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Biomechanical Evaluation of Plate Versus Lag Screw Only Fixation of Distal Fibula Fractures

Amirhossein Misaghi, MD [1], Josh Doan, MEng [2], Tracey Bastrom, MA [3], Andrew T. Pennock, MD [4]

[1] Orthopedic Resident, Department of Orthopaedic Surgery, University of California, San Diego, CA
[2] Biomechanical Engineer, Orthopedic Biomechanics Research Center, San Diego, CA
[3] Program Manager, Division of Orthopedics, Rady Children's Hospital, San Diego, CA
[4] Orthopedic Surgeon, Rady Children's Hospital and University of California, San Diego, CA

A R T I C L E I N F O

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A B S T R A C T

Traditional fixation of unstable Orthopaedic Trauma Association type B/C ankle fractures consists of a lag screw and a lateral or posterolateral neutralization plate. Several studies have demonstrated the clinical success of lag screw only fixation; however, to date no biomechanical comparison of the different constructs has been performed. The purpose of the present study was to evaluate the biomechanical strength of these different constructs. Osteotomies were created in 40 Sawbones® distal fibulas and reduced using 1 bicortical 3.5-mm stainless steel lag screw, 2 bicortical 3.5-mm lag screws, 3 bicortical 3.5-mm lag screws, or a single 3.5-mm lag screw coupled with a stainless steel neutralization plate with 3 proximal cortical and 3 distal cancellous screws. The constructs were tested to determine the stiffness in lateral bending and rotation and failure torque. No significant differences in lateral bending or rotational stiffness were detected between the osteotomies fixed with 3 lag screws and a plate. Constructs fixed with 1 lag screw were weaker for both lateral bending and rotational stiffness. Osteotomies fixed with 2 lag screws were weaker in lateral bending only. No significant differences were found in the failure torque. Compared with lag screw only fixation, plate fixation requires larger incisions and increased costs and is more likely to require follow-up surgery. Despite the published clinical success of treating simple Orthopaedic Trauma Association B/C fractures with lag screw only fixation, many surgeons still have concerns about stability. For noncomminuted, long oblique distal fibula fractures, lag screw only fixation techniques offer construct stiffness similar to that of traditional plate and lag screw fixation.

Ankle fractures are among the most common fractures treated by orthopedic surgeons, with an incidence reported as high as 248 cases per 100,000 person-years (1,2). Unstable ankle fractures are often treated with open reduction and internal fixation to maintain anatomic alignment, allow early motion, and reduce the risk of subsequent arthritis (3–5). Surgical intervention, however, is not without risk. The complication rates for operatively treated closed ankle fractures have been reported to be 5% to 40% (6,7).

Traditional rigid internal fixation of fibula fractures involves lateral plating, which can result in a symptomatic subcutaneous plate that necessitates a second surgery for plate removal (8,9). Attempts to obtain rigid internal fixation while avoiding prominent lateral plating include posterolateral plating, intramedulary fixation, and bioabsorbable fixation (10–13). However, these methods also have drawbacks, such as peroneal tendonitis, the inability to control length and rotation, and inflammatory reactions. Lag screw only fixation has been described as an alternative to plate fixation and has been shown to have excellent results clinically when used for appropriate fracture patterns. The proposed advantages of this technique include its lower likelihood of wound complications owing to the smaller incision, a lower risk of symptomatic implants, and, ultimately, a reduced need for a second surgery to remove the implants (8,14,15).

Although good clinical results have been reported with lag screw only fixation of Webber B/C oblique fibula fractures, it remains an uncommon treatment method at many institutions, including our own (8,14,15). Previous studies have not reported on the biomechanical data comparing lag screw only fixation with the reference standard of lateral plating with a single lag screw. We sought to perform a biomechanical analysis of traditional lateral plating

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Address correspondence to: Andrew T. Pennock, MD, Department of Orthopedics, Rady Children's Hospital, 3030 Children's Way, Suite 410, San Diego, CA 92123.
E-mail address: apennock@rchsd.org (A.T. Pennock).

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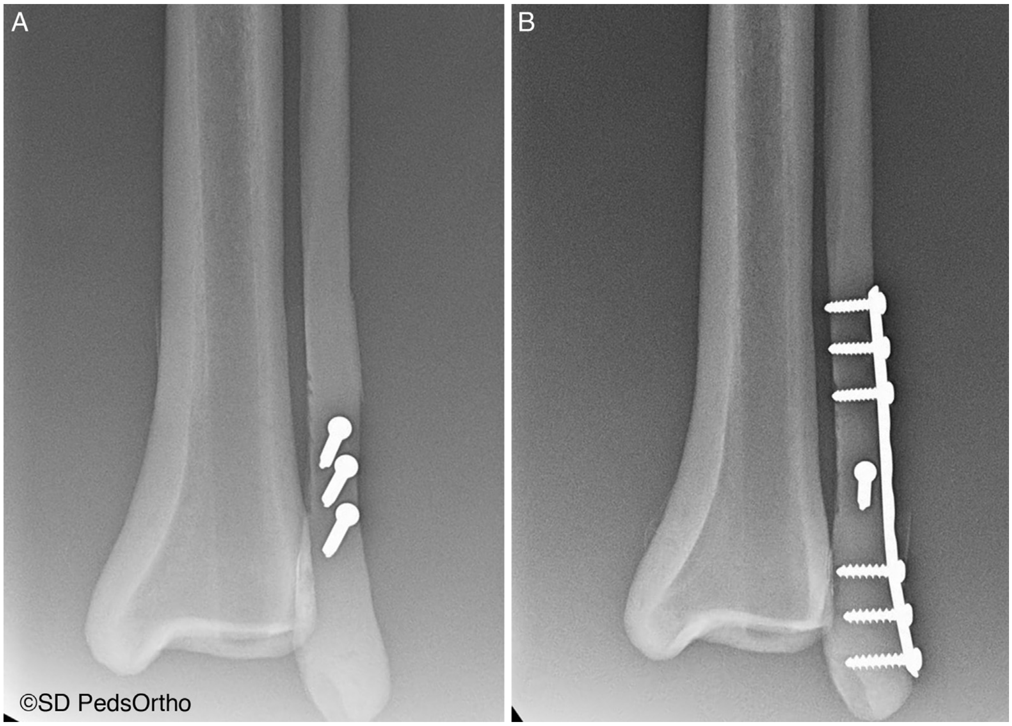

Fig. 1. (*A* and *B*) Screw fixation constructs used to reduce the osteotomies.

compared with lag screw only fixation using an oblique fibula fracture model.

Materials and Methods

Using a custom jig, standardized distal fibula osteotomies were created in 40 Sawbones® (catalog no. 1127, Pacific Research Laboratories Inc, Vashon, WA), simulating a 4-cm-long oblique, anteroinferior to posterosuperior, Weber B/C ankle fracture. The Sawbones® were divided into 4 treatment groups, and the osteotomies were reduced using either 1 bicortical 3.5-mm stainless steel lag screw (1 LS), 2 bicortical 3.5-mm lag screws (2 LSs), 3 bicortical 3.5-mm lag screws (3 LSs), or a single 3.5-mm lag screw coupled with a one third tubular 9-hole stainless steel neutralization plate with 3 proximal cortical and 3 distal cancellous screws (LSNP) (Synthes USA, Paoli, PA) (Fig. 1). All lag screws were placed 1 cm apart, equidistant from the osteotomy edges and orthogonal to the osteotomy. The fibulas were secured with a custom rig to an MTS 858 Bionix testing machine (MTS Systems, Eden Prairie, MN) for biomechanical testing (Fig. 2). First, a nondestructive lateral bending test was performed on each specimen to determine the stiffness in lateral bending. For this test, the proximal end of the fibula was attached to a linear actuator, and the distal end was supported by a pin attached to a load cell, with the distance between supports standardized at 60 mm. The load-displacement data were monitored at 95 Hz, and the proximal end of the fibula was displaced 3 mm at 0.5 mm/s. The slope of the load-displacement curve was calculated to yield the lateral bending stiffness (N/mm). Next, each fibula was loaded to failure in rotation. For this test, the proximal end of the fibula was attached to a rotary actuator and the distal end was fixed to a torsion cell, with the distance between the supports again standardized at 60 mm. Load-displacement data were monitored at 95 Hz, and the proximal end of the fibula was rotated at 2° per second until failure. Failure was defined as a fibula fracture or a decrease in maximum force, whichever came first. The initial slope of each load-displacement curve was calculated to yield rotational stiffness (Nm/°). The maximum load achieved (Nm) before failure was also reported for each fibula.

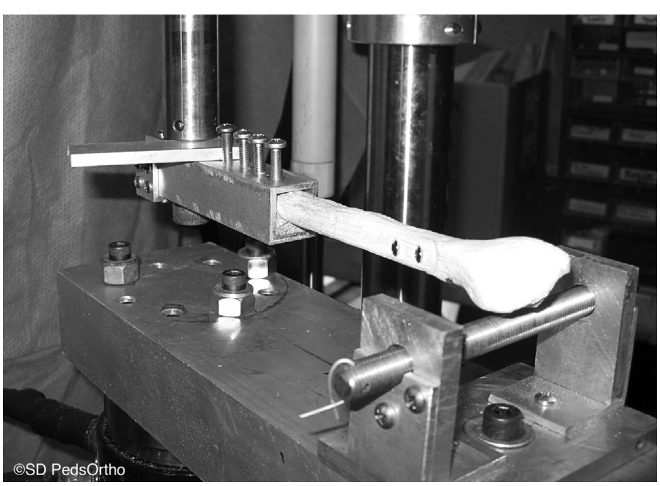

Fig. 2. The MTS 858 Bionix testing machine used for biomechanical testing.

Analyses of variance with Bonferroni post hoc comparisons were used to compare the differences in the 3 biomechanical parameters among the 4 construct groups. The data were checked for normality and homogeneity of variances. In the case of any violations of these assumptions, the nonparametric median test was used. Statistical analyses were performed using the Statistical Package for Social Sciences, version 12 (SPSS Inc, Chicago, IL). Alpha was set at $p \leq .05$ to determine significance. A post hoc power analysis was performed to determine the magnitude of the difference in stiffness that the present study was adequately powered to detect.

Results

The descriptive results are listed in the Table. A significant main effect in lateral bending stiffness and rotation stiffness was found ($p < .001$). The post hoc analysis revealed no significant differences between the LSNP or 3 LSs in lateral bending stiffness ($p > .10$). No significant difference was detected in the post hoc analysis among the 2 LSs, 3 LSs, or LSNP in rotational stiffness ($p > .10$). One LS fixation resulted in significantly less stiffness than 2 LS, 3 LS, and LSNP fixation in lateral bending and rotation ($p < .001$). All constructs were rotated to failure, and a main effect of maximum torque was observed ($p < .001$). Post hoc testing demonstrated no significant differences in the failure maximum torque among 2 LS, 3 LS, and LSNP fixation. The mean maximum torque in the 1 LS group was significantly lower than that in the 2 LS, 3 LS, and LSNP groups ($p < .001$). The power analysis revealed that the present study was adequately powered to detect a