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Original Article

Freehand technique with the predrilled hole method for ulnar-shortening osteotomy

Hui-Kuang Huang [a,b,c,d], Jung-Pan Wang [a,b,*], Shih-Tien Wang [a,b], Yi-Chao Huang [a,b], Chien-Lin Liu [a,b]

[a] Department of Surgery, National Yang-Ming University School of Medicine, Taipei, Taiwan, ROC
[b] Department of Orthopedics and Traumatology, Taipei Veterans General Hospital, Taipei, Taiwan, ROC
[c] Department of Orthopedics, Chia-Yi Christian Hospital, Chiayi, Taiwan, ROC
[d] Chung Hwa University of Medical Technology, Tainan, Taiwan, ROC

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Abstract

Background: Ulnar shortening is a common and useful method for treating ulnar wrist pain from many causes. Many devices used to perform osteotomy have been introduced in the literature; however, the devices are not universally available. The standard freehand technique is still commonly used in clinical practice; however, it is associated with several complications and is time-consuming. We present a freehand technique for ulnar-shortening osteotomy using a predrilled hole method.
Methods: From 2011 to 2013, we performed the predrilled hole method for ulnar shortening in 18 cases using the six-hole limited-contact dynamic compression plate (LC-DCP) and in two cases using the Acumed six-hole Locking Midshaft Ulna Plate.
Results: All patients had uneventful union, and the average operative time was 39.7 minutes (range, 32–50 minutes). The average follow-up period was 21 months (range, 12–30 months). There were no complications except in three patients in the LC-DCP group who complained of implant irritation. Good functional outcomes were achieved with this method.
Conclusion: Our technique is easy and quick to use and can minimize soft-tissue manipulation. The union rate is high and complications are few.

Keywords: freehand; osteotomy; shortening; triangular fibrocartilage; ulnar impaction syndrome

1. Introduction

Ulnar-sided wrist pain is frequently encountered in clinical practice. One of the common causes is the ulnar impaction syndrome. It may also be caused by disruption of the distal radioulnar joint (DRUJ), tear of the triangular fibrocartilage complex (TFC), tear of the lunotriquetral (LT) ligament, and other issues. Many surgical treatments for ulnar impaction syndrome to unload the ulnocarpal joint have been reported. Wafer resection procedure under arthroscopy and ulnar-shortening osteotomy are the most commonly discussed and performed.[1–4] Wafer resection can be done in a minimally invasive manner, but the other coexisting problems cannot be simply addressed by this procedure alone. Ulnar shortening is another choice, and many of the causes of ulnar-sided wrist pain, including DRUJ disruption, TFC tear, and LT ligament tear, can be treated with this procedure.[5–9] Ulnar shortening was first introduced by Milch[10] with two parallel saw cuts. To date, many devices have been used to facilitate the osteotomy in order to prevent complications associated with the freehand method.[11–14] However, not all institutions possess the

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* Corresponding author. Dr. Jung-Pan Wang, Department of Orthopedic and Traumatology, Taipei Veterans General Hospital, 201, Section 2, Shih-Pai Road, Taipei 112, Taiwan, ROC.

E-mail address: jpwang@vghtpe.gov.tw (J.-P. Wang).

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necessary devices to offer this procedure. The freehand technique is still not uncommon, especially in Taiwan. Although some of the freehand methods have been reported, there are still several difficulties associated with this procedure.[15–18] Another freehand technique with the predrilled hole method was reported by Chennagiri and Burge,[19] but the shortening length is limited to the numbers of holes of limited-contact dynamic compression plate (LC-DCP). Also, the screw insertion sequence is crucial; otherwise, insufficient closure of the osteotomy gap will occur. In this study, we present a freehand technique using the predrilled hole method to simplify the procedure, which can be used for any desired shortening length.

2. Methods

The indication for ulnar shortening should be static or dynamic positive ulnar variance confirmed in radiographs.[20,21] Magnetic resonance imaging should show the changes in the ulnar head, lunate, or triquetrum in the ulnar impaction syndrome, lesions in the TFC complex, or in the LT ligament. Patients with significant osteoarthritis of the DRUJ in radiographs are not candidates for this procedure.[22]

Informed consent was obtained from all patients prior to enrollment. From 2011 to 2013, we enrolled patients with ulnar impaction syndrome who underwent the ulnar shortening procedure by the predrilled hole method performed by a single surgeon at our institute. Patients with symptoms related to immunological diseases; inflammatory diseases; carpal bones avascular necrosis; previous forearm, arm, or wrist fractures; or infectious disease were excluded. There were 20 patients included in the final evaluation with at least 12 months of follow-up.

During preoperative planning, zero-rotation posteroanterior and lateral views are obtained. The pronated grip view is taken if symptoms due to dynamic positive ulnar variance are suspected. Magnetic resonance imaging is performed for all patients to identify other possible causes of ulnar wrist pain. The amount of ulnar bone resection depends on the ulnar variance on a zero-rotation posteroanterior view. The goal of ulnar shortening is to reach a mild minus ulnar variance (1 mm) on the zero-rotation posteroanterior view.

The procedure is performed under general anesthesia and pneumatic tourniquet with the patient in the supine position. Arthroscopic evaluation is performed first if lesions other than ulnar impaction syndrome are suspected. If TFC injury is noted, arthroscopic debridement is performed for the central tear and repair for the peripheral tear. Midcarpal portal evaluation is not routinely performed unless there are causes that require the midcarpal portals for evaluation. After arthroscopy, the traction force is then released but the finger traps are kept to hold the forearm on the traction tower in an upright and neutral position to facilitate the ulnar-shortening procedure. A longitudinal skin incision is made between the flexor carpi ulnaris and the extensor carpi ulnaris (ECU) muscle, beginning at the distal third of the forearm and extending about 10 cm proximally. The approach is carried down through the interval between the flexor carpi ulnaris and ECU to the ulna. Care should be taken not to damage the dorsal sensory branch of the ulnar nerve if the approach goes further distally.

We use either a 3.5-mm six-hole LC-DCP (described first, Fig. 1) or an Acumed six-hole Locking Midshaft Ulna Plate (Acumed LLC, Hillsboro, OR, USA). The plate is placed on the dorsal aspect at the level between the mid- to distal third of the ulnar shaft. The dorsal cortex can be revealed after the ECU is retracted. We set the six-hole LC-DCP properly on the dorsal surface of the mid- to distal third of the ulna and aligned with the long axis of the ulna shaft. The plate is then held with the reduction clamps in place. The distal second screw hole is drilled and fixed first. Then we make a mark on the compression side of the proximal second hole. After this, we mark a line obliquely at an angle of 45° to the ulnar shaft. The marked line is used for the osteotomy and must be between the third and fourth screw holes.

The LC-DCP is removed after removing the distal second-hole screw. Another mark proximal to the previous mark on the proximal second hole is then made. The distance between the two marks is precisely equal to the planned shortening length. Attention should be paid to keep the two marks and the distal screw hole in the same axis parallel to the ulnar shaft. The proximal mark is then drilled with the drill bit. The length of the screw is measured with the LC-DCP placed on the bone temporarily for gauging. Then the hole is tapped for screw fixation.

Another oblique line is marked proximal and parallel to the marked oblique osteotomy line. The distance between the two lines is precisely equal to the planned shortening length. The soft tissue around both the osteotomy lines is well elevated from the ulna and protected with the mini Hohmann retractors. An oscillating saw is used to make the osteotomies on the two parallel lines. It is very important to avoid completely sawing the first cut; rather, it is advised to leave a portion of the cortex to make the second cut easier (Fig. 2). Also, placing a saw blade in the first saw slot can make it easier to make the parallel second cut. Then, the second cut can be made completely and the first osteotomy cut can be finished. Do not use a Rongeur or clamps if the first osteotomy cut is incomplete as it may create a butterfly fragment fracture on the intact cortex side. Furthermore, it is important to decrease the temperature when sawing with normal saline irrigation to prevent thermal injury to the bone or soft tissue.

The LC-DCP is then applied, and the distal second screw is set but not tightened. The proximal second screw is then set through the predrilled hole and not tightened. Both fragments can be easily reduced and aligned to the LC-DCP using reduction clamps. The distal and proximal second screws can then be tightened to close the gap of junction and compress the junction. The left screws can be set easily because of the good reduction of the junction (Fig. 3). Further compression of the junction can also be made when setting the left four screws if the compression of the junction is not ideal after tightening the first two screws. Achieving adequate compression is very important because excessive compression could lead to fracture of the osteotomy surfaces.

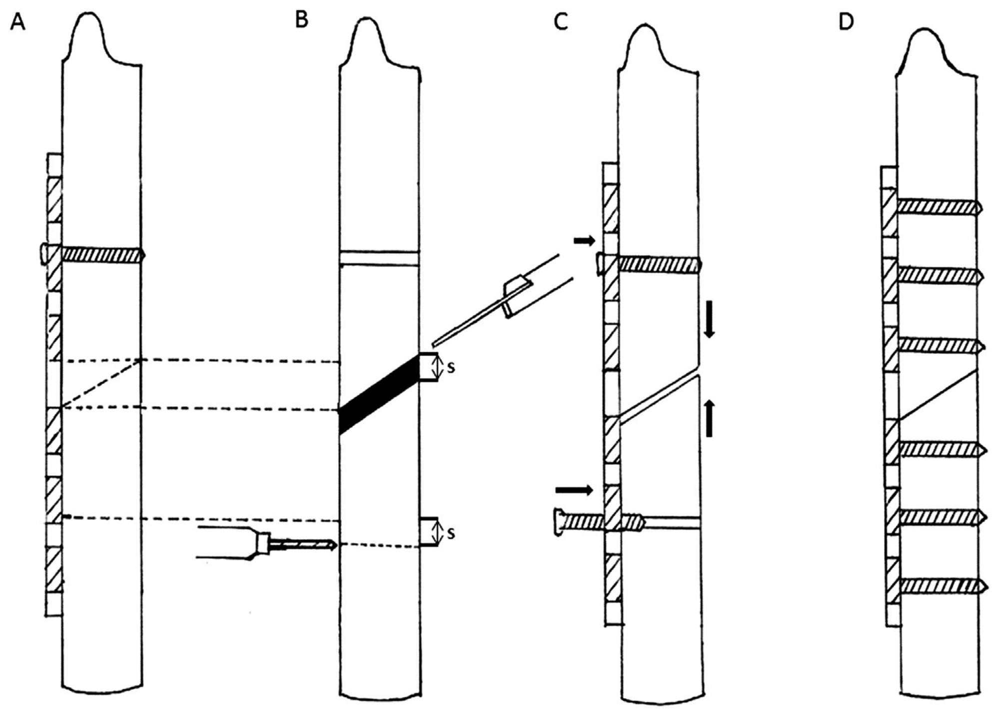

Fig. 1. Schematic illustration of the technique. (A) Fixation of the distal second-hole screw; (B) predrill of the proximal second-hole in the compression site with the shortening length added and osteotomy for the shortening; (C) tightening the screws to compress the osteotomy ends; and (D) fixation of the left screws to achieve stability. S = shortening length.

The method is also suitable for locking plate application. We used the Acumed six-hole Locking Midshaft Ulna Plate. The plate has four compression holes in the central area and two locking holes in the margin. With the same procedure of the predrilled hole for the distal and proximal second screw fixation, compression of the osteotomy ends can always be achieved. If the compression is not enough, the other two compression holes (the third and fourth holes) can still provide compression. After all compression holes are fixed, the marginal locking holes (the first and sixth holes) can then be fixed (Fig. 4).

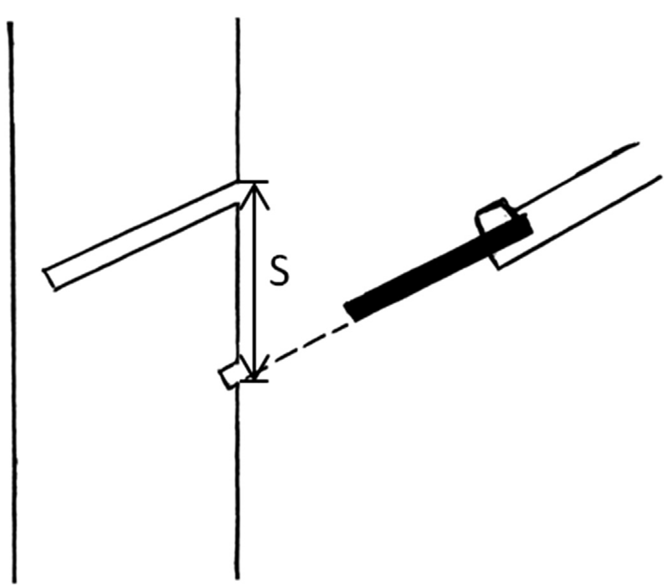

Fig. 2. Performing an incomplete first cut. The shortening length is measured from the top margin of the first cut to the lower margin of the saw kerf. S = shortening length.

After discharge, follow-up with each patient was arranged once every 2 weeks in the 1st month and once every month thereafter until 3 months after the junction healed. Then, follow-up every 6 months was arranged. Additional visits were arranged if indicated. Radiographs were taken after the surgery and at every visit. All patients were encouraged to attempt immediate finger and elbow motion postoperatively. If the TFC repair was performed arthroscopically, a sugar-tong splint was applied for 4 weeks. Patients were allowed to return to full-strength sports or work when healing of the junction was confirmed.

Functional evaluations were performed prior to the operation and in the follow-up visits by using the Visual Analog Pain Scale (VAS) for pain (where 0 = no pain; 10 = worst pain) at rest and during activity. Grip strength was evaluated by using a Jamar dynamometer (Sammons Preston, Bolingbrook, IL, USA) set to the second position. The level of activity to which each patient retuned was also recorded.

Data are presented as mean for the continuous response variables. We analyzed the data by using the paired Student *t* test for each continuous variable. STATA version 14 (Stata Corp., College Station, TX, USA) software was used to test the differences between results. The *p* value was set at 0.05 prior to the analysis for each test.

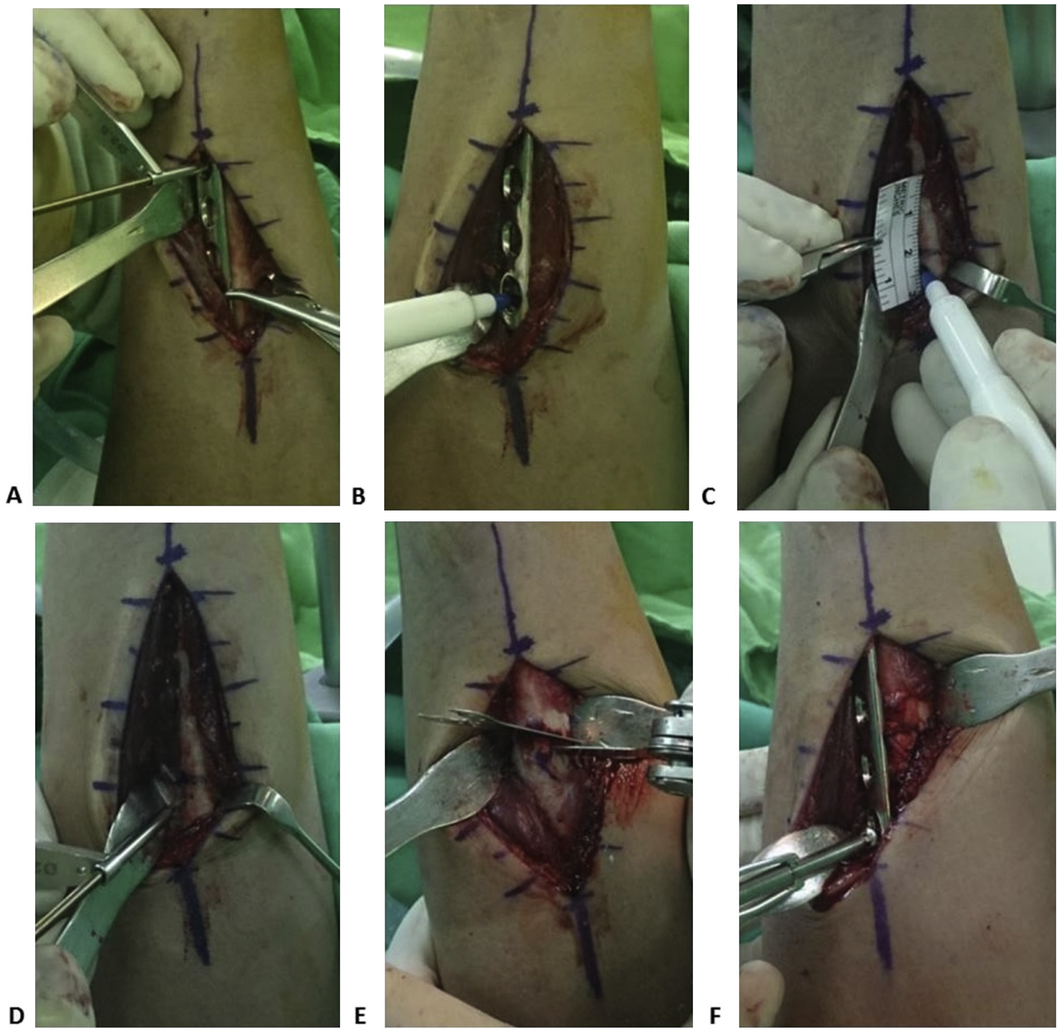

Fig. 3. Shortening with six-hole limited-contact dynamic compression plate (LC-DCP) fixation. (A) Preparation of the distal second hole; (B) marking the proximal second hole on the compression site; (C) marking the predrill point for the proximal second hole with shortening length added; (D) predrill the proximal second hole; (E) using a free saw blade as a guide for parallel cutting and (F) good compression of the junction after tightening of the proximal and distal-hole screws.

3. Results

From 2011 to 2013, we performed ulnar shortening in 18 cases with the six-hole LC-DCP and in two cases with the Acumed six-hole Locking Midshaft Ulna Plate. There were 11 males and 9 females. All patients had uneventful union at an average of 10.6 weeks (range, 10–14 weeks) after the surgery. The average shortening length was 4.4 mm (range, 3.5–7 mm), and the postoperative ulnar minus variance was between 0 and 1.5 mm in the radiographic measurement. The average operative time was 39.7 minutes (range, 32–50 minutes). The average follow-up period was 21 months (range, 12–30 months). There were no complications except in three patients in the LC-DCP group who complained of implant irritation. All three patients had implant removal after 1 year of the shortening procedure, and symptoms were then relieved.

The mean VAS scores at rest improved from 1.8 (range, 0–4) to 0.2 (range, 0–1) ($p < 0.001$), and the score during activity improved from 6.6 (range, 5–8) to 0.8 (range, 0–2) ($p < 0.001$). The mean grip strength improved from 26.5 kg (range, 16–37 kg) to 37.9 kg (range, 26–52 kg) ($p < 0.001$). All patients were able to return to their previous full level of work and activities within 6 months after the surgery with no or mild pain, and no wrist braces were required.

4. Discussion

Unparallel osteotomy is the complication mainly related to freehand technique error. It can lead to incorrect shortening length and poor junctional coaptation. In all 20 of our patients, good junctional coaptation was noted after the plate fixation. However, in our previous experience of freehand ulnar shortening, we did encounter the complication of unparallel osteotomy and a gap appearing at one side of the junction. In such cases, we used part of the resected bone as the bone graft to fill the junctional gap at one side. The junctions healed well,

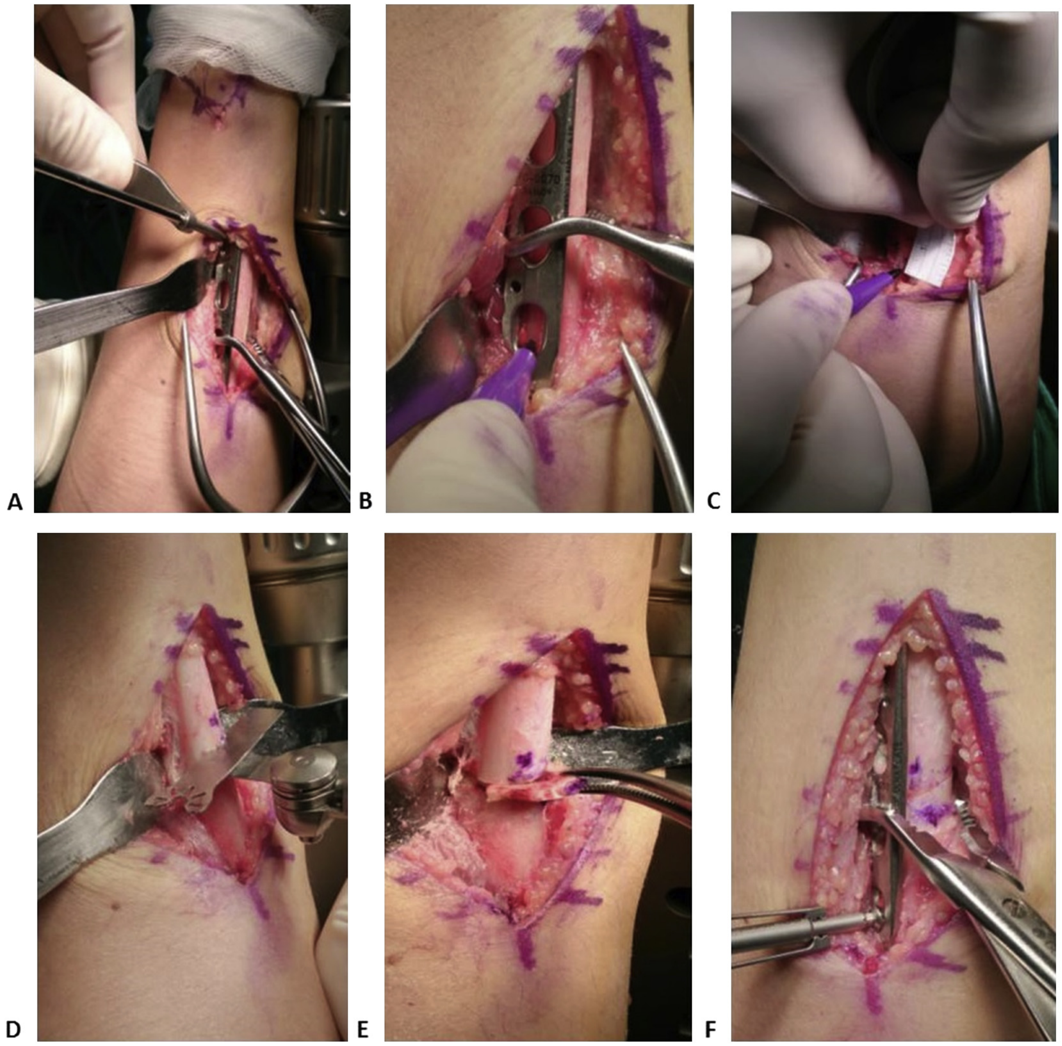

Fig. 4. Shortening with the Acumed six-hole Locking Midshaft Ulna Plate fixation. (A) Preparation of the distal second hole; (B) marking the proximal second hole on the compression site; (C) marking the predrill point for the proximal second hole with shortening length added; (D) using a free saw blade as a guide for parallel cutting; (E) removing the resected bone fragment; and (F) good compression of the junction after tightening of the proximal and distal second-hole screws.

and the ulnar levels were not discrepant more than 1.5 mm in the postoperative radiographic measurement compared with the designed level.

Also, the precise shortening length is very important. The shortening length is equal to the resected bone plus twice the thickness of the saw kerf. After marking the cutting lines, we prefer not to saw the first cut completely. As illustrated in Figure 2, we then measure from the distal osteotomy margin of the first cut and mark the shortening length again. If the distal margin of the saw blade is aimed at the marking line, the length will be more precise.

In performing the ulnar-shortening osteotomy, there are several other key points to consider, including less soft-tissue manipulation and good stability of implant fixation. This predrilled hole method can minimize soft-tissue manipulation because of the easy reduction, and good coaptation will be achieved after gradually tightening the first two screws in the predrilled holes. Shortening with the plate fixation and with an interfragmentary screw added is common in reported studies.[11,15,23,24] We found that the osteotomy junction could be compressed well after fixation of the six side screws in our previous experience with seven-hole plate fixation, and the interfragmentary screw did not seem to be necessary. Therefore we used the six-hole plate for fixation thereafter, and the union rate was still reliable. It made the procedure easier without the interfragmentary screw setting, and made the wound smaller.

Malrotation is another concern. A prerequisite to avoid rotational malreduction is to drill holes on either side in an axis parallel to the ulnar shaft prior to the osteotomy. There is an inherent risk of malrotation in our method. In order to prevent such malrotation, any rotational change during gradual tightening of the first two screws should be carefully inspected. If there is no rotation, tightening the two screws to achieve adequate compression can be performed directly. If any rotation appears, the two screws should be tightened to just reduce or close the gap and hold the correct alignment with the reduction clamps. Then, the remaining screws are set to maintain the reduction and achieve compression. The first two screws are tightened at the end with an adequate force so as not to make any rotational change.

Use of a shortening device is still the standard for ulnar shortening. It can prevent the complications associated with the freehand method. The freehand technique we have described can achieve the same results with less soft-tissue manipulation, easy performance, effective compression, and high union rate as by the use of a shortening device. However, the osteotomy cut still cannot be as precise as when using the jig.

In conclusion, the predrilled hole method in the freehand technique is easy and reliable in union of ulnar shortening and can achieve good functional outcomes. This method can be helpful in clinical practice for institutions without shortening devices and surgeons familiar with the freehand technique.

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