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Outcomes of Locking-Plate Fixation for Hindfoot Fusion Procedures in 15 Patients

Kenneth Smith, MD [1], Ibukunoluwa Araoye, MS [2], Caleb Jones, BS [3], Ashish Shah, MD [4]

[1] Orthopaedic Resident, Postgraduate Year-4, Orthopaedic Division, Department of Surgery, University of Alabama at Birmingham, Birmingham, AL
[2] Orthopaedic Research Fellow, University of Alabama at Birmingham, Birmingham, AL
[3] Medical Student, Year 3, University of Alabama at Birmingham, Birmingham, AL
[4] Director, Foot and Ankle Fellowship, Orthopaedic Division, Department of Surgery, University of Alabama at Birmingham, Birmingham, AL

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ABSTRACT

Tibiotalocalcaneal arthrodesis is a salvage procedure for various end-stage foot and ankle pathologic entities. Several factors are known to influence the union rate after these procedures, including construct rigidity. The data on locked plates as a fixation technique have been inconclusive, with variable union rates reported. One recent study suggested that locking plates can lead to high nonunion rates owing to excessive rigidity. The purpose of the present study was to retrospectively examine the outcomes of locking plate fixation. We retrospectively reviewed the cases of 15 patients (7 [46.7%] male, 8 [53.3%] female) who underwent tibiotalocalcaneal, tibiocalcaneal, or tibiotalar arthrodesis fixed with a locking plate from January 2013 to January 2014. The average age was 52.19 ± 5.8 years. The mean follow-up period was 17 ± 5.3 months. We examined the overall union rates and the effects of smoking, diabetes, and rheumatologic status on the union rate. Of the 15 cases, 11 (73.3%) did not achieve union. The mean time to failure was 10 ± 5.3 months. Age, gender, smoking, diabetes, use of augmentation screws outside the plate, and operating surgeon did not have an effect on the failure rate ($p > .50$). In addition, gender, smoking, and diabetes did not predict for nonunion. The high failure rate of rigid locking plate fixation reported might be attributable to the high incidence of smoking and diabetic comorbidities in our study. However, excessive construct rigidity might play an important role. Larger studies are needed to establish more reliable union rates with the use of locking plates in foot and ankle fusion.

Tibiotalocalcaneal arthrodesis was described as early as 1906 using cadaver bone as fixators (1–4), with today's technique fully developed by Russotti et al (5) in 1988. It is a salvage procedure for the treatment of end-stage pathologic disease of the tibiotalar and subtalar joints, such as primary arthritis, severe deformity, talus avascular necrosis, and Charcot arthropathy, as well as failed total ankle arthrodesis or arthroplasty. The goal of this procedure is to create a stable, plantigrade foot that supports ambulation. For many decades, this has been achieved using a variety of fixation strategies, including crossed screw constructs, external fixators, plate and screw constructs, and intramedullary nails (1,6,7). These various fixation strategies have their respective bone union rates and complication rates. During the past decade, locking plates have seen more use as a fixation strategy in foot and ankle surgery (1,8,9). Previous studies have described the outcomes of hindfoot fusion using several different plates, including blade plates and even proximal humerus locking plates in a novel application (1).

The fixation construct type is an important consideration to achieve the best surgical outcomes. Patients' comorbid conditions influence the decision regarding the fixation construct type. For example, in osteopenic patients, one might consider a locking screw and plate construct, because studies have shown these constructs to have increased strength in osteoporotic bone (10). Likewise, in the presence of skin ulcers, advanced deformity, or Charcot arthropathy, external fixator devices should be considered, because these circumvent the concerns regarding poor healing or infection that can accompany open surgical approaches. The selection of fixation construct requires that the construct provide adequate rigidity to keep the bone surfaces fully apposed but also provide enough micromotion to permit optimal axial loading to stimulate and promote secondary bone healing (8,11,12).

Locking constructs have been used to treat comminuted metaphyseal fractures for years, with relatively good results. Recently, however, several studies have questioned whether some of these constructs provide excessive rigidity (stiffness), thereby preventing the requisite

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Address correspondence to: Ashish Shah, MD, Orthopaedic Division, Department of Surgery, University of Alabama at Birmingham, Orthopaedic Specialties Building, 1313 13th Street South, Room 226A, Birmingham, AL 35205.
E-mail address: ashishshah@uabmc.edu (A. Shah).

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amount of interfragmentary micromotion necessary for these fractures to heal by secondary bone healing (8,13,14). As a result, fractures fixed with locking plates are subjected to a greater requirement for primary bone healing. Because the natural response of bone is to heal secondarily, this theoretically creates an unfavorable healing environment that favors nonunion (11,12). In the present study, we describe our experience using a highly rigid locking plate construct, the 4.5-mm PERI-LOC ankle fusion locking plate (Smith & Nephew, Inc., Andover, MA).

Patients and Methods

After obtaining institutional review board approval from our institution, we retrospectively reviewed the medical records of 16 patients who had undergone tibiotalocalcaneal, tibiotalar, or tibiocalcaneal arthrodesis with fixation using the 4.5-mm PERI-LOC ankle fusion locking plate (Smith & Nephew) from January 2013 to January 2014. One patient was excluded because of the lack of follow-up data. Of the 15 patients, 7 were male and 8 were female. The data collected from the medical records included basic demographic data, initial presentation, medical and surgical history, surgical procedures, operative and postoperative course, and the clinical and radiographic follow-up findings. Positive rheumatologic status was defined as a diagnosis of systemic lupus erythematosus, rheumatoid arthritis, or other rheumatologic disease. All patients underwent a standardized nonoperative management protocol before surgery that included the use of orthotics, custom-made ankle braces, shoe modification, physical therapy, and activity modification. After 3 to 6 months of conservative management, all these patients chose surgical management with 1 of 2 senior foot and ankle fellowship-trained orthopedic surgeons (A.S.).

Surgical Technique

After adequate sedation using general anesthesia, the patients were positioned supine with elevation of the ipsilateral hip using surgical bone foam. A tourniquet was placed on the upper thigh and inflated to 300 mm Hg. An incision was made laterally overlying the fibular, and curving anteriorly along the fourth ray. Subcutaneous dissection followed, with development of full-thickness skin flaps. Care was taken to preserve the superficial peroneal nerve in the proximal aspect of the incision. The fascia was then incised for visualization of the fibula. An oblique osteotomy was then performed just proximal to the level of the syndesmosis, and the distal fibular fragment was removed and morselized for later bone grafting.

Next, we began joint preparation by denuding the articular surfaces of the tibiotalar and subtalar joints until subchondral bone was visualized. Microfractures were created by drilling through the subchondral bone in several locations. Large bone deficits were filled with allograft and/or autograft. The fully prepared joints were then aligned under fluoroscopic guidance, with the hindfoot in a neutral to slight valgus position and the midfoot and forefoot in a plantigrade position. Satisfactory alignment was immobilized using Kirschner wires. The PERI-LOC locking plate (Smith & Nephew) was placed laterally across the joint spaces to be fused and fastened using a combination of cortical and locking screws. The number of screws placed in the plate ranged from 6 to 8. Of the 15 cases, 8 had augmentation screws placed outside the locking plate. In 6 cases, these crossed the tibiotalocalcaneal joints and in the other 2 were placed either across the tibiotalar or talocalcaneal joint. Once fixation was completed, absorbable sutures were used for fascial and subcuticular closure. Skin closure was accomplished using interrupted nylon sutures. Next, the patients were placed in a posterior slab and ankle stirrups plaster splint.

Postoperative Care

The patients were instructed to remain non-weightbearing for a period of ≥8 weeks. All the patients were seen at 2 weeks postoperatively for a wound check and suture removal. The patients were evaluated clinically and radiographically at 6 weeks and 3, 6, 9, and 12 months postoperatively to assess for bony union across the fusion site (Figs. 1–5). Successful union was defined as the presence of ≥3 bridging cortices across the fusion site on the radiograph obtained at the sixth month postoperative visit. Radiographic nonunion in itself was not categorized as a failure unless implant failure had occurred or revision surgery was required. A computed tomography (CT) scan was performed in 5 cases of suspected nonunion. For the cases of frank nonunion or hardware failure, a CT scan was deemed unnecessary.

Statistical Analysis

Using SPSS, version 24.0, statistics software (IBM Corp., Armonk, NY), we examined the overall union rates in these patients and the effects of smoking, diabetes, and rheumatologic status on the failure rate using the Fisher exact test. The patients were stratified into 1 of 3 age classes of 29 to 44, 45 to 60, and 61 to 76, with 5, 6, and 4 patients in each age class, respectively. The effect of this age stratification on the failure rate was examined using a χ^2 test of independence. Binary logistic regression was used to determine the odds ratios for failure stratified by smoking, diabetes, and rheumatologic status. Statistical significance was defined at the 5% level ($p < .05$).

Results

The mean patient age was 51.4 ± 13.87 years. The mean body mass index was 32.5 (range 20.6 to 41.4) kg/m^2. The mean follow-up period was 17.5 ± 5.3 (minimum 12) months. Of the 15 patients, 4 (26.7%) were smokers, 4 (26.7%) had diabetes, and 4 (26.7%) had rheumatologic disease. Of the 15 cases 11 (73.3%) failed to achieve union. Also, 5 (33.3%) of the 15 surgeries were revision cases, of which 4 (26.7%) did not achieve union (Table 1). The average time from presentation to surgery was 22.9 ± 13.8 weeks, and this did not differ between the success (29.5 ± 18.4 weeks) and failure (20.2 ± 11.6 weeks) groups ($p = .27$). Similarly, the 2 groups did not differ in mean age (52.5 versus 51.0 years), proportion with diabetes (25% versus 27%), smokers (25% versus 27%), or positive rheumatologic status (25% versus 27%; Table 2). The average time to failure was 10.2 ± 5.3 months. Patient comorbidities included diabetes in 4 (26.7%) patients, Charcot neuroarthropathy in 2 (13.3%), systemic lupus erythematosus in 2 (13.3%), rheumatoid arthritis in 3 (20%), and neuropathy in 3 (20%) patients (Table 3). Complications other than nonunion included hardware failure (with screws and/or plate fracture; Fig. 4) in 1 (6.7%) patient, osteomyelitis in 1 (6.7%), septic arthritis in 1 (6.7%), and wound infection in 2 (13.3%) patients. Two (13.3%) patients required transtibial amputation for chronic infected nonunion (Table 4).

Fisher's exact test (or the χ^2 test when applicable) revealed that age class, gender, smoking, diabetes, use of augmentation screws, and

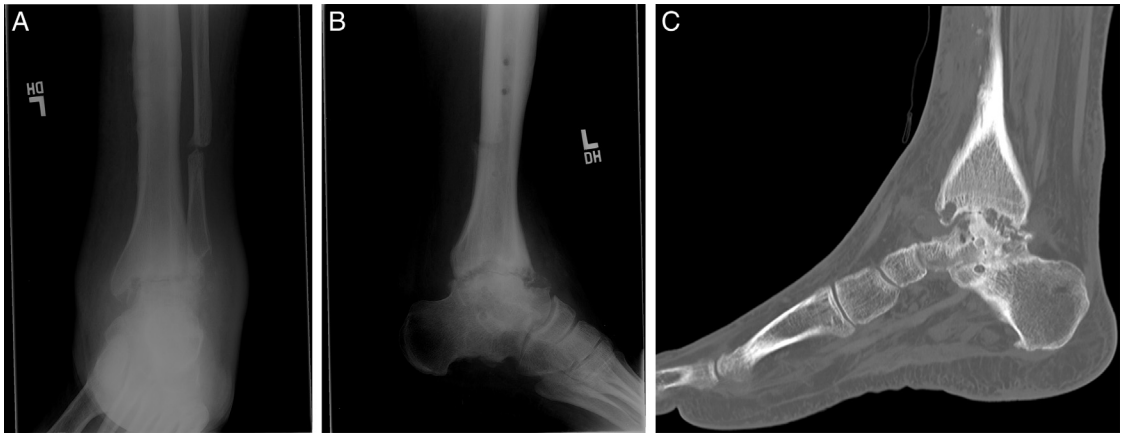

Fig. 1. (*A*) Preoperative anteroposterior radiograph of patient 15. (*B*) Preoperative lateral radiograph of patient 15. (*C*) Preoperative computed tomography scan of patient 15.