SUBSPECIALTY PROCEDURES

STEP-CUT ULNAR SHORTENING OSTEOTOMY FOR ULNAR IMPACTION SYNDROME

Loukia K. Papatheodorou, MD, PhD, Dean G. Sotereanos, MD

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Introduction

The step-cut ulnar shortening osteotomy for the treatment of ulnar impaction syndrome is a safe, reliable, and less expensive technique that uses a 7-hole 3.5-mm standard neutralization plate and a lag screw for fixation, thus avoiding the need for the special instrumentation that other ulnar shortening techniques require.

The extra-articular ulnar shortening osteotomy is a common and widely accepted procedure for the surgical treatment of ulnar impaction syndrome, or ulnocarpal abutment syndrome, which is characterized as a degenerative condition of the ulnar side of the wrist that is related to excessive load-bearing between structures of the ulnocarpal joint^{1,2}. Ulnar impaction syndrome is frequently associated with positive ulnar variance, which can be congenital or posttraumatic.

A variety of surgical techniques for this osteotomy, transverse or oblique, have been developed using special instrumentation (jigs, cutting guides, and shortening systems) and several fixation techniques³⁻¹². However, no method has demonstrated clinical superiority. The concept of the step-cut ulnar shortening osteotomy was designed to overcome the morbidity associated with suboptimal rotational control (nonunion or malunion) when performing a transverse or oblique osteotomy technique and to avoid the need for, and thus eliminate the cost of, special equipment.

The step-cut ulnar shortening osteotomy is performed freehand with its long arm oriented in the coronal plane and the short arms perpendicular to the long axis in the axial plane. Stable fixation is performed with a volar 3.5-mm standard neutralization plate and a lag screw. The osteotomy is designed using the 7-hole 3.5-mm standard neutralization plate as a template. The step-cut osteotomy provides larger contact surfaces and better rotational control than transverse or oblique osteotomies without the use of special equipment^{13,14}.

The goal of the osteotomy is to unload the ulnocarpal joint by shortening the ulna by only a few millimeters and not necessarily to reduce ulnar variance to neutral or negative. It is important to resect the same amount of bone at both proximal and distal ends of the osteotomized ulna.

We present the surgical technique of a step-cut ulnar shortening osteotomy for the treatment of ulnar impaction syndrome.

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Indications & Contraindications

Indications

- Symptomatic idiopathic ulnar impaction syndrome.
- Symptomatic posttraumatic ulnar impaction syndrome.

Contraindications

- Allergy to metal.
- Distal radioulnar joint arthritis (relative contraindication).

Step 1: Preoperative Planning

Perform a physical examination and obtain imaging studies to identify all associated abnormalities.

- Identify the pain pattern, functional disability, and any causal factor through the history.
- Perform a physical examination of the wrist, including the ulnocarpal stress test, which is done with maximum ulnar deviation with the wrist pronated and then flexed and extended.
- Obtain anteroposterior, lateral, and pronated grip-view radiographs of the wrist to assess the ulnar variance and carpal chondromalacia (Fig. 1).
- A magnetic resonance imaging scan can also identify associated abnormalities such as chondromalacia of the lunate, lunotriquetral ligament tears, and attritional triangular fibrocartilage complex tears (Fig. 2).

Fig. 1

Fig. 2

Fig. 1 A preoperative pronated grip-view radiograph of a 37-year-old man with idiopathic ulnar impaction syndrome indicates positive ulnar variance with cystic lesions of the ulnar aspect of the lunate.

Fig. 2 Magnetic resonance imaging scans show signal change in the ulnar aspect of the lunate (arrow) in T1-weighted and T2-weighted views and signal change in the triangular fibrocartilage complex in the T2-weighted view.

Step 2: Wrist Arthroscopy (Video 1)

Verify the diagnosis of ulnar impaction syndrome and treat concurrent intra-articular abnormalities.

- Place the patient in the supine position.
- Place the arm in an arthroscopic wrist tower with traction.
- Assess the wrist with an arthroscopic probe to confirm the diagnosis of ulnocarpal abutment and diagnose any concurrent intra-articular abnormalities.
- Address any central triangular fibrocartilage complex tears with arthroscopic debridement.
- Address any chondral flaps of the lunate with arthroscopic debridement.
- Address any partial lunotriquetral ligament tears with arthroscopic debridement.

Video 1 Arthroscopic assessment of the wrist and treatment of concurrent intra-articular pathology.

Step 3: Incision for the Ulnar Shortening Osteotomy (Video 2)

Make a longitudinal skin incision along the distal third of the ulna.

- Place the forearm in an arthroscopic wrist tower with traction or on a hand-table extension. (It is easier to control the rotation with the wrist tower.)
- Apply a tourniquet to the humerus and inflate it to 100 mm Hg above the patient's systolic blood pressure.
- Make an 8-cm longitudinal skin incision slightly volar along the distal third of the ulna.
- Dissect the interval between the extensor carpi ulnaris and flexor carpi ulnaris muscles.
- Expose the distal aspect of the ulna.
- Elevate the periosteum at the distal aspect of the ulna at the intended site of the osteotomy.

Video 2 The exposure, the design, and the cutting method used with the step-cut ulnar shortening osteotomy.

Step 4: Design the Step-Cut Ulnar Shortening Osteotomy (Video 2)

Design the step-cut ulnar shortening osteotomy.

- The step-cut osteotomy has its long arm oriented in the coronal plane parallel to the long axis of the ulna, and its short arms are perpendicular to the long axis in the axial plane (Figs. 3 and 4).
- Design the step-cut ulnar shortening osteotomy using a 7-hole 3.5-mm standard neutralization plate as a template.
- Apply the plate to the volar surface of the ulna 1 to 2 cm proximal to the ulnar head to avoid impingement of the plate or screws into the distal radioulnar joint with rotation of the forearm.
- Design the long arm of the osteotomy (approximately 15 to 20 mm long) to extend from the third to the fifth holes of the plate, allowing placement of bicortical screws in these 2 holes.
- Use a marking pen to outline the planned osteotomy on the cortex of the ulna, and remove the plate from the field.
- Design the short arms of the osteotomy to be perpendicular to the long arm.
- Mark the length of the shortening on the proximal and distal aspects of the step-cut osteotomy parallel to the short arms of the osteotomy (approximately 1 to 2 mm of resection on each arm).

Fig. 3

Fig. 4

Fig. 3 Schematic diagram of the step-cut ulnar shortening osteotomy.

Fig. 4 Schematic diagram of the step-cut ulnar shortening osteotomy, reduction with a lag screw (dorsal to volar), and volar placement of the plate. (Reproduced from: Papatheodorou LK, Baratz ME, Bougioukli S, Ruby T, Weiser RW, Sotereanos DG. Long-term outcome of step-cut ulnar shortening osteotomy for ulnar impaction syndrome. J Bone Joint Surg Am. 2016 Nov 2;98[21]:1814-20.)

Step 5: Perform the Step-Cut Ulnar Shortening Osteotomy (Video 2)

Create the step-cut ulnar shortening osteotomy using an oscillating saw.

- Place 2 Hohmann retractors around the ulna to protect the soft tissues.
- Cut the long arm of the osteotomy first, using an oscillating saw along the long axis of the ulna.
- Use irrigation during the operation of the oscillating saw.
- Take care to orient this cut in a medial to lateral direction (coronal plane) and to cut both cortices.
- Cut the 2 short arms perpendicular to the long cut, dividing the ulna into a dorsal and a volar half as opposed to radial and ulnar halves.
- Use an osteotome to complete the cut.
- Shorten the proximal and distal ends of the osteotomized ulna approximately 2 to 4 mm by cutting parallel to the initial short-arm osteotomies.

Step 6: Fixation of the Osteotomy (Video 3)

Fix the osteotomy with a lag screw and volar plate.

- Release the traction in the arthroscopic wrist tower.
- Reduce the osteotomy site anatomically and secure it with a reduction clamp across the osteotomy.
- Compress the arms of the osteotomy using a lag screw.
- Place the lag screw across and central to the osteotomy from dorsal to volar and perpendicular to the long arm.
- Fix the osteotomy with the 7-hole 3.5-mm standard neutralization plate on the volar surface of the ulna (Fig. 4).
- The shortening is provided by the bone removal at each limb of the horizontal osteotomy. The lag screw provides compression at the vertical osteotomy site, and the plate is used for neutralization.
- Center the plate on the osteotomy with the fourth hole of the plate being opposite to the lag screw.
- Insert in the plate 3 screws proximal and 3 screws distal to the lag screw.
- Place the 2 screws adjacent to the osteotomy site obliquely away from the osteotomy to avoid insertion through the osteotomy site (Fig. 5).
- Under fluoroscopy, confirm appropriate ulnar shortening, reduction of the osteotomy, and placement of the plate and screws without impingement or impaction sign (no contact between ulna and carpal bones) with pronation, supination, and ulnar deviation of the wrist.

Fig. 5

Video 3 The fixation method used with the step-cut ulnar shortening osteotomy.

Figs. 5-A, 5-B, and 5-C A 37-year-old woman with idiopathic ulnar impaction syndrome who had a step-cut ulnar shortening osteotomy. **Fig. 5-A** Preoperative pronated grip-view radiograph. **Fig. 5-B** Twelve-week postoperative pronated grip-view radiograph. **Fig. 5-C** Lateral radiograph made 12 weeks after the step-cut ulnar shortening osteotomy.

Step 7: Wound Closure

Meticulously close the wound in layers.

- Release the tourniquet.
- Apply meticulous hemostasis.
- Irrigate the wound with copious amount of normal saline solution.
- Close the wound in layers.
- Place the wrist in a short arm plaster splint.

Step 8: Postoperative Care

Protect the affected arm for the first 6 weeks.

- Apply a plaster short-arm splint that is worn for the first 2 weeks.
- At 2 weeks postoperatively, remove the nylon skin sutures.
- At 2 weeks postoperatively, replace the initial splint with a short arm removable splint that is worn for 4 weeks.
- At 6 weeks postoperatively, have the patient initiate active range of motion of the wrist.
- Allow weight-bearing after clinical and radiographic osseous union is achieved.

Results

In our original study, 164 patients with symptomatic ulnar impaction syndrome were treated with a step-cut ulnar shortening osteotomy using a volar 3.5-mm standard neutralization plate and a lag screw¹⁴. The ulnar impaction syndrome was idiopathic in 116 patients and posttraumatic in 48 patients. The mean preoperative ulnar variance was +3.5 mm (range, +1 to +6 mm) as depicted by the pronated grip-view radiograph for all patients.

The median follow-up was 66 months (range, 24 to 86 months). The mean postoperative ulnar variance was +0.2 mm (range, -1 to +1.5 mm), and the mean overall shortening was 2.5 mm. Union at the site of the osteotomy was achieved at a mean of 8.2 weeks (range, 5 to 18 weeks), and the union rate was 98.8%¹⁴. The healing progress was evaluated clinically and radiographically at 2 weeks postoperatively and then approximately every 4 to 6 weeks. Union was defined radiographically as trabecular bone bridging the osteotomy site with blurring of the cortical margins of the osteotomy in combination with clinical absence of tenderness to direct palpation at the osteotomy site.

Although previous studies have noted nonunion rates after ulnar shortening osteotomy that were as high as 13%^{7,15}, our large serial study of 164 patients had only 2 patients (1.2%) with a nonunion and both healed after secondary surgery with autologous iliac crest bone-grafting¹⁴. One of the 2 patients with nonunion was a heavy smoker, and the other was a nonsmoker.

For all patients, the pain score, range of motion, grip strength, and Mayo Modified Wrist Score significantly improved postoperatively regardless of the postoperative ulnar variance (that is, negative, neutral, or positive)¹⁴. All patients returned to their previous work at a mean of 4 months postoperatively.

Plate irritation is the most common complication resulting in a reoperation after ulnar shortening osteotomy, with a rate as high as 55%^{4,9,10,15-18}. In our study¹⁴, we found that the step-cut ulnar shortening osteotomy had a lower rate of hardware removal (7.3%; 12 of 164 patients) because of the better soft-tissue coverage of the plate with volar placement.

Previous studies have found a rate of degenerative changes at the distal radioulnar joint after ulnar shortening osteotomy of up to 38%, and most of those patients were asymptomatic^{6,15,19}. The step-cut ulnar shortening osteotomy resulted in a lower rate of asymptomatic degenerative changes at the distal radioulnar joint (5.5%; 9 of 164 patients)¹⁴. We believe that this was due to the smaller amount of ulnar shortening, which diminishes the rate of distal radioulnar joint articular incongruity and the subsequent development of arthritis of the distal radioulnar joint.

The results of our original study¹⁴ demonstrated that the step-cut ulnar shortening osteotomy with a 7-hole 3.5-mm standard neutralization plate and a lag screw for fixation is an effective method for the treatment of ulnar impaction syndrome, resulting in rapid healing and providing good to excellent functional results without the need for expensive surgical equipment.

Pitfalls & Challenges

- The goal of the osteotomy is to reduce ulnar variance by shortening the ulna a few millimeters and not necessarily to create neutral or negative ulnar variance.
- The long arm of the step-cut osteotomy is oriented in the coronal plane, and the short arms are perpendicular to the long axis in the axial plane.

- Perform a wrist arthroscopy at the time of the procedure prior to the ulnar shortening osteotomy to confirm the diagnosis and address concurrent intra-articular pathology.
- Place the arm in an arthroscopic wrist tower with traction to facilitate proper rotational alignment of the bone and volar placement of the plate.
- Use an oscillating saw to perform the step-cut shortening osteotomy.
- Shorten the ulna by removing a total of 2 to 4 mm of bone from both ends of the osteotomized ulna.
- Place a lag screw from dorsal to volar, perpendicular to the long arm, to compress the osteotomy.
- Fix the osteotomy with a 7-hole 3.5-mm standard neutralization plate on the volar surface of the ulna.
- Place the 2 screws adjacent to the osteotomy site obliquely away from the osteotomy to avoid insertion through the osteotomy site.
- Intraoperative fluoroscopy is essential to confirm appropriate reduction of the osteotomy and placement of the plate and screws without impingement or impaction with pronation, supination, and ulnar deviation of the wrist.
- Have the patient start active range of motion at 6 weeks postoperatively and begin progressive weight-bearing after there is clinical and radiographic evidence of osseous union.

Loukia K. Papatheodorou, MD, PhD¹

Dean G. Sotereanos, MD^{1,2}

¹Orthopaedic Specialists–UPMC, University of Pittsburgh, Pittsburgh, Pennsylvania

²University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

E-mail address for L.K. Papatheodorou: loukiapapath@yahoo.gr

E-mail address for D.G. Sotereanos: dsoterea@hotmail.com

References

1. Friedman SL, Palmer AK. The ulnar impaction syndrome. *Hand Clin.* 1991 May;7(2):295-310.
2. Nishiwaki M, Nakamura T, Nagura T, Toyama Y, Ikegami H. Ulnar-shortening effect on distal radioulnar joint pressure: a biomechanical study. *J Hand Surg Am.* 2008 Feb;33(2):198-205.
3. Boudas HJ, Milek MA. Ulnar shortening for tears of the triangular fibrocartilaginous complex. *J Hand Surg Am.* 1990 May;15(3):415-20.
4. Wehbe MA, Cautilli DA. Ulnar shortening using the AO small distractor. *J Hand Surg Am.* 1995 Nov;20(6):959-64.
5. Hulsizer D, Weiss AP, Akelman E. Ulna-shortening osteotomy after failed arthroscopic debridement of the triangular fibrocartilage complex. *J Hand Surg Am.* 1997 Jul;22(4):694-8.
6. Minami A, Kato H. Ulnar shortening for triangular fibrocartilage complex tears associated with ulnar positive variance. *J Hand Surg Am.* 1998 Sep;23(5):904-8.
7. Rayhack JM, Gasser SI, Latta LL, Ouellette EA, Milne EL. Precision oblique osteotomy for shortening of the ulna. *J Hand Surg Am.* 1993 Sep;18(5):908-18.
8. Labosky DA, Waggy CA. Oblique ulnar shortening osteotomy by a single saw cut. *J Hand Surg Am.* 1996 Jan;21(1):48-59.
9. Mizuseki T, Tsuge K, Ikuta Y. Precise ulna-shortening osteotomy with a new device. *J Hand Surg Am.* 2001 Sep;26(5):931-9.
10. Chen NC, Wolfe SW. Ulna shortening osteotomy using a compression device. *J Hand Surg Am.* 2003 Jan;28(1):88-93.
11. Horn PC. The long ulnar sliding osteotomy. *J Hand Surg Am.* 2004 Sep;29(5):871-6.
12. Chennagiri R, Burge P. Pre-osteotomy plate application technique for ulnar shortening. *J Hand Surg Br.* 2004 Oct;29(5):453-7.
13. Darlis NA, Ferraz IC, Kaufmann RW, Sotereanos DG. Step-cut distal ulnar-shortening osteotomy. *J Hand Surg Am.* 2005 Sep;30(5):943-8.
14. Papatheodorou LK, Baratz ME, Bougioukli S, Ruby T, Weiser RW, Sotereanos DG. Long-term outcome of step-cut ulnar shortening osteotomy for ulnar impaction syndrome. *J Bone Joint Surg Am.* 2016 Nov 2;98(21):1814-20.
15. Köppel M, Hargreaves IC, Herbert TJ. Ulnar shortening osteotomy for ulnar carpal instability and ulnar carpal impaction. *J Hand Surg Br.* 1997 Aug;22(4):451-6.
16. Iwasaki N, Ishikawa J, Kato H, Minami M, Minami A. Factors affecting results of ulnar shortening for ulnar impaction syndrome. *Clin Orthop Relat Res.* 2007 Dec;465:215-9.
17. Pomerance J. Plate removal after ulnar-shortening osteotomy. *J Hand Surg Am.* 2005 Sep;30(5):949-53.
18. Loh YC, Van Den Abbeele K, Stanley JK, Trail IA. The results of ulnar shortening for ulnar impaction syndrome. *J Hand Surg Br.* 1999 Jun;24(3):316-20.
19. Baek GH, Lee HJ, Gong HS, Rhee SH, Kim J, Kim KW, Kong BY, Oh WS. Long-term outcomes of ulnar shortening osteotomy for idiopathic ulnar impaction syndrome: at least 5-years follow-up. *Clin Orthop Surg.* 2011 Dec;3(4):295-301. Epub 2011 Dec 1.