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Case Report

Staple Fixation in Ulnar-Shortening Osteotomies

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Ulnar-sided wrist pain is commonly caused by the ulnar impaction syndrome. Ulnar-shortening osteotomy is a surgical treatment that is used to address ulnar impaction syndrome that fails conservative management. Unfortunately, hardware irritation and nonunion are well-known complications of this procedure. This case report details the course of two patients with nonunion after ulnar-shortening osteotomy who were treated with a combination of a nitinol compression staple and neutralization plate. Further investigation is required to determine the long-term outcomes and indications for nitinol-staple fixation for nonunion after ulnar-shortening osteotomy.

Ulnar impaction syndrome, defined as ulnar abutment of the carpus, is a common cause of ulnar-sided wrist pain. Although patients can have idiopathic ulnar-positive variance, distal radius malunion, radial head excision, and premature radial physeal closure are known risk factors. Surgical management of ulnocarpal abutment involves decompression of the ulnocarpal joint with an ulnar-shortening osteotomy (USO). Numerous osteotomy and fixation techniques have been described.[1] Although hardware irritation is the most common cause of revision surgery, nonunion is a known complication with documented rates ranging from 1% to 18%.[2–4] Risk factors for nonunion include smoking status, diabetes, and the size of ulnar resection.

This case study describes the clinical course of two patients who had failed USO for ulnocarpal abutment that was managed with nitinol staple supplemented fixation to achieve compression followed by the use of a 3.5-mm neutralization plate. Although further study is necessary to determine the long-term outcomes of the use of nitinol staples, it is possible that this surgical technique may provide low-profile compression at the osteotomy site, which augments more traditional compression plating.

Case Report

Two patients were treated with nitinol compression staple fixation in combination with neutralization plate at our institution for revision surgery for prior USO failure. The first patient experienced nonunion of prior USO, and the second patient experienced early failure of fixation and loss of alignment. Written informed consent was obtained from the patients for the publication of this case report and accompanying images.

Case 1: Staple and neutralization plate for USO nonunion

A 65-year-old woman presented to the clinic experiencing persistent, atraumatic, long-standing ulnar-sided right wrist pain. She underwent radiography and magnetic resonance imaging that revealed an ulnar-positive variance of 3 mm, cystic changes in the proximal lunate, and a central triangular fibrocartilage complex (TFCC) tear, consistent with diagnosis of ulnocarpal abutment syndrome. The patient underwent right wrist arthroscopy, TFCC debridement, and USO. At the 2-week appointment, radiographs demonstrated stable fixation of her USO with neutral ulnar variance (Fig. 1).

The patient was followed for 7 months during which she experienced continued forearm pain despite appropriate immobilization and weight-bearing precautions. Serial radiographs were concerning for atrophic nonunion at her ulnar osteotomy site with worsening lucency and no evidence of any callous formation (Fig. 2).

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Figure 1. Two-week postoperative radiographs of forearm and wrist after ulnar shortening osteotomy.

Figure 2. Seven-week postoperative radiographs of forearm and wrist with evidence of ulnar nonunion.

Her nonunion was treated with removal of hardware, take down of the nonunion, and autogenous bone grafting. She then underwent placement of a neutralization plate (a 3.5-mm locking compression plate) with two points of fixation, followed by placement of a 15 × 12–mm nitinol staple (DePuy Synthes) for compression and completion of the screw fixation of the plate in compression (Fig. 3). The patient was placed in a bivalved short-arm cast after surgery for 6 weeks. After this point, she was allowed to come out of the cast intermittently and followed <5 pound weight-bearing restrictions until 3 months. Three-month radiographs demonstrated complete healing (Fig. 4). She was weaned out of the brace entirely at 4.5 months after surgery, and her function improved.

Case 2: Staple and neutralization plate for early USO fixation failure and displacement

An 80-year-old man presented to the clinic with subacute, atraumatic right ulnar-sided wrist pain that had been present for 4 months and recalcitrant to bracing and an intra-articular corticosteroid injection. His radiographs revealed a 3-mm ulnar-positive variance and TFCC calcifications (Fig. 5). The patient underwent right wrist arthroscopy, TFCC debridement, and an USO. The USO was performed with the TriMed system with an oblique osteotomy and compression plate. During surgery, we did not have good purchase with the lag screw;

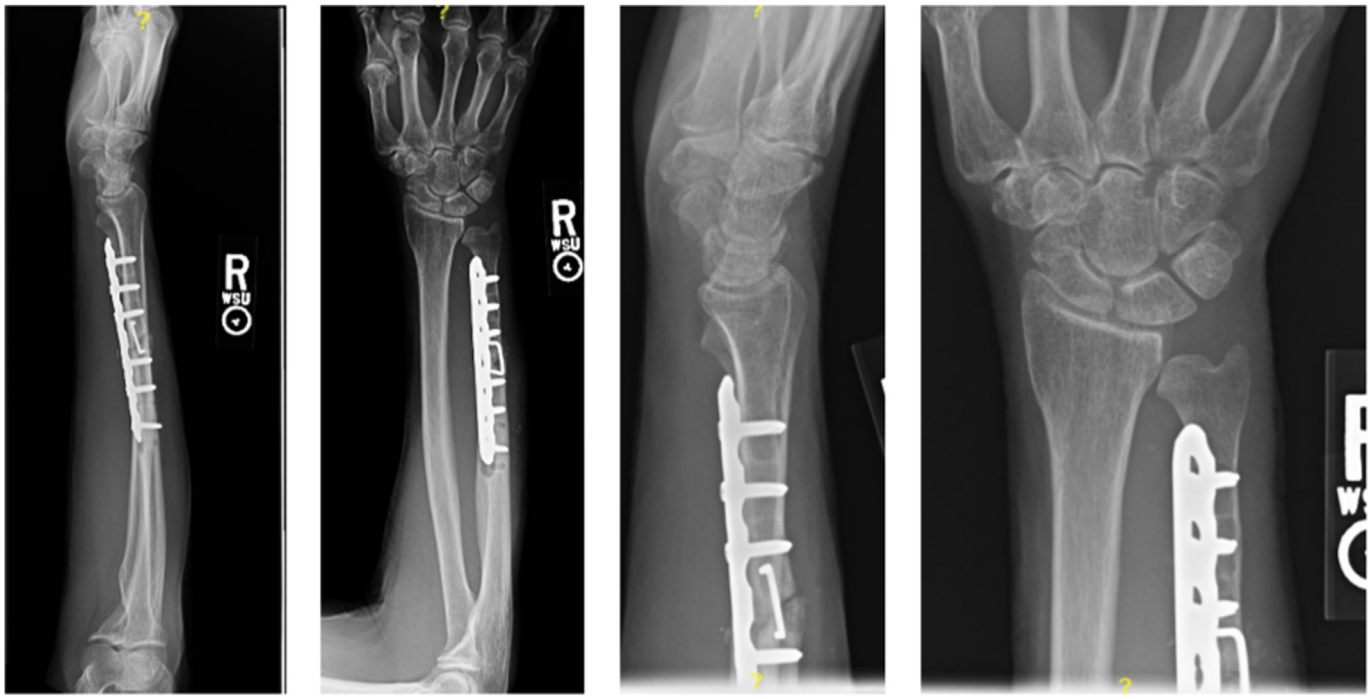

Figure 3. Two-week postoperative radiographs of the compression staple and neutralization plate fixation of ulnar shaft nonunion.

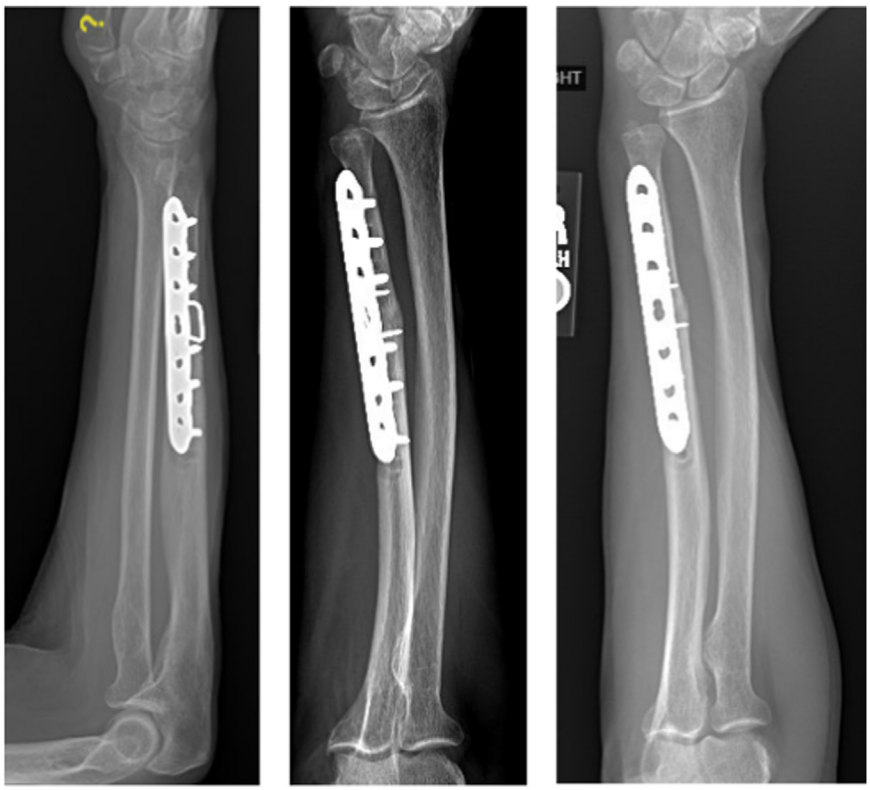

Figure 4. Three-month postoperative radiographs of forearm and wrist after nonunion repair with neutralization plate and compression staple.

therefore, the screw was removed. He returned to the clinic 3 weeks after his surgery, and his radiographs demonstrated displacement of his osteotomy and failure of the hardware (Fig. 6).

The patient returned to the operating room and underwent revision fixation of his ulnar osteotomy. The fixation construct included a 3.5-mm locking compression plate neutralization plate along the volar ulna and a 15 × 10–mm nitinol staple along the ulnar

Figure 5. Preoperative radiographs of the right wrist.

Figure 6. Three-week postoperative radiographs of the forearm and wrist with displacement of ulnar osteotomy.

border of the shaft. This was allowed by the improved compression at the osteotomy site, and a 90-90 construct (Fig. 7). Excellent compression and stability were obtained during surgery. The patient returned 2 weeks after this surgery with placement in a fiberglass cast for another 4 weeks with coffee cup weight-bearing restriction. The patient went on to consolidate and heal his osteotomy at 3 months after surgery (Fig. 8). He was cleared for all activities at that point and experienced no forearm pain and minimal wrist pain.

Discussion

Ulnar-shortening osteotomy is a common procedure for treatment of ulnocarpal abutment with increased contact between the ulnar head and the carpus. Nonunion is a well-documented complication of this surgery, with reported nonunion rates as low as 1% and as high as 18%.[2–4] Patient risk factors, such as smoking and diabetes, have been found to increase the risk of nonunion. Specifically, Chen et al[5] found that patients who smoke had longer increased times for radiographic healing (4.1 months in nonsmokers vs 7.1 months in smokers) and higher rates of delayed union and nonunion. These findings were reinforced in a study by Gaspar et al[6] in a clinical series of 72 patients treated with a dynamic compression plating system. Overall, they found nonunion in 4 of 72 patients, with a 6% nonunion rate. Smoking was a significant risk factor for nonunion, although the number of packs smoked daily did not correlate with time to bony union. In a multivariable analysis, patients with diabetes also had increased risk of nonunion (odds ratio 12.7; 95% confidence interval, 1.03–17.5; $P = .45$).[6] Overall, the highest risk of nonunion was in diabetic patients who smoked (odds ratio, 65; 95% confidence interval, 7.3–580; $P = .00$).[6]

It was previously believed that oblique osteotomies had lower rate of nonunion due to greater surface area along the osteotomy site. However, in a meta-analysis performed by Owens et al,[4] they found comparable rates of nonunion of 4.16% and 3.86% in transverse and oblique osteotomies, respectively. Although the angle of the osteotomy does not affect rate of nonunion, literature exists that suggests that the size of the resected bone can impact bone healing. Specifically, Pereira et al[7] retrospectively assessed 87 patients who had undergone USO. When patients with resection length of <5.5 mm versus >5.5 mm were compared, they found that

Figure 7. Two-week postoperative radiographs of the forearm and wrist after revision surgery for ulnar osteotomy displacement.

Figure 8. Three-month postoperative radiographs of forearm and wrist.

patients with >5.5 mm resection were at 20.2 greater odds of developing nonunion. Most studies investigate the rate of nonunion use dynamic compression plates, and there is a paucity of data comparing other fixation modalities.[1,4,7] Jungwirth-Weinberger et al[1] investigated the rate of healing for USO fixed with a locking plate versus a dynamic compression plate. Overall, they found that locking compression plates had significantly less time to complete consolidation compared with limited contact dynamic compression plates (247 days vs 311 days; $P = .01$).[1]

Nitinol staples are an alloy of nickel and titanium and have property-shape memory as they reversibly transition between the martensitic and austenitic phase.[8] The use of nitinol memory staples has been previously described in the setting of temporary fixation for a fracture in both bones of the forearm.[8] Furthermore, nitinol staples have been used in the setting of scaphoid nonunions with good outcomes. Specifically, Zhou et al[9] treated 18 patients with scaphoid nonunion with nitinol staples and autologous autografts. Overall, average fracture healing time was 4.2 months, and

patients had improved visual analog scale and Mayo wrist scores (mean visual analog scale of 6.8 before surgery and 1.6 after surgery and mean Mayo wrist score of 57.4 before surgery and 91.4 after surgery).[9]

Although nitinol staples can provide efficient, effective, and low-profile fixation, there is an increased cost associated with its implant. Specifically, the cost of each nitinol staple is approximately $1,000 USD. A standard construct with a 3.5-mm limited contact dynamic compression plate with six cortical screws is between $700 and $800. In comparison, a number of different commercial USO systems are available with the construct cost being approximately $2,000. Although commercial USO sets are associated with higher implant costs, a study by Luria et al[10] found significantly shorter surgical times with the commercial USO kit compared with dynamic compression plates. The cost of a construct with a nitinol staple combined with a standard 3.5-mm plate and screws is similar to the cost of a commercial system. Supplemental fixation with a nitinol staple allows for increased compression at the osteotomy site as well as perpendicular fixation (90-90) of the osteotomy. In addition, the technique is simple and may lead to cost savings from decreased operating room time. However, further study is needed to fully assess the cost benefit analysis of nitinol staples. In both cases presented here, the use of nitinol memory staple was effective in providing stable fixation in the setting of complicated revision surgery and led to eventual union of the osteotomy.

In summary, nonunion after USO is a well-known complication. Nitinol staples have previously been used for supplemental fixation in forearm fractures as well as in the treatment of scaphoid nonunions; it has demonstrated to be an effective alternative to headless compression screws in intercarpal fusions. Nitinol staples may also have a role in the adjunctive treatment of USO to improve compression at osteotomy and provide low-profile supplemental fixation. Further investigation is indicated to determine the indications and long-term outcomes of USO treated with nitinol staple fixation.

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