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ORIGINAL STUDY

The pre-drilled hole method in the freehand technique for ulnar shortening osteotomy : a case series study

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Ulnar shortening is a common procedure for treating ulnar wrist pain of various causes. Many tools and devices had been reported in the literature to facilitate the procedure, but not all are universally available. Freehand technique is still useful in clinical practice. Here we present a pre-drilled hole method to improve the outcomes of the freehand technique. From 2008 to 2012, a total of 51 patients at our institution underwent ulnar shortening with this method, with an average follow-up period of 24.4 months (range, 12-62 months). The average shortening length was 4.6 mm (range, 3-8.5 mm). All patients had uneventful union at an average of 9.8 weeks (range, 8-14 weeks) after the surgery. All had improved functional results. All patients returned to their previous full level of work and activities. The pre-drilled hole method for ulnar shortening is an easy assist to the freehand technique. Also, the union rate is high, and complications are uncommon.

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

INTRODUCTION

Ulnar wrist pain is a common problem encountered by hand surgeons and ulnar impaction syndrome is one of the main causes. Wafer procedure and ulnar shortening osteotomy are commonly used in treating the ulnar impaction syndrome (*4,7,16,26*). Unfortunately, the wafer procedure is not suitable for some of the coexisted problems, such as disruption of the distal radioulnar joint, tear of the triangular fibrocartilage complex, tear of the lunotriquetral ligament. Also the wafer procedure is contraindicated if the distal ulnar head has to be resected more than 4 mm (*6,7*). Ulnar shortening is a good choice in treating these problems and especially indicated if more than 4 mm of shortening length is needed (*11,18,21,25*). Milch firstly described a straightforward method of two parallel saw cuts perpendicular to the long axis of the ulna (*17*). Many devices have been introduced to facilitate the osteotomy in order to prevent malalignment and shorten the operative

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time (3,12,14,24,28). But not all institutions have the ulnar shortening devices and the surgeons still have to perform the freehand technique. Here we present a freehand technique with the pre-drilled hole method to simplify the procedure and decrease the operative time.

MATERIALS AND METHODS

The candidates enrolled for this procedure should have static or dynamic positive ulnar variance (8,10). Patients with significant osteoarthritis of the distal radioulnar joint are not indicated for this procedure (27).

In the preoperative planning, zero-rotation posteroanterior and lateral radiologic views are obtained. The pronated grip view is taken if dynamic ulnar positive variance is suspected. The ideal level of ulnar shortening is to create a neutral to mild ulnar minus variance (1 or 0.5 mm) in the zero-rotation posteroanterior view (19). Magnetic resonance imaging was performed for all patients to evaluate the possible concomitant lesions.

The study enrolled patients with ulnar impaction syndrome who underwent ulnar shortening by the pre-drilled hole method at our institution from 2008 to 2012. In our protocol of the treatment for ulnar impaction syndrome, ulnar shortening is considered only if the wafer procedure is not suitable. Usually, it is performed in patients who need more than 4 mm shortening length or those who need less than 4 mm shortening but with laxity in the distal radioulnar joints or lunotriquetral ligaments. In this study, patients with symptoms related to immunological, inflammatory, or infectious disease were excluded. Also, patients with carpal bone avascular necrosis, previous wrist fracture, or concomitant procedures of the same side upper limb were excluded. A total of 53 patients were enrolled. Two patients were lost to follow-up. The remaining 51 patients (16 men, 35 women ; 25 right wrists, 26 left wrists ; mean age, 41.5 years [range, 17-63 years]) were included in the final evaluation.

Surgical techniques

We perform the operation under general anesthesia and pneumatic tourniquet with the patient in the supine position. Arthroscopic evaluations were performed for the patients with the suspicion of other pathologies than ulnar impaction. During the arthroscopy, any possible lesion in the radiocarpal or ulnocarpal joint was evaluated. Central tears of the triangular fibrocartilage complex were debrided if seen. Evaluation of the midcarpal portals was not routinely performed unless problems of the lunotriquetral ligament or other causes involving the midcarpal portals were suspected. After the arthroscopy, the traction force was released but the finger traps were kept to hold the forearm in an upright and neutral position. If the patients did not receive arthroscopy, we also used the wrist arthroscopy traction tower without traction force for the shortening procedure. A longitudinal skin incision was made between the flexor carpi ulnaris (FCU) and the extensor carpi ulnaris (ECU) muscle, starting 2 inches (5.1 mm) proximal to the ulnar styloid. The approach was carried down through the interval of the FCU and ECU to the ulna bone. We used a 3.5 mm limited-contact dynamic compression plate (LC-DCP ; Synthes Inc., West Chester, PA) for shortening fixation.

The dorsal cortex was well revealed after retracting the ECU. We placed the 7-hole LC-DCP onto the dorsal surface of the ulna and aligned it along the long axis of the ulna. The LC-DCP was then held in place with reduction clamps. The distal second screw was fixed first. Then, we marked the proximal second hole at its compression site. We then marked an oblique line at a 45° angle along the ulnar shaft to the fourth hole.

The distal second-hole screw and LC-DCP was then removed. Another mark proximal to the previous mark of the proximal second hole was then made. The distance between the two marks was precisely equal to the planned length of shortening (Fig. 1). In order to prevent malalignment, attention should be paid to keep the proximal two marks and the distal screw hole in the same longitudinal line parallel to the ulnar shaft. The hole on the proximal mark was then drilled. The length of the screw hole was measured with the LC-DCP placed temporarily onto the bone. Then, the hole was tapered.

Another line was marked proximal and parallel to the previously marked 45° oblique line and the distance was precisely equal to the planned length of shortening. Extraperiosteal dissection was performed around both osteotomy lines and protected with Homan retractors. An oscillating saw was used to make the osteotomies on the two parallel lines. It

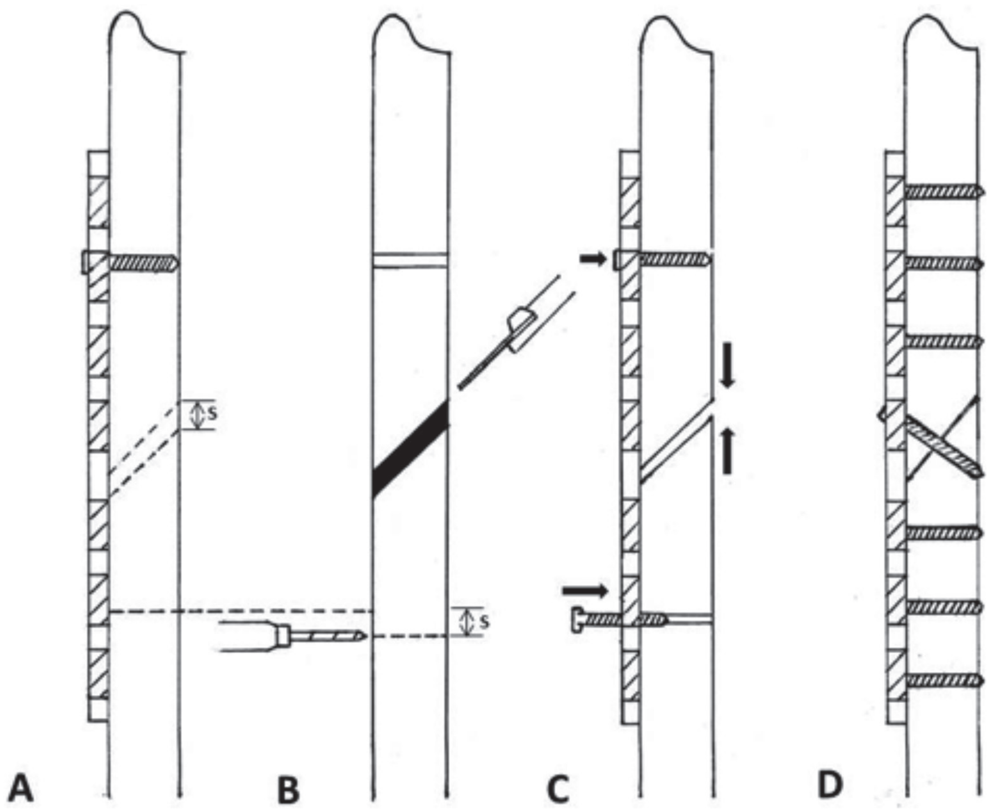

Fig. 1. — Diagram of the process of fixation of the distal second-hole screw. **A.** Final result of fixation of the distal second-hole screw. **B.** The proximal second hole is prepared on the compression site with the shortening length added and an osteotomy for the shortening. **C.** The screws are tightened to compress the osteotomy ends. **D.** The left screws and the interfragment screw are fixated.
Abbreviation : S, shortening length.

is very important to saw the first cut incompletely with a part of the cortex left. This procedure allows the surgeon to make the second cut more easily. The second cut can be done completely. Then, the surgeon can saw through the left cortex of the first cut. The resected bone segment should not be removed with the Rongeur or clamps if the osteotomies are not complete, because a butterfly fragment fracture may occur. Also, saline irrigation is important to prevent thermal injury during the osteotomy.

After the osteotomies, the surgeon should check both sides of the cutting surface to be parallel and without any bone spike. The LC-DCP is then applied and the distal second screw is set but not tightened. The proximal second screw is then fixed into the pre-drilled hole and also not tightened. Both fragments can be very easily reduced with the reduction clamps. Then the distal and proximal second screws can be tightened and good conjunction of the osteotomies will be observed. All of the left screws (except the fourth one) then can be fixed easily. Finally, the interfragment screw is set through the fourth hole perpendicular to the osteotomy plane.

Immediate finger and elbow movement were allowed under sugar tone splint for four weeks after the surgery. Full strength of sport or work were allowed after the junction healing. Each patient was followed once every two weeks in the first month and once every month thereafter until three months after the junction healing. Then, a follow-up appointment was made for every six months. Additional visits were arranged if indicated. Radiographs were taken at every visit and radiologic union was defined as having trabeculation crossing the osteotomy site (*23,29*).

Functional evaluations were performed before the operation and in the follow-up visits by using the Quick Disability of the Arm, Shoulder, and Hand (Quick DASH) score, and the Visual Analog Pain Scale (VAS) for pain (0, no pain ; 10, worst pain) at rest and during activity. Grip strength measurements were evaluated by using a Jamar dynamometer (Sammons Preston, Bolingbrook, IL) set to the second position. Also, each patient had detailed records of their personal data, smoking habits, interval between appearance of symptoms and operation, operative time, length of hospital stay, complications, and functional recovery.

Data were presented as mean and standard deviation for continuous response variables. We analyzed the data by using the paired Student t test for each continuous variable. The software "STATA, Sigmaplot" was used to test the differences between results. The p-value was set before analysis at 0.05 for each test.

RESULTS

Fifty-one patients were enrolled and operated on using the aforementioned technique. All had uneventful union at an average radiologic union time (and standard deviation) of 9.8 ± 1.9 weeks (range, 8-14 weeks) after surgery. The average follow-up period was 24.4 ± 11.9 months (range, 12-62 months). The average operative time was 33.4 ± 3.7 minutes (range, 28-45 minutes). The average preoperative ulnar plus variance was 3.7 ± 1.3 mm (range, 1.5-6.5 mm) and the average postoperative ulnar minus variance was 0.9 ± 0.6 mm (range, 0-2 mm). The average shortening length was 4.6 ± 1.5 mm (range, 3-8.5 mm). No complications occurred, except that nine patients had plate removal due to implant irritation.

The Quick DASH score improved from an average of 61.8 ± 4.7 (range, 55-71) preoperatively to 15.3 ± 4.9 (range, 7-23) in the final follow-up ($p < 0.01$). The VAS pain at rest improved from 1.7 ± 1.2 to 1.3 ± 0.7 ($p = 0.03$) and the score during activity improved from 6.3 ± 1.0 to 2.1 ± 0.7 ($p < 0.01$). Grip strength improved from 24.1 ± 6.3 Kg to 33.9 ± 7.8 Kg ($p < 0.01$). All patients returned to their previous full level of work and activities with no or mild pain and no wrist braces were needed.

DISCUSSION

Free-hand osteotomy for shortening is technically demanding and can lead to such errors as gap formation, angulation, malrotation, inadequate length of excision, malalignment of the plate against the bone, and poor coaptation of the junction surface. Many authors have introduced techniques or devices for this procedure to prevent error and achieve precise bone cut. Use of an osteotomy device is the current standard practice, but not all institutions can offer the devices to surgeons. Some surgeons still perform osteotomies using a freehand technique. Problems related to this practice include error in performing the technique and the time-consuming nature of the procedure.

For the operative plan, the aim for the final level of shortening is to achieve neutral or mild minus (about 0.5-1 mm) variance. We prefer to make the shortening achieve neutral ulnar variance in the preoperative plan. The final osteotomy length should be the length of the resected bone plus two-fold the thickness of the saw blade. This will create mild minus variance in the ulna after the procedure. The saw blade we use is 0.4 mm thick, from Hall Surgical (Linvatec, Largo, FL). Therefore, the planned neutral variance plus 0.8 mm of the two-blade thickness will make the ulna mildly minus. Also we make the predrilled hole on the compression side of the LC-DCP, to prevent gap formation after the thickness of the saw blade is added.

Oblique osteotomy is preferred by most surgeons nowadays. Rayhack et al were the first to compare transverse and oblique osteotomy and reported that oblique osteotomy has a shorter healing time and significantly stiffer torsion than transverse osteotomy (*23*). Also, Koppel et al reported shorter healing time and a lower nonunion rate for oblique osteotomy than for transverse osteotomy (Table I) (*13*). The most difficult part of performing freehand osteotomy is making the two parallel oblique cuts and this step will be the main source of technical error. This

Table I. — Comparison of the Results of Ulna Shortening Techniques

Study	Case (ulna) number	Device	Osteotomy	Nonunion	Delayed union	Radiologic union (wk)
Darrow (*5*)	35	Freehand	Transverse	1	8	13
Rayhack (*23*)	23 17	Freehand Rayhack specialized equipment	Transverse Oblique	1 0	Not documented	21 11
Wehbe (*29*)	24	Freehand and AO small distractor	Transverse	0	3	9.7
Koppel (*13*)	32 15	Freehand	Transverse Oblique	5 1	Not documented	28 20
Mizuseki (*19*)	24	Specially designed devices	Oblique	0	0	8.1
Chen and Wolfe (*3*)	18	Freehand and AO compression device	Oblique	0	Not documented	6.8
Sunil (*28*)	45 52	Freehand Rayhack specialized equipment	Transverse Oblique	3 0	Not documented	Not documented
Kitzinger (*12*)	27	Freehand	Oblique	0	Not documented	9.2
Ahsan (*1*)	30	TriMed dynamic compression system	Oblique	2	Not documented	10
Pouliot (*22*)	30	Osteotomy jig	Oblique	2	Not documented	10

is the main reason to develop the shortening tools or devices which can more precisely make the cuts. If the freehand technique is needed, we prefer to use the technique described by Baek *et al* (*2*). We make the first cut incomplete, leaving a small part of the cortex intact, and then we put a free saw blade in the first cut slot. This practice makes it easier to make the two cuts parallel.

We perform the osteotomy at the diaphyseal level although the metaphyseal osteotomy is suggested by some authors due to its good healing potential (*9,20*). Because the diaphyseal approach can achieve a wider operative field, it makes the osteotomy cut easy and safe. In addition, a narrow operative field for the osteotomy cut and plate fixation will jeopardize the surrounding soft tissue. Also, the ulnar neck and head are not perfectly straight, so the plate must therefore be bent accordingly. Bending of the plate will prolong the operative time and make it difficult to compress the osteotomy site (*2*). Implant irritation is another problem. It will be more obvious around the wrist level if the plate is set more distally. Although using the diaphyseal level could potentially lead to longer healing time than using the metaphyseal level, our patients experienced no nonunion or delayed union after the ulnar shortening.

We prefer to place the LC-DCP on the dorsal surface of the ulna. This is because we use the traction tower setting on the volar side to facilitate the procedure. In all our cases, both function and pain were improved after the procedure. However, nine patients had plate removal due to implant irritation ; surgery relieved the symptoms. To minimize plate prominence, we first evaluate whether the patient is a good candidate for the wafer procedure as a minimally invasive surgery without implant or not. In our treatment protocol, if the ulnar shortening length is small or involves dynamic impaction, and there is no distal radioulnar joint laxity, we perform the arthroscopic wafer procedure. In this study, the average shortening length was 4.6 ± 1.5 mm (range, 3-8.5 mm). If the ulnar shortening osteotomy procedure is necessary, the volar surface could be another good choice for placing the plate due to its robust soft tissue coverage (*15,22*). Whether the volar or the dorsal surface is a better spot for the plate is still not decided and needs studies for further evaluation. Also, using a thinner plate is another choice to decrease the hardware irritation.

The advantage of our method is that it is easy and can decrease the operative time. In the enrolled 51 cases, the average operative time was 33.4 minutes (range, 28-45 minutes). Sunil et al reported a mean operative time of 62 minutes in a freehand group and 61 minutes in a group using the Rayhack system (Wright Medical, Arlington, TN) (*28*). Although comparisons of the operative time across studies is problematic, our operative time was short because all operations were performed by a single surgeon and no shortening device had to be applied. In addition, fast reduction can be achieved by fixing the first two screws in the pre-drilled holes. When using the shortening device, it takes time to put the jig on and take it off. With the freehand method, it is not always easy to reduce both ends with a gap and sometimes the manipulation can jeopardize the surrounding soft tissue.

With this technique, we minimize the manipulation of the soft tissue. We had 100% union rate in the 51 cases and no delayed union. Also the series had no complications except for nine patients who had implant irritation. In the summary of results from other studies listed in Table I, the freehand groups had a higher nonunion and delayed union rate than the shortening device groups. In our cases, the results of our freehand technique were equal to or better than those of studies using a shortening device. We believe that this technique can effectively minimize the soft tissue manipulation and reach a good coaptation of the osteotomy ends, which can ensure a good union rate and prevent complications.

CONCLUSION

To have a good union rate of the ulnar shortening osteotomy, one must have minimal soft tissue manipulation, good stability of the implant fixation, and good coaptation of the junction. Although our study was limited by the lack of comparative data with other freehand methods, the pre-drilled hole method is easy and fast in our practice and results. It can minimize soft tissue manipulation, and the 7-hole LC-DCP can achieve good stability of fixation. Making the osteotomies parallel is the keystone of the freehand technique and it must be performed meticulously. For institutions without shortening devices or those surgeons familiar with the freehand method, the method can help improve results for patients and reduce complications.

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