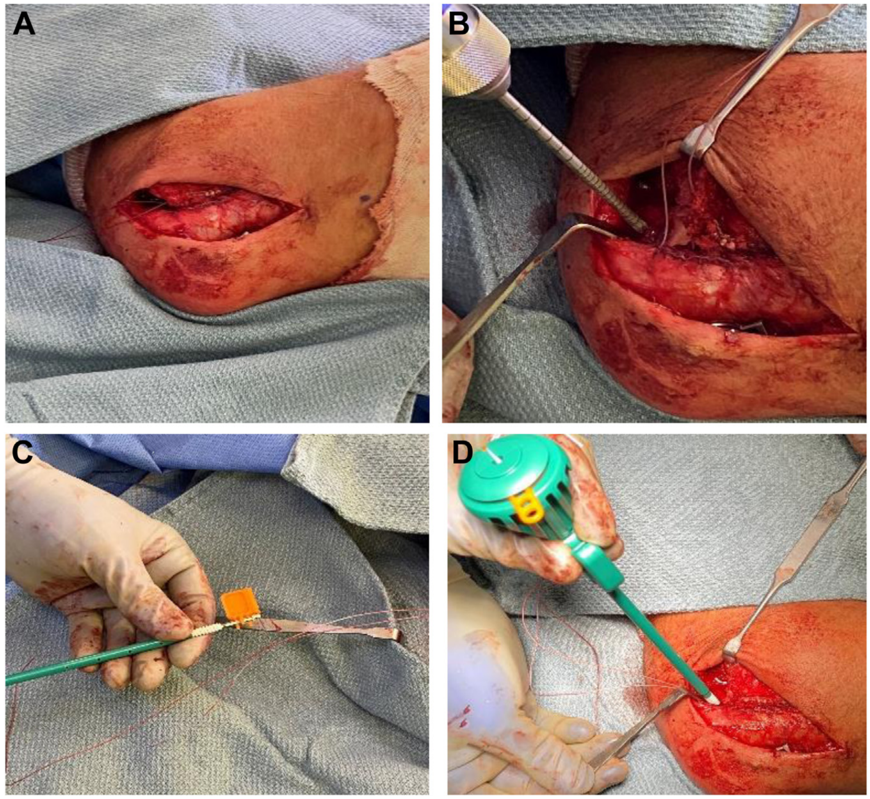

Figure 3 (**A**) LUCL Krackow technique using large non absorbable suture* used to repair the LUCL to its footprint. (**B**) Predrilling over the isometrically placed guide wire in the distal humerus after position has been confirmed fluoroscopically. (**C**) Placement of the whipstitch sutures into the anchor. (**D**) Intraoperative demonstration of the anchor placed at both the anatomic footprint and center of rotation of the elbow within the distal humerus.

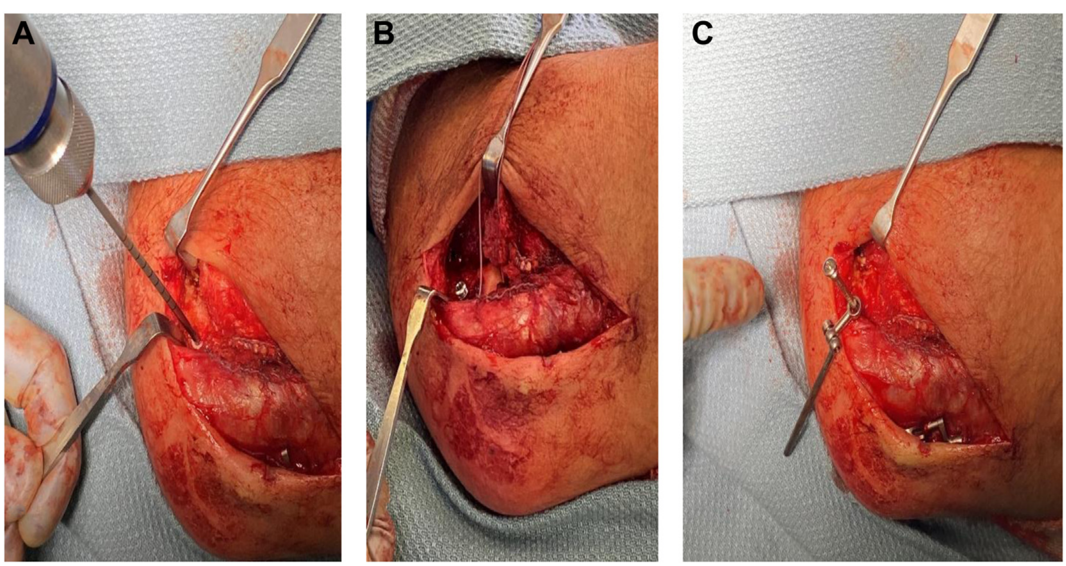

Figure 4 (**A**) Intraoperative demonstration of 2.5 mm drill preparing the inner diameter of the LUCL suture anchor to accept central IJS pin. (**B**) Insertion of the central IJS pin demonstrating appropriate depth and seating of the pin. (**C**) Demonstration of IJS central pin slotted within both the IJS hinge construct and the suture anchor. *IJS*, internal joint stabilizer; *LUCL*, lateral ulnar collateral ligament.

Although the inner core of the suture anchor is drilled, the purpose is to change the square central opening of the suture anchor to a rounded shape that will accept the humeral pin. To date, there have been no incidents of anchor or suture failure on intraoperative examination. This method allows continued fixation for the LUCL repair suture within the humerus as the fixation relies on the interdigitation of the suture between the suture anchor outer thread and the bone interface. A cannulated drill system may be used for this step if desired. An additional potential complication is nonisometric placement of the IJS humeral pin, preventing

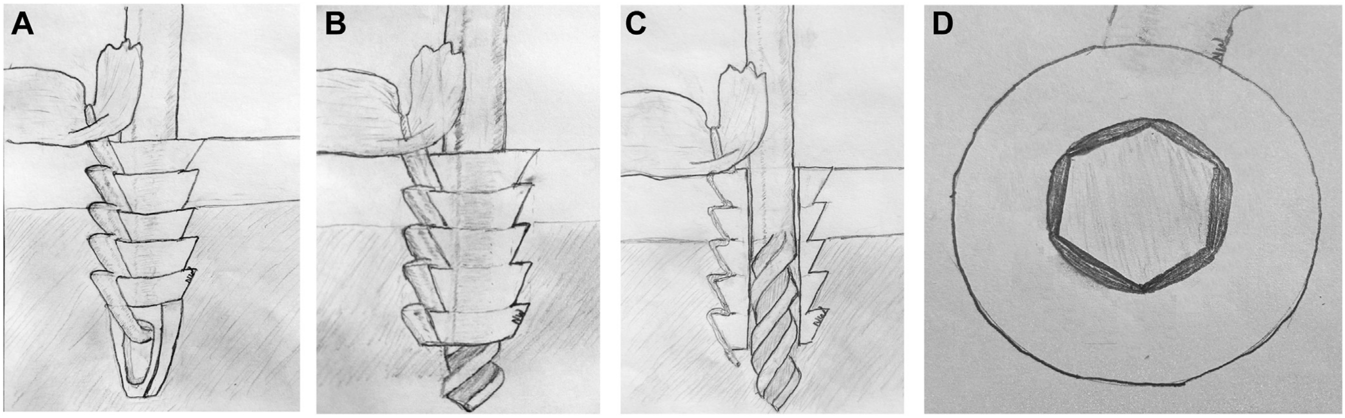

Figure 5 (**A**) is an artist representation of suture anchor within bone with interference fit of sutures between the interdigitation of the anchor threads and bone. (**B**) demonstrates the LUCL suture anchor as the inner diameter of the anchor being prepared with a 2.5 mm drill to accept the IJS pin. (**C**) is the cross-section of the suture anchor construct as the inner diameter is being cored by the 2.5 mm drill. The drill does not contact the interface of the suture, anchor threads, and bone which provide the biomechanical strength to the LUCL repair to the LUCL footprint. (**D**) depicts an axial representation of the suture anchor. The inner diameter of the anchor (approximately 2.5 mm) represented by the hexagon. The suture anchor inner diameter cored by the 2.5 mm drill is represented by the dark circle and the structure exiting the outer circle is the suture as it exits the bone anchor interface. (**D**) illustrates the minimal impact of the drill on the suture anchor wall integrity and the drill's relative location compared to the suture. *IJS*, internal joint stabilizer; *LUCL*, lateral ulnar collateral ligament.

concentric range of motion of the ulnohumeral joint. Utilization of the distal humeral condylar guide, included with the IJS system, combined with placement of the guidewire under fluoroscopy to confirm correct placement are helpful adjuncts. Additionally assuring true anterior-posterior and lateral projection radiographs of the elbow to ensure correct central axis placement is necessary. Finally, hardware prominence, common to many constructs placed on the proximal ulna, is a consideration. Intraoperatively, the surgeon must evaluate the soft tissues, and hardware prominence can be minimized by achieving coverage of both deep and superficial layers during wound closure.

Conclusion

Elbow fracture dislocations continue to be challenging injuries for treating orthopedic surgeons. While the IJS device has produced an attractive treatment option for persistent instability, the technical demands of central IJS humeral pin placement within the axis of rotation of the ulnohumeral joint can preclude adequate space for an anatomic repair of the LUCL to its humeral footprint. Anatomic reconstruction of the patient's native anatomy continues to be of upmost importance to joint stability. This technique confers multiple benefits including the elimination of footprint competition between the LUCL reconstruction and IJS humeral pin, achievement of isometric placement of both constructs within the distal humerus, and provision of ligament tensioning without concern for additional drill sites to accommodate the IJS humeral pin. Our modified technique offers the surgeon additional tools in the treatment armamentarium of this challenging pathology and has produced good results in the experience of the authors.

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Conflicts of interest: Kristofer Matullo, MD: This author serves as an editor for SurgiColl, a review for Hand and the Journal of Hand Surgery, and committee member for the American Society for Surgery of the Hand. He, his immediate family, or to his knowledge any research foundation with which he is affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article. The other author, his immediate family, and any research foundation with which he is affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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