

Functional Outcomes of Compression Plating and Bone Grafting for Operative Treatment of Nonunions About the Forearm

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Purpose To describe one center's experience with nonunion of one or both bones of the forearm and report on the functional recovery of patients treated for a single- or 2-bone forearm nonunion.

Methods We performed a retrospective analysis of 23 patients who presented to our institution over an 11-year period and underwent surgical repair of a forearm nonunion (radius, ulna, or both bones). The main outcome measurements included time to union, visual analog scale pain scores, range of motion, Short Musculoskeletal Function Assessment scores, and post-operative complications.

Results Of the 23 patients, 21 (91.3%) healed their nonunion after a single surgical procedure. All patients ultimately healed their nonunion; 7 patients were healed at 3-month follow-up, 11 healed at 6-month follow-up, and 5 healed at 12-month follow-up. Mean visual analog scale pain scores improved considerably from presentation to latest follow-up. The mean range of motion at the latest follow-up was as follows: elbow 130.9° flexion-extension arc, forearm 78.5° pronation/77.8° supination, and wrist 76.1° palmar flexion/74.3° dorsiflexion. Mean Short Musculoskeletal Function Assessment arm and hand index scores improved significantly from baseline to the latest follow-up. Mean Short Musculoskeletal Function Assessment function, activity, and bothersome indices demonstrated improvement, though this was not statistically significant. Two patients required further surgery to achieve osseous union. One patient sustained an iatrogenic posterior interosseous nerve palsy, which resolved spontaneously.

Conclusions Repair of forearm nonunion with compression plating and bone grafting provides reliable clinical and functional outcomes. Patients treated surgically for nonunion of one or both of the forearm bones can expect to heal with the potential for considerable improvements in pain and function postoperatively. (*J Hand Surg Am.* 2017;■(■):1.e1-e9. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic IV.

Key words Bone graft, forearm, functional outcome, nonunion.



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THE FOREARM IS REGARDED AS A “functional unit” because of the radius’s ability to rotate around the ulna, a unique bony relationship not encountered elsewhere in the body. The unique relationship between these bones allows the palm—the “working surface” of the hand—to be precisely positioned in space. Furthermore, the radius and ulna serve as origins for several muscles of the forearm, which in turn enable function.¹ Failure to achieve bony union or restore anatomic length and alignment after a fracture of the forearm may result in a substantial functional deficit.

Fortunately, nonunion after acute fracture of one or both bones of the forearm is a rare event with a reported incidence between 1% and 5%.² The pathophysiology of nonunions about the forearm is similar to nonunions at other sites throughout the skeleton; there is either failure of stability or failure of biology.^{3,4} Failure of biology refers to inability to complete one or more of the critical cellular events leading to osseous union: inflammatory response, callus formation, differentiation and proliferation of osteogenic cells, angiogenesis, conversion of woven bone to lamellar bone. Compression plating and autologous bone grafting is largely regarded as the mainstay of treatment in the case of nonunion. This method addresses both mechanical and biologic failure by restoring stability (via compression plating) and introducing osteoinductive and/or osteoconductive agents (via autologous bone graft).

Although several studies exist that report nonunion healing after intervention, there is a lack of outcome-oriented literature available to guide surgeons as they inform patients of postoperative expectations after compression plating and bone grafting for repair of forearm nonunion. The purpose of this study was to describe our experience with this treatment method and report on outcomes after the treatment of these injuries.

METHODS

This institutional review board-approved study reports on a retrospective cohort of patients with diaphyseal single- or both-bone forearm fracture nonunions. We identified and reviewed the records of all patients treated operatively for nonunion of the forearm at one of 2 hospitals within our institution between August 2005 and April 2016. Inclusion criteria included the presence of a symptomatic nonunion, age more than 18 years, and willingness to participate in the requisite follow-up. After obtaining consent, we documented demographic, radiographic,

clinical, and functional data. Twenty-four patients with a nonunion of one or both bones of the forearm (radius, ulna, or both bones) were identified. One patient was excluded because the patient reported more than 20 forearm surgeries before arriving at our institution and had been treated for a posterior interosseous nerve palsy as well as infection. The decision to exclude this patient was made because the patient’s situation differed substantially from the rest of the study sample. This left a final cohort of 23 patients for the analysis.

All patients were treated surgically for their fracture nonunion by a fellowship-trained orthopaedic trauma surgeon using a standardized method including revision compression plating with 3.5-mm locking plates with locking and nonlocking screws and cancellous iliac crest bone grafting (17 forearms) or iliac crest aspirate on a carrier (ie, osteoconductive agents such as crushed cancellous bone chips or demineralized bone matrix) (6 forearms). Diagnosis of nonunion was made on the basis of continued pain at the fracture site, radiographic findings of absent bony bridging, persistent lucency at the fracture site, unstable or broken hardware, lack of progression toward healing based on serial radiographs, and/or a fracture deemed unlikely to heal without further intervention (Figs. 1–3). Nonunion was classified according to the system of Weber and Cech, but limited to atrophic and hypertrophic types.^{5,6} The surgical technique used a volar Henry and a subcutaneous ulnar approach as needed. In all cases of revision surgery, deep cultures were obtained, any previous hardware was removed, and all fibrous tissue at the nonunion site was resected by hand using a combination of scalpel, rongeur, and curettes until healthy bleeding cortical bone was encountered. This was followed by antegrade and retrograde drilling of the medullary canals. Compression plating of the radius, ulna, or both bones was performed using 3.5-mm plates and screws. Reduction was achieved with specific attention paid to the restoration of forearm length, rotational alignment, and radial bow. Assessment of this was made using image intensifier views of the radius and confirming radial styloid and tuberosity difference of 180°, followed by full length forearm films. Radial bow was confirmed intraoperatively with the radial tuberosity 90° to the styloid. Furthermore, clinical evaluation of forearm rotation with the elbow at 90° demonstrated full pronation and supination. At the discretion of the treating surgeon, either autogenous iliac crest bone graft or iliac crest aspirate with an osteoconductive carrier was packed into or around the nonunion site in

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