Distal Ulna Hook Plate: Angular Stable Implant for Fixation of Distal Ulna

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Abstract

Keywords

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- ▶ ulna nonunion
- ▶ ulna fracture
- ▶ ulnar shortening osteotomy

Distal ulna fractures, especially styloid injuries, classically have not been repaired, and only recently have these injuries been considered important. Certain fracture patterns of the distal ulna contribute to distal radioulnar joint (DRUJ) incongruity and potential instability. Appropriate fixation of the distal ulna is frequently difficult for several reasons: (1) high incidence of osteoporosis in the affected patient population, (2) proximity of the injury to articular surfaces, and (3) lack of a proper implant to treat these injuries. The 2.0-mm locking compression distal ulna plate (LC-DUP) is an anatomically contoured implant with a low profile and fixed angle that provides proper stability to treat injuries of the distal ulna. The plate was designed for the treatment of distal ulna fractures, but its success has led to an extension of its indications to be used in treating symptomatic basistyloid ulnar nonunions and in ulnar shortening osteotomy for ulnocarpal abutment syndrome. The authors' description of the techniques used for each indication as well as their perspectives in the treatment of distal ulna injuries are described in detail in this report.

While the relevance of ulnar styloid fractures remains debatable, certain fracture patterns in this area undoubtedly contribute to distal radioulnar joint (DRUJ) incongruity and potential instability.^{1–4}

An anatomically specific low-profile implant, the Locking Compression Distal Ulnar Plate (LC-DUP), has been designed to provide secure and stable fixation with a variety of different screw placement options to reliably treat the spectrum of distal ulna fractures.

The success of this implant has led to an extension of its indications to be used in treating symptomatic basistyloid ulnar nonunions, and in ulnar shortening osteotomy for ulnocarpal abutment.⁵

This technical report describes the implant's features, principles of design and technical application, and reports the early clinical results of use.

Implant Description and Surgical Technique

Locking Compression Distal Ulna Plate

The LC-DUP, recently designed for use in distal ulna fractures, provides adequate fixation strength, different fixation options, and angular stability as well as a low external profile and smooth, rounded edges. Its anatomically precontoured design reduces soft-tissue dissection and the need for hardware removal. The section of the implant applied to the ulnar head accepts fixed-angle locking screws for angular stability, while the shaft component accepts both locking and non-locking cortical screws for dynamic compression and improved length adjustment. Distally, an undercut allows plate bending for further adjustment. Distally the plate has two pointed hooks designed to hold the styloid securely and also to provide a reference point for plate application. The gap

Fig. 1 2.0-mm LC-DUP features: anatomically precontoured plate; pointed hooks to hold the styloid; three holes for intercrossing locking screws for ulnar head fragment; four Combi holes for nonlocking cortex or locking screws for the diaphyseal fixation. Note that one of the shaft holes is oblong in shape to allow length adjustment. With permission from Synthes GmbH, Solothurn, Switzerland.

between the hook arms can be used to house a lag screw, should it be necessary to stabilize the ulnar styloid (→Fig. 1).

In total, the plate has seven holes:

- Three 2.0-mm locking coaxial screw holes for ulnar head fixation, which are divergent in direction to enhance stability and pullout strength in cancellous bone and to prevent screws interfering with each other.
- Four proximal Combi holes, which allow both locking and nonlocking screws to be inserted into the ulnar shaft. One of these holes is oval in shape to allow minor adjustments during initial positioning of the plate. These holes also allow screw placement in an eccentric fashion to apply axial compression when indicated by the fracture pattern.

Indications

Although designed for distal ulna fractures, the indications for the plate have now been extended to the treatment of distal ulna nonunion, including ulnar styloid nonunion, providing improved security in osteopenic bone. A recent publication further extends its use for a novel ulnar shortening osteotomy technique performed at the metaphysis for the treatment of ulnocarpal abutment syndrome (UCAS), offering benefits

over diaphyseal osteotomy.⁵ However, the major benefit the plate brings is angularly stable fixation of unstable and/or displaced distal ulna fractures, including comminuted head fractures, which frequently present a challenge to the surgeon.

Contraindications

The LC-DUP should not be used when the ulnar styloid fragment of nonunion is so distal and small that it would be difficult to obtain appropriate fixation. These injuries tend to be asymptomatic and generally do not require surgical intervention.

Other absolute contraindications are severe comminution or open fractures with large skin defects that limit cutaneous coverage of the osteosynthesis.

Large nonunions of the neck of the ulna, with bone defects exceeding more than 2 cm, require bone grafting to avoid inappropriate shortening of the ulna. In these cases, the nonunion gap is so large that using the LC-DUP could limit fixation to two screws, causing instability of the construct. This potential instability should be considered a relative contraindication and evaluated on a case-by-case basis.

Distal ulna nonunion or ulnar impaction syndrome in patients who present with significant degenerative changes in the DRUJ should not undergo fixation or ulnar shortening osteotomy, respectively. Different management options should be considered for these patients.

Surgical Technique

Surgical Technique for Distal Ulna Fracture Fixation

A direct approach to the distal ulnar shaft is made using a 6–8-cm-long longitudinal medial incision that starts at the tip of the ulnar styloid and continues proximally. The dorsal sensory branch of the ulnar nerve is identified and carefully protected; great attention is required at this stage to avoid injury to this nerve, which crosses the bone at this level to supply the dorsal skin of the hand. Neuromas in this area tend to be troublesome and are often the source of significant symptoms. Sharp dissection is performed between the flexor carpi ulnaris (FCU) and extensor carpi ulnaris (ECU) to expose the ulna subperiosteally (→Fig. 2a). Complete exposure of the ulnar head should not be performed, because this will detach essential soft-tissue stabilizers. A bare area exists between the tendons of the FCU and ECU. This bare area continues on toward the ulnar styloid and represents the optimum site for application of the LC-DUP.

After the fracture is exposed, irrigated, and reduced, Kirschner wires (K-wires) may be used to stabilize the reduction temporarily if necessary. The use of pointed-reduction forceps should be limited to avoid further fragmentation of the ulnar head, which is often fragile.

The plate is placed over the previously prepared surface. First, the hooks are engaged on the tip of the ulnar styloid. This placement serves as a guide for correct positioning of the implant. The plate is then centered proximally over the ulnar shaft. This is best facilitated by screwing a drill guide into one of the proximal locking holes and using it as a handle

Fig. 2a–c (a) Surgical approach between ECU and FCU exposes fracture site. (b) Placement of the plate: The hooks are engaged to the ulnar styloid, and the plate is centered proximally using a drill guide as a handle. (c) Definite fixation of ulnar fracture with one locking screw distal to the fracture and three screws proximal to the fracture.

(► **Fig. 2b**). Fracture fixation is then performed, starting with distal 2.0-mm screw fixation of the ulnar head. If length adjustment is necessary, a 2.0-mm nonlocking self-tapping screw is inserted in the middle of the oblong hole of the shaft; the screw is fully tightened after the correct length of reduction is obtained and confirmed fluoroscopically. A total of four screws are recommended to achieve stability: one locking screw distal to the fracture, and three shaft screws, of which at least one should be inserted in locking mode (► **Fig. 2c**).

In the case of unstable fractures of the base of the ulnar styloid, a 2.0-mm locking screw can be applied through the most distal hole in the DUP. This screw does not need to reach the far cortex. If required, the tip of the styloid can be fixed by leaving the most distal hole empty and using the gap between the arms of the distal hooks to insert a 1.5-, 1.3, or 1.1-mm screw in lag mode. Once definite fixation and joint reconstruction are confirmed fluoroscopically in all planes, DRUJ motion and stability are assessed clinically. It is essential to ascertain that no screw violates the DRUJ or ulnocarpal joint.

After proper hemostasis and skin closure, a sugar-tong splint is applied for 2 weeks, after which supervised rehabilitation is indicated. A molded thermoplastic wrist gauntlet is also provided to be worn between rehabilitation sessions for 3–4 weeks after surgery.

The ► **Fig. 3** sequence demonstrates the treatment of ulnar styloid base fracture.

Surgical Technique for Distal Ulna Nonunion Fixation

When treating a distal ulna nonunion that is causing DRUJ instability, the approach is performed as described in the section for fracture fixation. Once the nonunion is exposed, proper débridement is performed to eliminate sclerotic edges of the bone fragments as well as any soft tissue that may be interposed within the nonunion. Special attention must be given to the radioulnar ligaments and their insertion on the ulnar styloid. If the TFCC and the radioulnar ligaments are not detached, a small osteotomy is created with an osteotome to fix the ulnar styloid more proximally. The total shortening

Fig. 3a–c (a) Articular shearing fracture of the radius (AO B2) with associated comminuted and displaced distal ulna fracture. The patient had previously been treated with open reduction, internal fixation (ORIF) for a both-bone forearm fracture, not associated with this injury. (b) 3D CT reconstruction. Displaced dorsal intraarticular fragment of the radius; unaffected volar rim of radius. Associated fracture of the base of the ulnar styloid with intraarticular fracture of ulnar head. (c) Radius fracture fixation: two 2.4-mm Locking Compression Plates (LCP) placed dorsally for buttress effect on dorsal fragment. Ulna fracture fixation with 2.0-mm LC-DUP: Distal hooks stabilize the styloid fracture, while two locking screws fix the ulnar head fracture.

Fig. 4a–d (a) Distal radius fracture with associated fracture of the ulnar styloid. This injury was initially treated conservatively; the radius healed with proper alignment, but the ulnar styloid fracture did not heal. Patient returned 9 months later with pain and DRUJ instability. (b) Surgical approach between FCU and ECU, exposing ulnar styloid nonunion. Normal radioulnar ligament attachment on the ulnar styloid is confirmed. (c) 2.0-mm LC-DUP: Distal hooks stabilize ulnar styloid, and axial compression was applied for nonunion stability. Note that no screw was inserted distal to the nonunion, the distal hooks stabilize the fixation. (d) Radiologic evidence of healing: At 1-year follow-up the DRUJ remains stable with painless range of motion. The distal plate seen in the image is due to an old fifth carpometacarpal (CMC) arthrodesis.

created by nonunion débridement and osteotomy is usually less than 4 mm. When addressing ulnar styloid nonunions, this step does not affect ulnar variance. However, during repair of ulnar neck nonunions, total shortening should result in neutral ulnar variance to no more than 2 mm of negative ulnar variance. In either case, this part of the procedure allows tightening of the TFCC and stabilization of the DRUJ. The hooks of the plate should then be engaged on the styloid tip as described above, and a locking drill guide is fixed to the plate to use as a handle. Once reduction is achieved, a 2.0-mm

nonlocking self-tapping cortex screw is inserted eccentrically into the oblong hole of the shaft to achieve compression of the nonunion. Two further nonlocking screws are then inserted: one proximal and one distal to the oblong hole.

If the foveal fibers are detached, they must be repaired to avoid persistent DRUJ instability. The area of insertion around the fovea is debrided, two perforations are made from the ulnar aspect of the ulnar head into the volar and dorsal fovea areas at the insertion site of the deep components of the radioulnar ligaments. The detached ligaments are secured

Fig. 5a–d (a) The LC-DUP is placed on the bare area between the FCU and ECU, the hooks are engaged on the ulnar styloid, and the plate is successfully centered proximally. Distal holes drilled with a 1.5-mm drill bit. A needle is used to determine the future site of the osteotomy. (b) The osteotomy site is marked in the metaphysis of the ulna. The plate is removed, and two transverse parallel osteotomies are performed immediately proximal to the DRUJ with a predefined thickness to obtain radius-ulna leveling (1 to 2 mm negative ulnar variance after osteotomy). (c) The plate is placed using locking screws through predrilled holes on the ulnar head. The proper placement is confirmed fluoroscopically. A drill guide or screwdriver is used as a handle to close the gap before screw fixation of the shaft. (d) Axial compression is used to achieve proper reduction of the osteotomy and provide absolute stability. The remaining screws are inserted, and proper correction of ulnar variance is appreciated after definite fixation. The figure shows the final result 2 years after surgery.

with a braided, nonresorbable 4-0 suture for each ligament, passed through the perforation holes and sutured together. Tightening the knot brings the ligaments together as they converge at the apex of the TFCC. Following TFCC repair, the osteosynthesis technique is completed as described above.

The sequence in ►**Fig. 4** demonstrates the treatment of ulnar styloid nonunion.

Surgical Technique for Ulnar Shortening Osteotomy

A 6–8-cm-long longitudinal lateral incision is made starting at the tip of the ulnar styloid and extended proximally. Surgical approach to the distal ulna is performed as described above, with great attention given to the dorsal sensory branch of the ulnar nerve. The LC-DUP is placed on the exposed ulnar surface and the hooks are engaged into the tip of the ulnar styloid. Once a satisfactory position of the plate is confirmed using fluoroscopy, distal drill holes are made using a 1.5-mm drill bit (►**Fig. 5a**). The site of the osteotomy in the metaphysis of the ulna is marked, the plate is removed, and two transverse parallel osteotomies are created just proximal to the DRUJ. The thickness of the osteotomy is determined by preoperative radiological measurement of positive ulnar variance (aiming to produce 1–2 mm negative ulnar variance after osteotomy) (►**Fig. 5b**). The osteotomized bone fragment is removed, the plate replaced, and the distal locking screws inserted in the previously drilled holes of the ulnar head. The osteotomy can be closed using pointed reduction forceps. A drill guide may be inserted into a locking hole of the plate proximal to the osteotomy and used as a handle to pull the plate along with the distal fragment proximally. This maneuver may help further reduce and compress the osteotomy (►**Fig. 5c**). Osteotomy closure is verified by fluoroscopy. Using a 1.5-mm drill, an eccentric drill hole is made in the oblong hole of the shaft, and a 2.0-mm self-tapping cortical screw is inserted to obtain axial compression of the osteotomy. Two more screws, of which at least one is a locking screw, complete the proximal fixation to guarantee stability (►**Fig. 5d**). Stability of the osteosynthesis and wrist joint range of motion are then tested. A bulky padded bandage with a dorsal splint is applied. Splinting restricts flexion and extension of the wrist; however, patients are encouraged to start gentle pronation and supination exercises as comfort allows. Two weeks after surgery, a removable thermoplastic splint is applied to allow patients to start wrist flexion and extension exercises three times a day. If radiological signs of consolidation are present after 6 weeks, physical therapy can begin.

Materials and Methods

Chart reviews were performed for consecutive patients who underwent surgical intervention with the techniques that are explained above.

To date, the authors have performed surgery on 37 patients with this plate (18 fractures, 10 nonunions, and 9 shortening osteotomies).

Outcomes

Bone healing was achieved in all patients. The mean follow-up for all cases is 25 months (range: 3–53 months), and no patient has reported hardware-related pain or required further surgery for hardware removal.

Discussion

The LC-DUP is an anatomical plate that provides rigid stability to treat distal ulna fractures, nonunions, and osteotomies. This single implant offers specificity for a variety of indications and can be used for both right and left wrists. Its low profile decreases the chance of hardware-related pain and subsequent surgery for hardware removal, while its distal screw configuration allows secure fixation to be reliably achieved even in osteopenic bone.

Disclaimer

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