Comparison of Compression Screw and Perpendicular Clamp in Ulnar Shortening Osteotomy

Daniel E. Martin, MD, Dan A. Zlotolow, MD, Stephanie A. Russo, MD, PhD, Scott H. Kozin, MD

Purpose To biomechanically quantify 2 techniques, compression screw and perpendicular clamp, for generating compression during ulnar shortening osteotomy (USO) in order to promote reliable primary bone healing.

Methods Fourteen fresh-frozen cadaveric human forearms were randomly assigned to 1 of 2 groups. Group I (n = 7) underwent USO according to the traditional AO plate fixation technique using a screw placed eccentrically in an oblong hole to generate compression at the osteotomy site. Group II (n = 7) underwent USO with a commercially available USO plating system using a clamp placed perpendicular to the osteotomy site to generate compression. Both techniques involved a 2-mm resection osteotomy performed with cutting jigs to minimize variability and an interfragmentary lag screw to augment compression. A digital pressure sensor measured contact area at the osteotomy site and average pressure in the observed contact area; these values were used to calculate force across the osteotomy site. Measurements were obtained after the following steps: reduction of osteotomy, compression screw placement (group 1 only), lag screw placement, and final construct with all clamps removed.

Results Group II demonstrated significantly greater force than group I, and lag screw placement resulted in significantly increased force independent of fixation technique. The effect of the lag screw on force was maintained after clamp removal. Although technique of fixation did not significantly influence contact area, lag screw placement significantly increased contact area independent of fixation method. However, this effect was not maintained after clamp removal. Average pressure in the observed contact area was not significantly influenced by fixation technique or stage of fixation.

Conclusions Perpendicular clamp compression significantly increased force as compared with traditional compression screw technique, and lag screw placement significantly increased force in both constructs.

Clinical relevance Larger compressive forces across the osteotomy may promote primary bone union and decrease the rates of delayed union or nonunion. *(J Hand Surg Am. 2014;39(8): 1558–1564. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Ulnar shortening osteotomy, ulnar impaction syndrome, nonunion, contact pressure, digital pressure sensor.

From the Philadelphia Hand Center, Department of Orthopaedic Surgery, Division of Hand Surgery, Thomas Jefferson University; the Upper Extremity Center of Excellence, Shriners Hospitals for Children, Philadelphia, PA; and the Biomechanics and Movement Science Program, University of Delaware, Newark, DE.

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Corresponding author: Scott H. Kozin, MD, Shriners Hospitals for Children, 3551 North Broad St., Philadelphia, PA 19140; e-mail: skozin@shrinenet.org.

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Palmer and Werner[1] demonstrated that, in neutral ulnar variance, the majority of force transmission at the wrist occurs through the radius and that even small alterations producing an ulnar-positive variance dramatically increase the force transmitted through the ulna. Palmer and Werner[2,3] also demonstrated that ulnar-positive variance is associated with triangular fibrocartilage complex tears and can initiate the degenerative cascade of ulnar impaction syndrome (UIS). Ulnar shortening osteotomy (USO) directly addresses ulnar-positive variance associated with UIS in an extra-articular manner. However, USO has been criticized for being more technically demanding and having higher complication rates than wafer and arthroscopic procedures.[4]

Application of traditional AO fracture fixation techniques to USO can be technically challenging because ligamentotaxis hinders reduction of bone fragments when a segment has been removed rather than facilitating reduction, as seen when treating fractures.[5] In addition, it is unclear whether familiar techniques such as the inclusion of a lag screw in the fixation are mechanically necessary in the augmentation of an osteotomy fixation construct. Techniques to facilitate a USO have included custom cutting jigs[6] to standardize osteotomies and the use of an AO small distractor (Synthes, Paoli, PA) to facilitate reduction.[7] Also, the use of a plating system designed specifically for USO has been shown to substantially decrease operative time.[8]

Concerning complications, most series examining USO have reported the need for frequent plate removal up to 100%.[7,9–13] Recently, the development of lower-profile plates designed specifically for USO has decreased the rate of hardware removal.[8,14,15]

Most problematically, delayed union and nonunion have been highlighted in both early and recent literature when using both traditional AO technique (13%–18% rate of delayed union or nonunion)[9,11,12] and USO plating systems (4%–7% rate of delayed union or nonunion).[15,16] Still, USO is already being implemented as a treatment for indications other than UIS, such as lunotriquetral tear[17] and distal radius malunion.[18,19]

This study aimed to quantify the amount of compression generated at the osteotomy site during USO using 2 techniques, compression screw and perpendicular clamp, because increased compression promotes primary bone healing[20] and thus decreases the risk of delayed union or nonunion. The study furthermore aimed to determine if the inclusion of a lag screw in the fixation construct generated additional compression across the osteotomy site or merely helped maintain the compression generated by the initial compression technique. The primary outcome was the generation of force across osteotomy site as measured using a digital pressure sensor.

MATERIALS AND METHODS

Specimen preparation

Two fellowship-trained, attending hand surgeons (S.H.K. and D.A.Z.) dissected 15 fresh-frozen human cadaveric forearms using the extensor carpi ulnaris/flexor carpi ulnaris interval to allow volar plate placement. The specimens were randomized into 2 groups.

An a priori power analysis was performed based on a previous application of a digital pressure measurement system in an olecranon fracture model.[21] Using a clinically significant difference for the primary outcome of 40 N and the SD of 19 N observed in the study by Wilson et al,[21] a sample of 6 specimens per group was determined to have 80% power to detect this difference with an alpha level of 0.05.[21] Three additional specimens were included in the study to account for possible equipment or specimen failures.

Osteotomy technique

A custom plate was manufactured to be compared with a commercially available USO system. The 3.2-mm TriMed Ulnar Osteotomy Compression Plate system (TriMed, Santa Clarita, CA) was selected because the cutting jigs and reduction devices that uniquely affix to the plate in this system were anticipated to provide the most reproducibility between specimens. The custom-made plate facilitated the use of cutting jigs. A custom-made reduction device affixed to the plate and allowed lag screw compression across the osteotomy site using the traditional AO technique (tightening a screw in an eccentrically placed hole at the edge of an oblong hole that crossed the osteotomy site). Again according to traditional AO technique, the mobile segment produced by the oblique osteotomy was wedged into an axilla formed by the stable segment and the plate. This custom plate and its corresponding reduction device were used in group I, and all remaining hardware was commercially available in the 3.2-mm TriMed Ulnar Osteotomy Compression Plate system.

The 2 plating systems resulted in identical final constructs when all reduction devices were removed (an oblique osteotomy with a lag screw across the osteotomy site and 3 nonlocking screws on each side of the osteotomy; Fig. 1) and differed only in the reduction and compression techniques employed before the placement of the lag screw. The study was thus designed to evaluate surgical techniques for generating compression but not to compare available hardware systems.