# Simplifying the Volar Distraction Osteotomy for Distal Radius Malunion Repair

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## Abstract

**Background** Extra-articular fractures of the distal radius are often treated with a trial of nonoperative management if radiographic parameters are within an acceptable range, especially in the elderly population. Unfortunately, some malunions become symptomatic or become grossly misaligned during nonoperative management which require corrective surgery to restore the normal osseous anatomy and restore function.

**Description of Technique** We describe correction of a distal radius malunion utilizing a distraction-type volar osteotomy, a volar plate specific distraction device, and a novel resorbable calcium phosphate bone cement (Trabexus) designed to withstand compressive loads.

**Patients and Methods** Twelve patients with 13 distal radius fractures were included in this study. The average patient age was 60.9 years and average time from injury to corrective osteotomy was 96.3 days. Radiographic measures (radial inclination, volar tilt, and ulnar variance) and clinical assessment (wrist/forearm range of motion and grip strength) were done pre- and postoperatively and compared.

**Results** The average time from corrective surgical osteotomy to final clinical follow-up was 375.8 days. After surgical intervention, there was a statistically significant improvement in mean volar tilt (−19.8 vs. +0.5 degrees) and mean ulnar variance (+2.8 vs. −0.4 mm). Improvements were also seen in grip strength (1.7 vs. 43.6 lb), wrist flexion (30.5 vs. 48.3 degrees), wrist extension (33.3 vs. 53.8 degrees), forearm pronation (75.0 vs. 88.8 degrees), and forearm supination (53.8 vs. 81.3 degrees). On average, 56.0% of Trabexus bone substitute remained on final clinical radiographs.

**Conclusion** This simplified technique of distraction corrective osteotomy after distal radius malunion results in improved clinical and radiographic outcomes for patients.

**Keywords**
- distal radius fracture
- malunion
- corrective osteotomy



Distal radius fractures are commonly encountered and up to 35% of fractures treated nonoperatively can result in malunion.[1,2] Radiographic deformity after malunion generally presents with radial shortening, loss of radial inclination, increased dorsal tilt of the joint, and radial translation of the distal fragment. When symptomatic, the combination of these factors often results in a challenging reconstruction to obtain near normal radiographic parameters.

Malunion of distal radius after fracture is tolerated well by some, especially older, low-demand patients. However, a large subset of patients develop symptoms, including ulnar-sided wrist pain, loss of motion, and gross deformity that can lead to decreased function and satisfaction after nonoperative treatment.[3] Patients with the following parameters have demonstrated a higher level of pain and disability: dorsal angulation $>10$ degrees, ulnar variance of $\geq 3$ mm, or radial inclination of $<15$ degrees.[4] In general, patients with higher functional demands tolerate less deviation from normal anatomic parameters. Despite this, oftentimes many extra articular fractures undergo a trial of nonoperative management. For those who

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have significant loss of reduction or continued symptoms weeks to months after the injury, surgical intervention involving correction may be warranted. Historically, malunion treatment involves either ulnar shortening osteotomy, the Darrach procedure, or hinge osteotomy of the distal radius with dorsal or volar plating.[5–8] These options do not all restore anatomy to its native state and previous techniques aimed at restoring anatomy resulted in significant intraoperative challenges, including working against contracted wrist tendons and the need for large amount of bone graft.

We propose a modified method to regain radial length and correct translation and tilt at the site of the malunion while avoiding donor site morbidity from bone autograft and minimizing intraoperative struggle seen with reestablishing length after malunion using a simplified distraction type volar osteotomy.

## Surgical Technique

Under general or regional anesthesia, the arm is placed on a hand table with an upper arm tourniquet. The modified volar Henry approach is used to expose the area of the malunion. Next, the periosteum of the dorsal distal radius is freed and a tenotomy of the brachioradialis tendon is performed. Under fluoroscopy, the site of osteotomy is marked using a Kirschner's wire. We make sure to perform the osteotomy just proximal to the sigmoid notch and angle obliquely to match the dorsal tilt of the radius. This oblique osteotomy provides more surface area for healing and allows for a larger distal fragment which ensures adequate distal fixation during the distraction process.

The osteotomy is made with a sagittal saw and a Freer elevator is used to ensure no soft tissues remain tight to prevent correction. With aggressive flexion of the wrist, two Kirschner's wires are placed in the styloid across the osteotomy site and fluoroscopy is used to confirm adequate restoration of tilt. A large Kirschner's wire can be placed distally to serve as a joystick to help correct dorsal tilt. Once tilt is restored and maintained with Kirschner's wires, a volar locking plate with a long cortical sliding hole is pinned in place. A distal radius radiolucent clamp (Synthes) is used to secure the plate distally against the bone and screws are placed distally to provide fixation of the distal fragment. Screws are placed safely in subchondral bone and care is made to ensure that they do not extend beyond the far cortex. With the plate fixed distally, a cortical screw is then placed into the most distal portion of the sliding hole of the plate. It is critical that this screw is grossly bicortical and can be changed later. Once it is nearly tightened, the previously placed Kirschner's wires used for provisional fixation are removed. The volar distraction device (Xpander Tool, TriMed) is placed and while using the screw as an anchor, the device engages a more distal screw hole and pushes the plate and metaphyseal fragment distally and ulnarly to restore radial length, appropriate ulnar variance, and correct any translation (►**Fig. 1**). This eliminates any cortical contact between proximal and distal fragments. The cortical screw is tightened once the correction is obtained. Fluoroscopy confirms adequate restoration of length based on a radiograph of the normal uninjured wrist preoperatively. If more than 6 mm of length is required, a second screw can be placed distally and the distraction process is repeated using the slotted cortical screw hole. With correction of the deformity maintained, screws are then placed proximally to complete fixation. For osteotomy gaps of more than 4 mm, a longer volar locking plate may be required to ensure adequate proximal fixation.

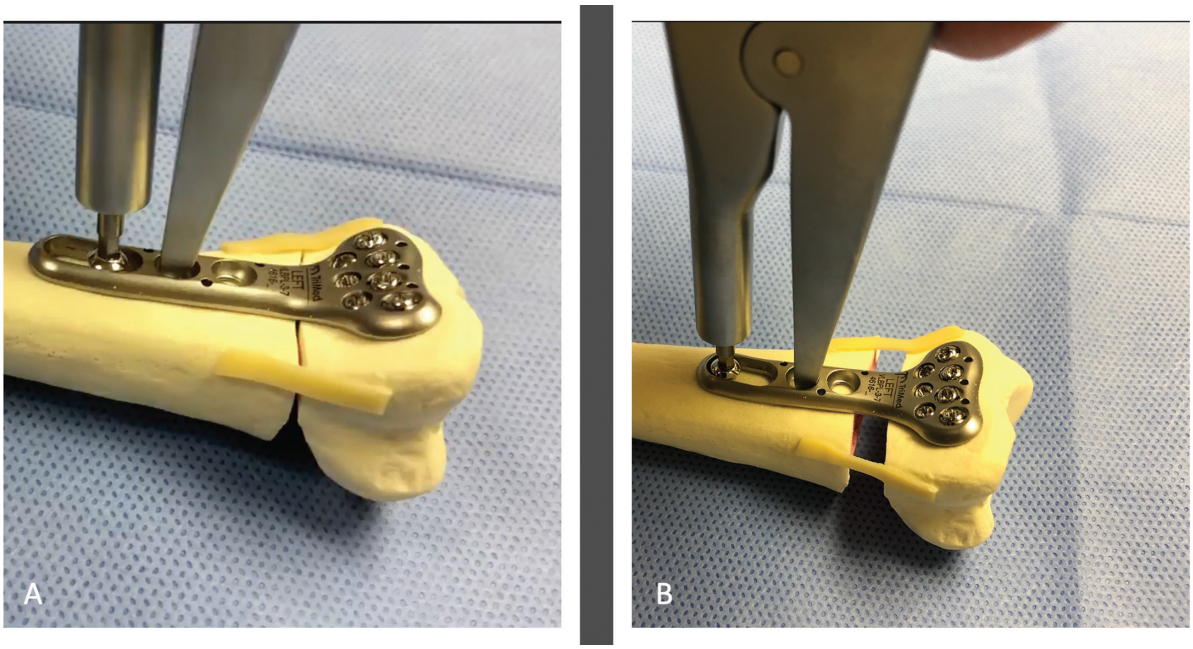


**Fig. 1** (**A**) Distraction device is positioned on the volar locking plate, with the cortical screw in the distal portion of the oblong hole. (**B**) Distraction device is now engaged on the volar locking plate, resulting in distraction (and translation if needed) at the simulated osteotomy site. The cortical screw is now in the proximal portion of the oblong hole as a result of the distraction.

 

The wound is irrigated and a self-setting calcium phosphate bone graft with engineered allograft particles (Trabexus) is placed into the bone void. The tourniquet is let down, the wound is irrigated and closed, and the patient is placed into a short-arm splint.

## Patients and Methods

This study was performed using a retrospective review of patients identified from 2016 to 2019 from a single surgeon who underwent a volar osteotomy, correction of a deformity using a plate specific distraction device with plating, and use of a novel calcium phosphate bone graft substitute (Trabexus and Vivorte) for treatment of a distal radius malunion. Inclusion criteria for the study include: age greater than 18 years at time of presentation, initial distal radius fracture with dorsal angulation or impaction treated nonoperatively, and follow-up of >60 days from osteotomy procedure. A total of 15 patients were identified. Of those, three patients did not meet the inclusion criteria. One patient had less than 60-day follow-up from osteotomy and two patients had volar shear type fractures at initial presentation. Overall, 12 patients and 13 wrists were evaluated, as one patient did undergo bilateral surgery. The patients preoperative and final postoperative images were evaluated by two separate hand fellowship-trained physicians and averaged together evaluating the following parameters: pre- and postoperative radial inclination, joint tilt, ulnar variance, gap distance of osteotomy, and percent calcium phosphate bone graft remaining at final follow-up appointment.[9] Pre- and postoperative wrist flexion, wrist extension, forearm pronation, forearm supination, and grip strength were compared, and all postoperative complications were noted.

## Results

Overall, 13 wrists of 12 patients were included in the study. Of the patients, three were males and nine were females. The mean age was 60.9 years (range: 26–82 years). The average time from date of injury to time of corrective osteotomy was 96.3 days (range: 31–213 days). The average time from corrective surgical osteotomy to final clinical follow-up was 375.8 days (range: 60–918 days).

The average preoperative radial inclination was 14.4 degrees and the postoperative radial inclination was 19.4 degrees. The preoperative joint tilt was dorsal 19.8 degrees and the postoperative joint tilt was volar 0.5 degrees. The preoperative ulnar variance averaged +-2.8 mm and postoperative averaged −0.4 mm. The average amount of distraction created at the osteotomy site was 6.5 mm. The amount of calcium phosphate bone substitute remaining at last follow up films was also evaluated with the average at 56% remaining at approximately 1 year postoperatively. ►**Figs. 2** and **3** compare pre- and

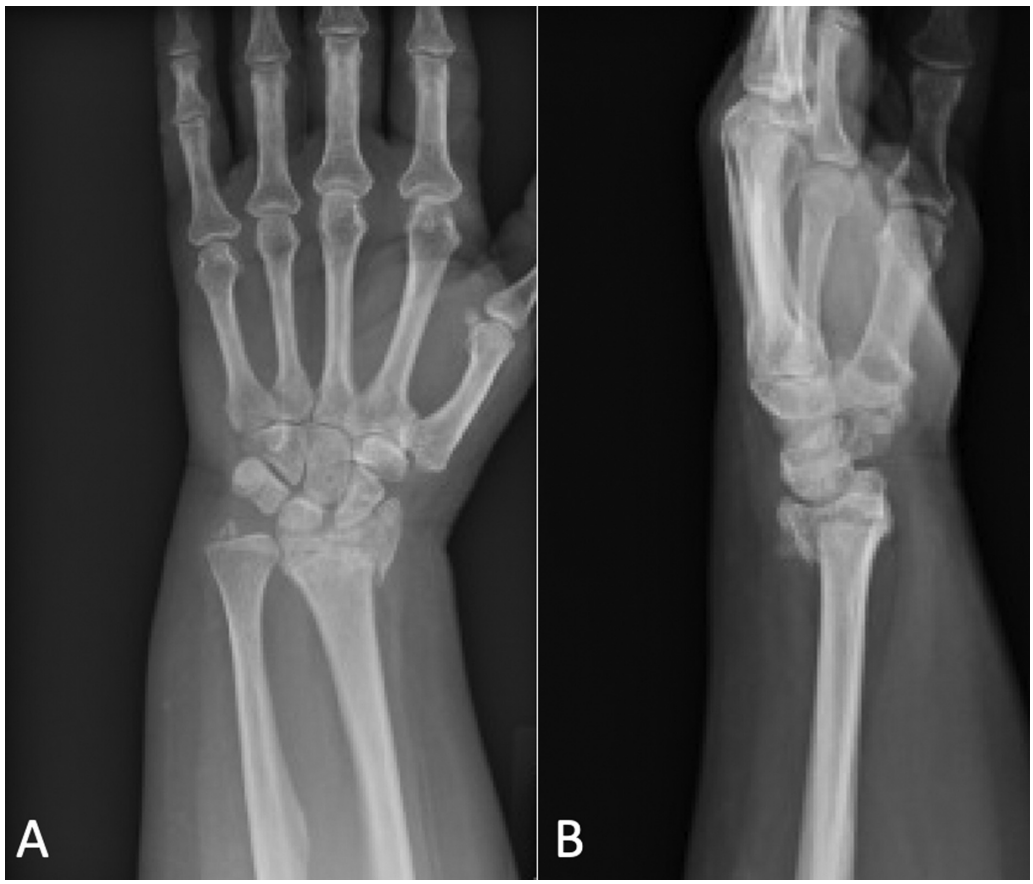


**Fig. 2** (A) Preoperative AP X-ray demonstrating a distal radius fracture malunion with loss of radial height and inclination. (B) Preoperative lateral X-ray demonstrating a distal radius fracture malunion with loss of volar tilt and radial height. AP, anteroposterior.

 

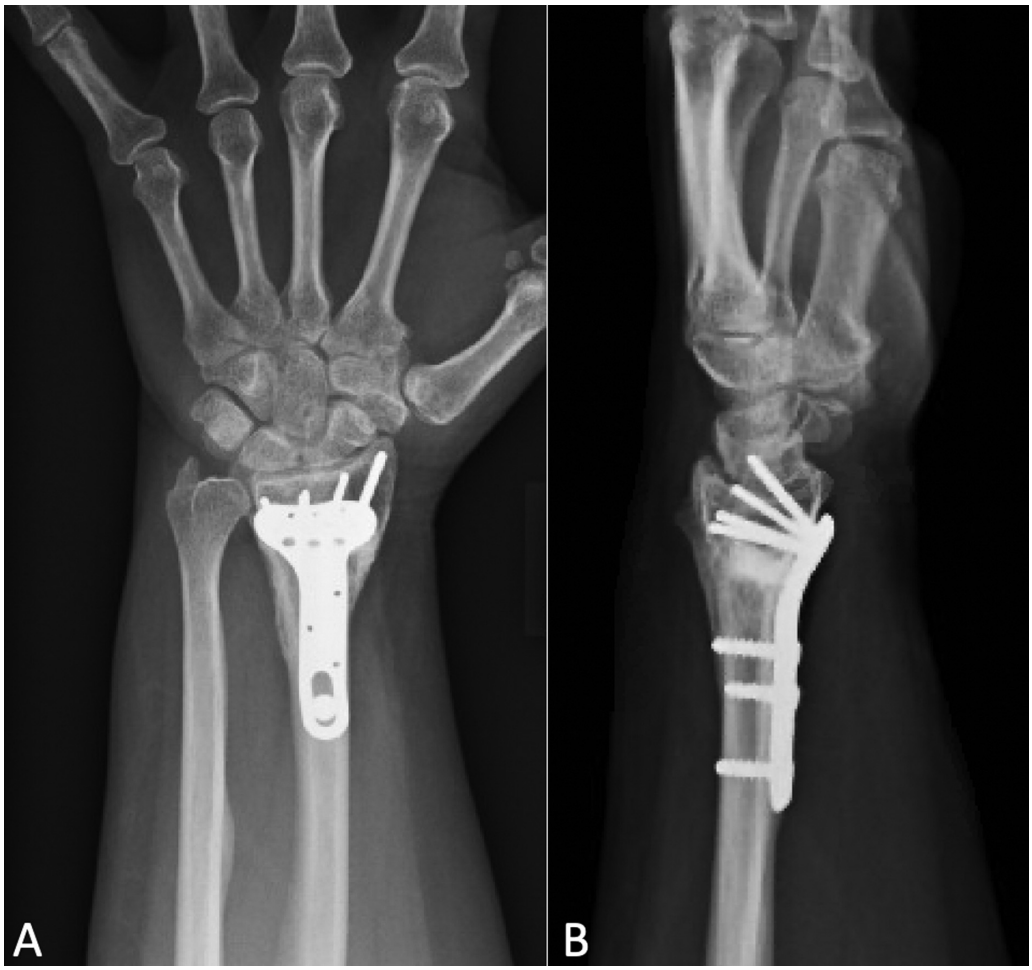


**Fig. 3** (**A**) Postoperative AP X-ray demonstrating correction of distal radius malunion with restoration of appropriate radial height and inclination. Trabexus bone substitute can be seen at the osteotomy site. (**B**) Postoperative lateral X-ray demonstrating correction of distal radius malunion with restoration of appropriate radial height and volar tilt. Trabexus bone substitute can be seen at the osteotomy site. AP, anteroposterior.

postoperative X-rays for a patient in this study, which shows the improvement in radiographic parameters after corrective osteotomy using the technique described in this manuscript.

Improvements were seen in pre- vs postoperative wrist flexion (30.5 vs. 48.3 degrees), wrist extension (33.3 vs. 53.8 degrees), forearm pronation (75.0 vs. 88.8 degrees), and forearm supination (53.8 vs. 81.3 degrees). Average postoperative grip strength at final follow-up using position II of the Jamar Dynamometer was 43.6 lb, compared with 1.7-lb preoperatively. Please see ►**Table 1** for a summary of pertinent radiographic and clinical data for all 12 patients included in this case series.

There were two postoperative complications involving the extensor pollicis longus (EPL) tendon. One patient did have a complete rupture of the EPL tendon at approximately 5-week postoperatively and did not wish to proceed with tendon transfer or repair. This occurred despite making a dorsal incision and debriding the sharp bone edges at the site of the osteotomy during the index procedure. No other patients underwent dorsal bony debridement. A separate patient underwent prophylactic EPL decompression for suspected impending rupture at 4-week postoperatively. A third patient sustained a fall from a bicycle at 4-month postoperatively and fractured through the osteotomy site and bent the plate, requiring revision surgery. There were no wound issues, nonunions, or atraumatic loss of reduction noted.

## Discussion

Corrective osteotomy for extra-articular malunion of a distal radius fracture is not novel. To reliably predict return of function and motion, restoration of anatomy in the wrist is critical. This includes reestablishing ulnar variance to prevent ulnar abutment and correction of excessive dorsal tilt to prevent mid carpal arthritis and restore DRUJ congruity. Dorsally based opening wedge "hinge" osteotomies historically have required iliac crest bone graft to allow for healing while preventing plate failure. Ring et al showed comparable results with nonstructural cancellous graft compared with iliac crest structural graft when using an opening dorsal wedge technique.[10] With the evolution of biologics, Luchetti reported successful results with carbonated hydroxyapatite in the osteotomy gap through a dorsal approach with

 

**Table 1** A summary of pertinent radiographic and clinical data

| Patient | Age (y) | Gender | Final follow-up (d) | Pre-/post-op radial inclination (degree) | Pre-/post-op joint tilt (degree) | Pre-/post-op ulnar variance (mm) | Osteotomy gap (mm) | Trabexus at final follow-up (%) | Final wrist flexion (degree) | Final wrist extension (degree) | Final grip strength (in lb) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 62 | F | 131 | 21.1/28.4 | −24.2/3.7 | −0.3/−2.2 | 6.5 | 88 | 30 | 40 | 49 |
| 2 | 61 | F | 918 | 14.6/23.8 | −20.4/6.0 | 3.6/2.1 | 4.8 | 5 | 65 | 65 | 45 |
| 2 | 61 | F | 692 | 16.9/21.5 | −20.9/2.5 | 2.6/1.2 | 6.0 | 33 | 60 | 50 | 40 |
| 3 | 78 | F | 106 | 21.7/26.1 | −18.3/5.3 | 2.8/2.1 | 6.8 | 75 | 50 | 38 | 40 |
| 4 | 64 | F | 650 | 5.3/13.6 | −23.7/2.1 | 1.0/−0.6 | 4.8 | 30 | 40 | 62 | 29 |
| 5 | 76 | F | 554 | 7.5/12.5 | −34.6/−8.6 | 1.5/−1.4 | 8.6 | 88 | 50 | 60 | 40 |
| 6 | 82 | M | 363 | 15.8/21.5 | 6.1/3.5 | 4.0/−1.4 | 7.0 | 70 | 30 | 40 | 40 |
| 7 | 61 | F | 92 | 13.3/19.0 | −20.0/0.5 | 4.5/−0.5 | 5.9 | 55 | 60 | 55 | 40 |
| 8 | 71 | F | 503 | 12.1/17.0 | −36.2/−8.8 | 2.4/−2.2 | 8.1 | 63 | 45 | 50 | 20 |
| 9 | 57 | F | 363 | 12.1/15.2 | −29.1/−5.8 | 2.6/−1.3 | 5.1 | 15 | 48 | 60 | 36 |
| 10 | 26 | F | 265 | 20.7/19.1 | −0.7/5.8 | 3.5/0.0 | 4.2 | 35 | 60 | 70 | 50 |
| 11 | 38 | M | 60 | 10.5/14.2 | −7.9/2.9 | 6.6/−0.7 | 8.8 | 95 | 40 | 50 | 50 |
| 12 | 55 | M | 188 | 15.5/20.5 | −27.5/−2.1 | 2.4/−0.5 | 7.9 | 75 | 50 | 60 | 90 |
| Average | 60.9 | – | 375.8 | 14.4/19.4 | −19.8/0.5 | 2.8/−0.4 | 6.5 | 56 | 48.3 | 53.8 | 43.8 |

Abbreviations: F, female; M, male; post-op, postoperative; Pre-op, preoperative.

multiple pin fixation and maintenance of volar cortical contact, although some loss of tilt occurred in the postoperative period.[11] With the advent of volar locked plating, techniques have developed using both hinge and distraction type osteotomies via volar approach. For some, this has resulted in relatively novel complications like EPL rupture.[12] Specifically, distraction type volar osteotomy has had higher rates of complications. Haghverdian et al reported a 63% rate of complications in the distraction type volar osteotomy (15 of 24 patients) which included nonunion with volar plate failure, delayed union, and EPL rupture. This was in contrast to their complication rate using a hinge type of volar osteotomy (10 of 36 patients) which had no nonunions.[13]

In this paper, we looked exclusively at the results of distraction type volar osteotomies treated with volar locked plating with a unique plate specific distraction device combined with use of a resorbable calcium phosphate bone graft with engineered allograft particles. We feel that the Xpander Tool compression/distraction device simplifies the restoration of length and translation, leading to reduced operative time and decreased procedure difficulty. Trabexus was selected in place of other autograft or bone substitutes for its unique compression properties and its specially engineered bone allograft particles with calcium phosphate that promote reliable host bone incorporation. Despite large bone voids and a distraction type osteotomy, the bone graft protected the plate from fatigue failure while resorbing reliably without wound issues, drainage, delayed union, or nonunion.

In our study, the average osteotomy gap created to restore appropriate anatomy of the distal wrist was 6.5 mm (range: 4.2–8.8 mm). The volar distraction device allows a surgeon to reliably obtain up to 6 mm of length, and the distraction process can be repeated as needed to gain further length. Our experience shows that there is no inherent limitation of lengthening the radius by this device and technique. Rather, the restriction in lengthening is from tension created in the soft tissues. If inadequate length of the radius has been achieved and there is excessive tension on the soft tissues, we would recommend an ulnar shortening osteotomy to help restore native distal wrist anatomy. In our case series, the maximum osteotomy gap created was 8.8 mm, and this did not result in any undue tension in the soft tissues.

Our study demonstrates a reliable and reproducible method of surgically treating distal radius fracture malunions. The issue of EPL rupture and tendonitis remains, and in this case series, a prophylactic bony debridement was not protective against this complication. The use of a distraction device with a volar locking plate allows for easy correction of deformity in all planes and the self-setting calcium phosphate bone graft with engineered allograft allows for early motion and reliable remodeling while protecting the plate from fatigue failure and preventing donor site morbidity.

### Conflict of Interest

L.P.R. reports personal fees from TRIMED, outside the submitted work. All the other authors report no conflict of interest.

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