Foot and Ankle Surgery 22 (2016) 158–163

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Comparison of modern locked plating and antiglide plating for fixation of osteoporotic distal fibular fractures

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ARTICLE INFO

Article history:
Received 15 March 2015
Received in revised form 21 May 2015
Accepted 24 June 2015

Keywords:
Fibula
Fixation
Osteoporosis
Antiglide
Locked plating

ABSTRACT

Background: Fractures in osteoporotic patients can be difficult to treat because of poor bone quality and inability to gain screw purchase. The purpose of this study is to compare modern lateral periarticular distal fibula locked plating to antiglide plating in the setting of an osteoporotic, unstable distal fibula fracture.

Methods: AO/OTA 44-B2 distal fibula fractures were created in sixteen paired fresh frozen cadaveric ankles and fixed with a lateral locking plate and an independent lag screw or an antiglide plate with a lag screw through the plate. The specimens underwent stiffness, cyclic loading, and load to failure testing. The energy absorbed until failure, torque to failure, construct stiffness, angle at failure, and energy at failure was recorded.

Results: The lateral locking construct had a higher torque to failure ($p = 0.02$) and construct stiffness ($p = 0.04$). The locking construct showed a trend toward increased angle at failure, but did not reach statistical significance ($p = 0.07$). Seven of the eight lateral locking plate specimens failed through the distal locking screws, while the antiglide plating construct failed with pullout of the distal screws and displacement of the fracture in six of the eight specimens.

Conclusion: In our study, the newly designed distal fibula periarticular locking plate with increased distal fixation is biomechanically stronger than a non-locking one third tubular plate applied in antiglide fashion for the treatment of AO/OTA 44-B2 osteoporotic distal fibula fractures.

Level of evidence: V: This is an ex-vivo study performed on cadavers and is not a study performed on live patients. Therefore, this is considered Level V evidence.

1. Introduction

An unstable ankle fracture has been shown to be an indication for open reduction and internal fixation in order to lower the risk of posttraumatic arthritis secondary to abnormal loading [1]. Overall, this has been associated with good surgical outcomes [2]. When occurring in osteoporotic bone, these fractures can be difficult to treat because of poor bone quality and inability to gain screw purchase [1].

There have been a variety of implants described to treat distal fibula fractures, including lateral non-locking plates, lateral locking plates, and posterolateral antiglide plating. Lateral application of a plate on the distal fibula is typically in neutralization mode after the placement of a lag screw across the fracture site. On the posterolateral surface, the plate is applied directly over the proximal apex of the fracture, in antiglide fashion. Lag compression can be achieved by inserting a lag screw through the plate in a posterior-to-anterior direction. Given these options, it is important for the treating surgeon to consider methods of fixation that will maximize the stability of anatomic reduction while minimizing complications.

Locked plating has been used in the treatment of metaphyseal fractures when there is a short distal end segment that limits the options for screw fixation, such as in the distal fibula. There is some

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http://dx.doi.org/10.1016/j.fas.2015.06.007
1268-7731/

evidence that the biomechanical effectiveness of lateral locking plate fixation is independent of bone mineral density (BMD) while non-locking lateral plate fixation is dependent on BMD [3]. However, when compared to antiglide plates in a cadaveric model that was tested in torsion, Minihane et al. suggests that lateral locking plates are biomechanically inferior in the setting of osteoporotic distal fibula fractures [4]. Additionally, antiglide plating has demonstrated its effectiveness in the setting of osteoporotic distal fibula fractures [5].

Antiglide plating has long been associated with tendon irritation and high rates of hardware removal [6]. Prior studies demonstrating the superior function of posterolateral non-locking antiglide fixation, such as that by Minihane et al., utilized a locking one third tubular plate in their comparison, which only provided two points of fixation in the distal segment [4]. However, more recently Zahn et al. have shown that anatomically contoured distal fibular locking plates are biomechanically superior to non-locking lateral plates in a cadaveric model [7]. By increasing the distal fixation with modern locked plating, this may decrease the rate of peroneal irritation while providing a construct that may exhibit biomechanical superiority, especially in patients with poor bone quality.

The purpose of this study was to evaluate an anatomically contoured distal fibular lateral locking plate that utilizes increased distal fixation and compare it to non-locked antiglide plating in unstable, osteoporotic distal fibula fractures. Prior to the study, we believed that there would be no difference in the construct stiffness, failure strength, and energy absorbed in the failure test between the lateral periarticular distal fibula locked plating to the antiglide plating.

2. Materials and methods

2.1. Specimen preparation

Eight paired (sixteen total) fresh frozen cadaveric ankle specimens were obtained from the mid-tibia to the foot and stored in a freezer at −20 °C. All specimens were Caucasian females over the age of 75. The average age of the specimens was 86 years old (range 75–94). Prior to dissection and experimentation, all specimens were thawed for 24 h at room temperature in a cooler. None of the specimens had any prior ankle surgery or deformity. BMD values were obtained for all specimens using dual-energy X-ray absorptiometry scans of the calcaneus (Hologic Explorer, Bedford, MA).

Preparation of the specimens started with dissection of the proximal 5 cm to expose the tibia and fibula. The fibula was secured to the tibia with a 3.5 mm fully threaded cortical screw, maintaining the interosseous distance between the tibia and fibula. This is consistent with prior studies done at our institution, and could find no evidence in prior biomechanical literature to suggest that this affected our ankle stability. Next, the fibula was resected proximal to the screw placement in order to allow placement of the tibia into the apparatus. An ankle fracture was then simulated to reproduce a Weber B or Supination-External Rotation (SER) IV deltoid equivalent [8] type of ankle fracture (AO/OTA 44-B2). The distal fibula was exposed, and the skin and subcutaneous tissues were removed to provide adequate exposure. The anterior and posterior tibiofibular ligaments were identified and sectioned. Next, the medial skin and subcutaneous tissues were removed, and the deltoid ligament was identified and sectioned. Lastly, a distal fibula fracture was simulated with the use of an oscillating saw to create an oblique osteotomy. The osteotomy started distally and anteriorly at the level of the tibiotalar joint, and was directed proximally and posteriorly at an angle of 60° to simulate a typical fracture orientation (Fig. 1A).

Fig. 1. (A) Exposure and preparation of distal fibula for testing; (B) Fixation with the antiglide plate and lag screw through the plate; (C) Fixation with the lateral periarticular locking plate and independent lag screw.

Each pair of specimens was then randomized to one construct on one side of the ankle using the posterolateral antiglide plate and the contralateral side using the lateral locking plate.

2.2. Surgical technique

All cadaveric surgery work was done by a senior level orthopaedic resident and the fractures were anatomically reduced and fixed in the following, standardized manner. For the antiglide plating group, a 5-hole one-third tubular plate (Synthes, Paoli, PA) was used. The plate was placed posterolaterally and secured with two 3.5 mm bicortical screws proximal to the fracture, a 3.5 mm bicortical lag screw placed through the plate starting distal to the fracture, and a unicortical 4.0 mm fully threaded cancellous screw in the most distal hole of the plate (Fig. 1B) [9]. These plates were minimally contoured to ensure an antiglide/buttress effect. For the lateral locking plate group, a six hole VariAx ® (Stryker, Mahwah,