The AO Ulnar Shortening Osteotomy System Indications and Surgical Technique

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Abstract

Ulnar shortening osteotomy is an established and frequently performed surgical procedure in wrist surgery. The technical aspects of the procedure have continued to develop in recent years, with instruments and implants being developed specifically for this purpose. Ulnar shortening osteotomy is required for different clinical indications and situations. These varying indications demand different amounts of shortening, but all must be precise and accurate. Controversy exists as to how this can best be achieved in terms of the location for osteotomy, the surgical approach and geometry of the osteotomy, as well as which implant to use to provide optimal stability. The goal of all techniques (besides successfully resolving the underlying problem) is to achieve reliable and rapid bone union without compromising early functional rehabilitation and also to avoid hardware complications. The AO Hand Expert Group has developed a specialized instrumentation system with dedicated and specifically designed implants to ensure exact and accurate cutting with precise and rigid stabilization of the ulna. The matched drill guides and double-blade saws allow accurate completion of the planned amount of shortening together with precise coaptation of the osteotomy fragments. The specific ulnar osteotomy LCP (locking compression plate) combines maximum stability with minimum bulk and soft tissue irritation. The features of the implant, its surgical technique, and early results are described.

Keywords
► ulnar shortening
► osteotomy
► ulnocarpal impaction

Painless load transmission along the distal part of the upper limb, from the elbow through the forearm to the wrist, largely depends upon the correct interaction of the radius with the ulna. Although other, more complex factors contribute, it is the shapes and the relative lengths of the two forearm bones that are the key in achieving such reliable function. Palmer et al[1] have shown that changing the length of the ulna by only 2.5 mm will dramatically alter the pattern of load transmission across the wrist to the distal forearm bones. Furthermore, the stability of the distal radioulnar joint (DRUJ) is significantly influenced by both the congruence between the distal radius and ulna[2] and the tension of the connecting ligaments.[3,4] As a result, those disorders of the wrist and forearm resulting from length discrepancies of the radius and ulna can be successfully treated by altering the relative length relationship and restoring biomechanical normality.

Distal radius fractures are common.[5,6] The combination of their frequency with the fact that more load is normally transmitted across the radius[1] means that problems resulting from shortening of the radius are more frequently encountered than problems resulting from shortening of the ulna.[7]

The most common term for ulnar-sided wrist pain deriving from structural or functional ulnar overlength is "ulnocarpal impaction."[8] Primary ulnocarpal impaction results from congenital, developmental, degenerative, or dynamic ulnar overgrowth, whereas secondary ulnocarpal impaction usually

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occurs after posttraumatic radial shortening. Usually, this situation develops after fractures of the distal radius, but it can also (rarely) occur after premature closure of the growth plate of the radius. These two different diagnostic entities require different treatment.

Primary ulnocarpal impaction will benefit from any amount of ulnar shortening as long as it does not affect the congruity of the DRUJ. In clinical practice 2–3 mm of skeletal shortening is significantly more effective than any soft tissue procedure, resulting in reduction of the ulnocarpal load transmission by up to 80%, whereas a simple triangular fibrocartilage (TFC) resection will produce a reduction of only 60%.[1] The upper limit of shortening depends on the shape of the ulnar head.[9,10] In most cases, DRUJ congruency will not be adversely affected by shortening of less than 4 mm.[11]

In secondary ulnocarpal impaction, the mismatched and excessive ulnar length must be reduced to the exact preexisting ulnar variance, determined by radiological assessment of the contralateral side.

To manage these conditions successfully, it becomes clear why accurate and precise surgical control of shortening is essential.

Shortening of the ulna can be performed in different ways. Open or arthroscopic resection of the distal surface of the ulna, the so-called wafer resection,[12,13] represents an alternative to diaphyseal shortening in primary impaction cases with large degenerative TFC complex (TFCC) lesions. This avoids the need for sectioning the bone and subsequent use of an implant, and therefore it also avoids any problems of bone healing or hardware irritation.[14–16] An ideal ulnar shortening osteotomy implant must ensure reliable bone union and, with unobtrusive shape and dimensions, eliminate the need for hardware removal. To date, published series have reported an average nonunion rate of 5% (ranging from 0[17,18] to 11%[19]), with 30[20]–100%[18] of the plates being removed (average 65%). These are regarded as frequent complications that can mar the reputation of an otherwise highly successful treatment.

The AO Ulnar Shortening Osteotomy System

The main concerns with shortening osteotomies of the ulna have been nonunion and soft tissue irritation due to hardware, often demanding subsequent implant removal in a second operation. To avoid these complications and to enhance the precision of the procedure, a new ulnar shortening osteotomy plating system has been designed and developed by the AO Hand Expert Group: the LCP Ulna Osteotomy System (DePuy Synthes, West Chester, PA, USA). This implant and its accompanying integral, yet innovative, instrumentation was launched in August 2010 and combines a novel ulnar locking compression plate (LCP) with dedicated instrumentation for precise bone cutting, resection, and osteosynthesis.

Main Features of the Plate

The plate is produced in either stainless steel or titanium–aluminum–nickel (TAN) alloy with a smooth surface, low profile, and rounded edges to minimize overlying tissue irritation (►**Fig. 1**). Two plate sizes are available: one "standard" six-hole plate (62 mm long and 9 mm wide) and one "extra long" eight-hole plate (76 mm long) for use in more osteoporotic bone or for salvage cases. The midsection of the plate has a cross-sectional area that incorporates the profile of the proven and reliable 3.5-mm DCP (Dynamic Compression Plate; DePuy Synthes, West Chester, PA) to ensure maximal rigidity over the osteotomy site. The plate tapers out at both ends to a width of only 7 mm and thickness of 3 mm, similar to the 2.4-mm LCP-plate to minimize issues relating to bulk. Three types of 2.7-mm plate holes are arranged symmetrically: a locking hole, an oblong combi-hole, and a special combi-hole allowing for placement of either a locking screw or a centric inclined cortical screw, providing the ability to compress the osteotomy with a lag screw introduced through the plate. The eight-hole extra long plate has two additional standard combi-holes. Thus, four different screw placements are possible:

- Cortex lag screws
- Neutral cortex screws
- Eccentric cortex screws
- Locking screws

The system is designed to be used with either a transverse or an oblique osteotomy, dependent on surgeon preference (►**Fig. 2**).

The two essential and innovative components of the system are the width-specific parallel saw blades that produce five different amounts of shortening (from 2 to 5 mm, both

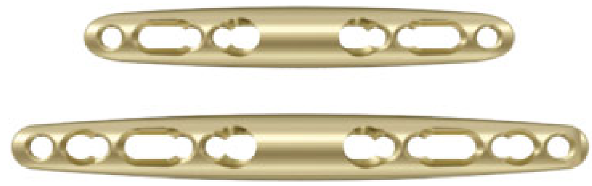

Fig. 1 Six-hole and eight-hole locking compression plates.

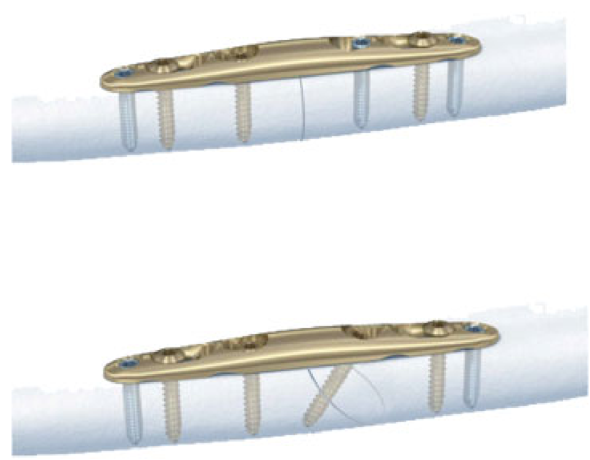

Fig. 2 Transverse and oblique osteotomy variants.

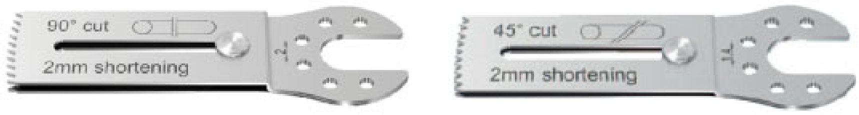

Fig. 3 Parallel double saws for transverse (90°) and oblique (45°) osteotomy.

transverse and oblique; ►**Fig. 3**) and the five matching width-specific drill-template guide blocks (►**Fig. 4**). These guide blocks have the same footprint and drill hole location as the system's standard plate, but with the midsection lengthened by the amount of planned shortening. This results in an automatic and accurate closure of the osteotomy after resection of the planned amount of bone. Compression and stability are achieved when the predrilled holes are filled with screws through the plate. The width precision and parallelism of bone resection is guaranteed by assorted single-use premeasured double saw blades. As the saw blades cut the bone, their accuracy is maintained by a sliding spacer in between the blades that precisely maintains their cutting distance.

Surgical Technique

A variety of surgical approaches, osteotomy shapes, and plate locations can be selected when performing this procedure. The authors recommend placing the plate on the palmar distal diaphysis, just proximal to the pronator quadratus. The ulna has a flat surface at this point, such that the plate lies flush on its surface, rendering contouring of the implant unnecessary (►**Fig. 5**). It is important to eliminate any "rocking" of the plate on the intact ulna by shaving off minor bone bumps with the saw. Contouring of the implant should be limited to the midsection of the plate; otherwise subsequent hole geometry can be distorted, compromising reduction and locking. The desired amount of shortening is measured on preoperative radiographs, and the appropriate drill-template guide block is selected and aligned on the bone with the "double barrel" (and the label "distal") pointing distally. The guide block is secured with three drilling bolts, introduced through the block into the bone bicortically (►**Fig. 6**). A double marking in the center of the guide block indicates the location for the transverse osteotomy (►**Fig. 6**). Care must be taken to select the correct saw blade: it must carry the inscription of the same shortening amount as the drill-template guide block and "90°" for perpendicular orientation of the cut. For unobstructed cutting, the drill-template block is slightly raised from the bone surface. With the soft tissue protected by two Hohmann retractors, the saw is run through the bone under constant irrigation. Care must be taken to remove a complete slice of bone and not leave bone spikes on the main fragments. If an oblique osteotomy is preferred, the triangular saw blade guide must be mounted on the drill template and a different double saw blade must be used, marked with the same amount of shortening but with "45°" instead of "90°." This is a key selection, because the saw blades are slightly narrower (by the factor of cotangent of the angulation) for an oblique osteotomy than for a transverse osteotomy. The saw blade guide allows for marking the exact site and inclination of the saw cut on the bone surface (►**Fig. 7**). Then, again the osteotomy is completed in the same manner as described above. After the osteotomy has been made and all fragments of bone removed, the drill-

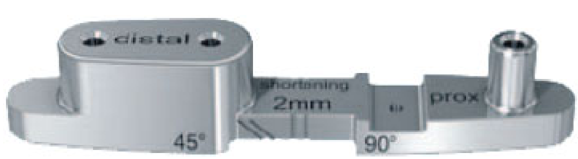

Fig. 4 Drill-template guide.

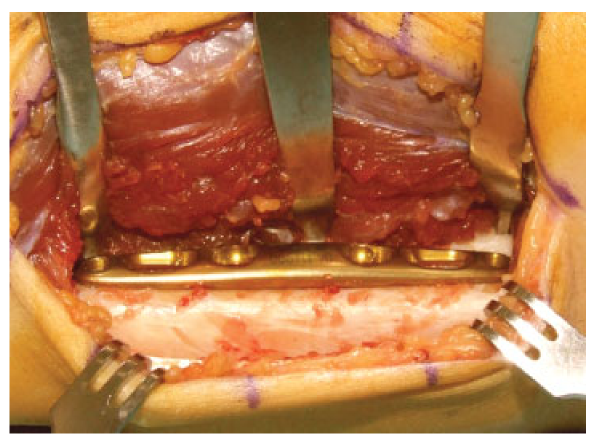

Fig. 5 Plate placed flush on palmar ulnar surface.

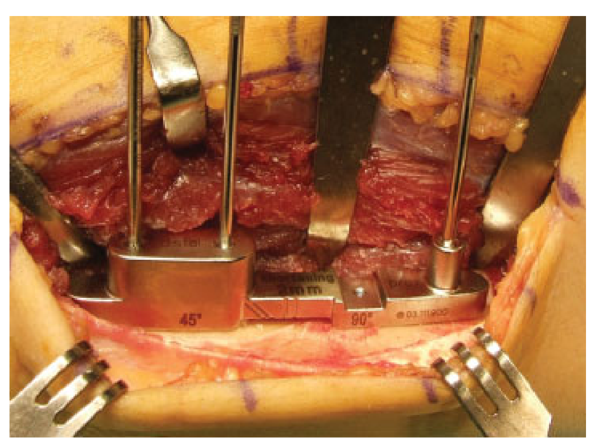

Fig. 6 Drill-templates guide for 2.5 mm shortening fixed with drill-bolts. The marking indicate the location of the transverse and also the oblique osteotomy.

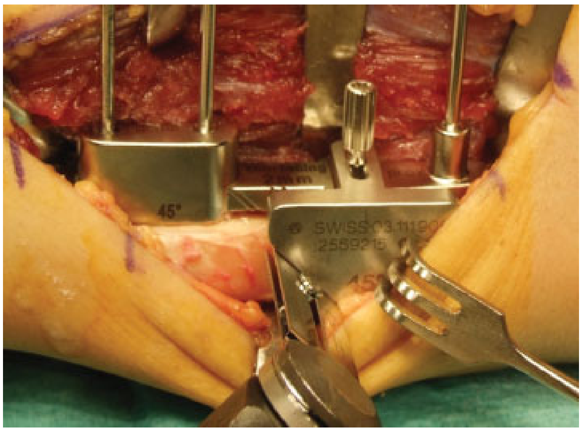

Fig. 7 The oblique osteotomy is performed using the triangular saw guide and the appropriate parallel double saw.

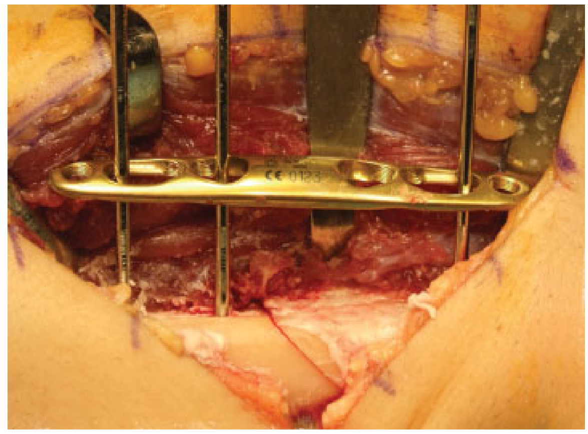

Fig. 8 The drill-template guide is replaced with the plate.

template guide block can be slid away off the drill-bolts and replaced with the definitive plate (►**Fig. 8**). In doing this, the outer bolts are first passed over the oblong combi-holes, and the plate is then clamped firmly onto the distal fragment. The two distal bolts are sequentially removed and replaced with cortical screws of the correct measured length (►**Fig. 9**). The plate is then clamped onto the proximal fragment and the last bolt replaced with a third cortical screw. The initial position of the screw appears slightly eccentric, but tightening of the screw will result in closure and compression of the osteotomy (►**Fig. 10**). If an oblique osteotomy cut was performed, stability and compression can be significantly enhanced by the introduction of a lag screw across the osteotomy (►**Fig. 11**). The remaining plate holes are filled with cortical or locking screws. The wound is closed in layers, with suction drainage occasionally indicated.

Following surgery, a short wrist splint is provided for analgesia. Light use of the hand is allowed, with external load not exceeding 2 kg.

We report a brief preliminary survey on the first 46 patients with follow-up of more than one year. There were no delayed unions or nonunions. Bony union was slightly quicker in oblique osteotomies (►**Figs. 12**, **13**), although the limited number of cases did not allow statistical significance. One patient required revision osteosynthesis after traumatic avulsion of the plate from the bone 6 weeks postoperatively.

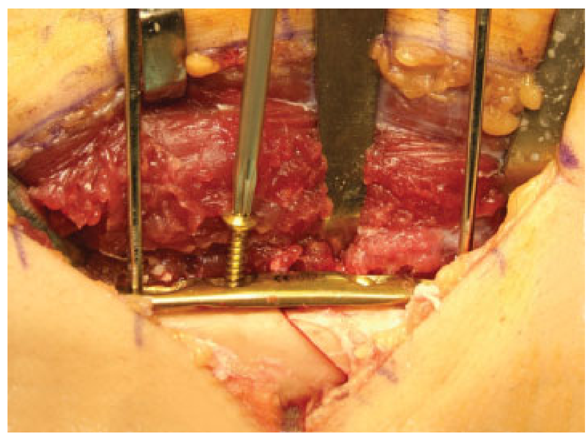

Fig. 9 The bolts are sequentially removed and replaced with cortical screws starting distally.

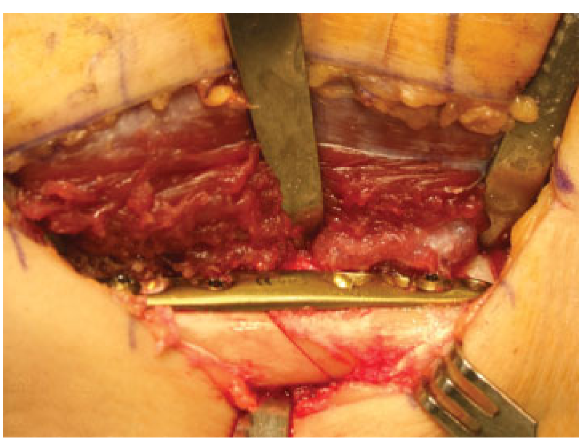

Fig. 10 Osteotomy is closed and compressed by an eccentric screw through the proximal oblong hole.

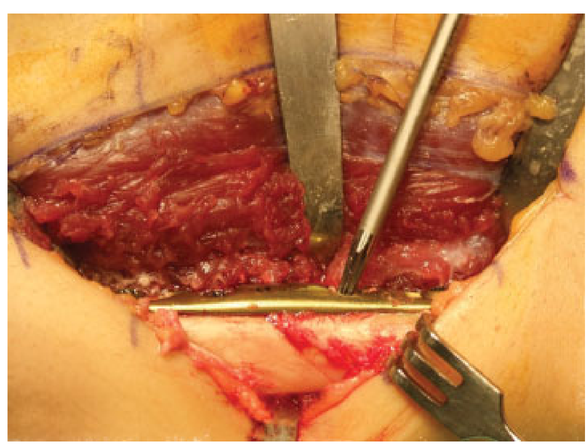

Fig. 11 Osteotomy is further closed and compressed by a lag screw.

Fig. 12 Case of an oblique osteotomy pre- and postoperatively.

Fig. 13 Case of a transverse osteotomy pre- and postoperatively.

There were no other postoperative complications. The implant was removed in 13 patients (28%).

Discussion

Ulnar shortening osteotomy has a long history since its first description in 1941.[21] Since then, it has proved to be a reliable procedure for treating length discrepancies between radius and ulna[17,19,20,22–27] and has also proved effective in some forms of instability of the DRUJ[19,27] and the wrist.[28,29] Ulnar shortening osteotomy is also a successful salvage-procedure following failed arthroscopic TFCC resection.[30,31] However, the osteotomy can present difficulties in bone healing,[32,33] and the implant often requires a further surgical procedure for removal.[18,19,23,34] As a result, attempts have been made to improve these results either by changing the site of osteotomy to a more distal location in the metaphysis[35–38] or by using different shapes of osteotomies[39–44] to improve the rate of union and/or decrease the bulk of the implant. Analysis of reported cases would suggest that most reporting surgeons prefer a diaphyseal location for their osteotomy. Not surprisingly, numerous techniques and systems have been developed to improve reliability, precision, and expedience of diaphyseal osteotomies.[18,45–56] The widespread popularity of many of these systems confirms the importance of the need for such an approach.

The authors of this paper and the designers of this system of instrumentation and matching implants have demonstrated that precision and accuracy can be combined with reliability and simplicity when performing this procedure. However, in contrast to alternative systems, the implant size has been reduced in size and profile to diminish the need for later removal, yet no compromise has been made with the mechanical stability and healing potential of the osteotomy. The preliminary clinical experience in over 40 cases is promising and suggests that the aims of this novel system have been achieved, allowing future patients to profit from this technical innovation.

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Conflict of Interest
The authors have received per diems and reimbursement of travel expenses to attend to the Hand Expert Group meetings from the AO Foundation. No honoraria are involved. One of the authors (LN) has received consulting fees from Synthes.

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