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Biomechanical comparison of a lateral polyaxial locking plate with a posterolateral polyaxial locking plate applied to the distal fibula

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ABSTRACT

Background: Polyaxial locking plates are becoming popular for the fixation of distal fibula fractures. This study establishes how construct stiffness and plate loosening, measured as range of motion, differs between lateral and posterolateral plate location.

Methods: Seven matched pairs of cadaver fibulae were osteotomized in standardized fashion to produce a Weber type B distal fibula fracture. The fragments were fixated with an interfragmentary lag screw and polyaxial locking plates, with one fibula in each pair receiving a posterolateral anti-glide-plate, and the other a lateral neutralization-plate. In a biomechanical test, the bending and torsional stiffnesses of the constructs and the ranges of motion (ROM) were measured and subjected to a paired comparison.

Results: The laterally plated group had a higher median (interquartile range) bending stiffness (29.2 (19.7) N/mm) and a smaller range of motion (2.06 (1.99) mm) than the posterolaterally plated group (14.6 (20.6) N/mm, and 4.11 (3.28) mm, respectively); however, the results were not statistically significant ($p_{\text{bending}} = 0.314$; $p_{\text{ROM}} = 0.325$). Similarly, the torsional stiffness did not differ significantly between the two groups (laterally plated: 426 (259) N mm/°; posterolaterally plated: 248 (399) N mm/°; $p_{\text{torsion}} = 0.900$). The range of motion measurements between the two groups under torsional loading were also statistically insignificant (laterally plated: 8.88 (6.30) mm; posterolaterally plated: 15.34 (12.64) mm; $p_{\text{ROM}} = 0.900$).

Conclusion: In biomechanical cadaver-model tests of Weber type B fracture fixation with polyaxial locking plates, laterally plated constructs and posterolaterally plated constructs performed without significantly difference. Therefore, other considerations, such as access morbidity, associated injuries, patient anatomy, or surgeon's preference, may guide the choice of plating pattern. Further clinical studies will be needed for the establishment of definitive recommendations. *Clinical relevance*: Information on the behavior of polyaxial locking plates is relevant to surgeons performing internal fixation of distal fibula fractures.

1. Introduction

Ankle fractures are among the most frequently encountered fractures in orthopedic practice [1]. The fractures are common also in elderly subjects [2] and their incidence may be expected to rise as the general population ages [3]. Undisplaced fractures below the level of the syndesmosis tend to respond well to conservative management, whereas displaced fractures at or above the level of the syndesmosis will require surgery [1,4]. As people live longer, risk factors for ankle fractures, and the prevalence of comorbidities such as diabetes and peripheral artery disease, will rise [5–9]. However, the expectations and the activity levels of today's geriatric patients are higher than in the past [10–13] and there is now a demand for operative treatment.

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For the operative management of uncomplicated fibula fractures at the level of the syndesmosis, many different techniques have been published [14–19]. Fixation with an interfragmentary lag screw plus a lateral neutralization plate, and fixation with an interfragmentary lag screw plus a posterolateral anti-glide plate have become established techniques [1]. The anti-glide plate has been shown to be biomechanically superior to the neutralization plate [19,20] without providing greater clinical benefit [20,21]. Usually surgery is followed from 6 to 8 weeks non-weight bearing of the injured leg. For treating geriatric patients primary full-weight bearing is claimed to prevent immobilization [22]. Referring to this biomechanical properties have to be improved, whereupon modern locking plates seems to be advantageous and should be investigated systematically.

Over the past years, modern polyaxial locking devices have proved clinically useful [22]. Several studies have been published regarding the biomechanical behavior of contemporary locking plates applied to the distal fibula. However, to the authors' knowledge, there has been no comparison between a lateral locking plate and a locking anti-glide plate. The present study was performed to establish whether the proven biomechanical superiority of the anti-glide plate over the lateral neutralization plate would also apply where the anti-glide plate used was of the locking design. We hypothesized that the known biomechanical advantages of the anti-glide plate would be even more pronounced with a locking, rather than a conventional, plate.

2. Materials and methods

The approval of the Ethics Committee was obtained prior to the initiation of the study.

2.1. Specimens

The present study performed using a matched – pairs design on the basis of 7 pairs of fresh-frozen human fibulae. The bones had been harvested from five female and two male donors; the median donor age was 79 years (range, 64–87 years). The specimens were thawed at room temperature, and stripped of their soft tissues. Next, they were cut to a length of 13 cm, and osteotomized in standardized fashion to produce a simple oblique Weber type B fracture starting anteriorly at a point 30 mm proximal to the tip of the fibula and extending in a posterior direction, at an angle of 55° (see Fig. 1).

2.2. Implants

The plates and screws used in this study were part of the VariAx Fibula Locking Plate System (Stryker Leibinger GmbH & Co. KG, Freiburg, Germany). In this system, both the (posterolateral) straight plates and the lateral plates are made of commercially pure (CP) titanium, while the locking screws and the non-locking screws are made of titanium alloy (Ti–6Al–4V), which is slightly

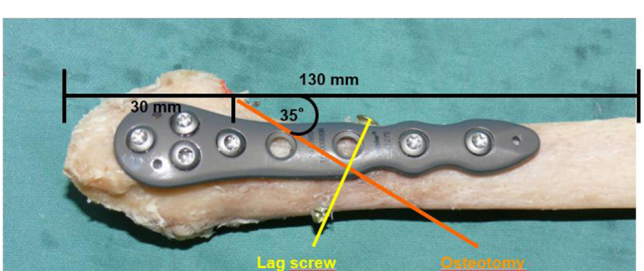

Fig. 1. Fracture model (showing lateral plate, with independent lag screw fixation).

Fig. 2. Posterolateral plate (straight plate). This plate has one elongated oblong hole for through-the-plate insertion of an interfragmentary lag screw.

harder than the plates. All (locking as well as non-locking) screws have an outer shaft diameter of 3.5 mm. The titanium alloy locking screws feature a threaded head which, upon insertion, deforms the softer CP titanium plate to achieve secure locking over a polyaxial angulation range of ±15° respect to the plate. The posterolaterally applied straight plates (Fig. 2) have an elongated oblong hole third from the distal end, which permits through-the-plate lag screw insertion. The lateral plates (Fig. 3) feature a spoon-shaped distal expansion with a cluster of holes. The lateral plate do not provide for through-the-plate placement of a lag screw.

2.3. Constructs

Within each pair of fibulae, the two plate designs were randomly allocated to either the right or the left fibula, with one fibula receiving a lateral plate (neutralization plate), while the contralateral fibula was fixated with a straight plate. In the present study, all the straight plates had overall 6 holes, while all the lateral plates had 4 holes along the plate shaft.

For the fixation of the laterally applied neutralization plate, an independent lag screw was inserted perpendicularly to the osteotomy plane, then a plate was applied over the osteotomy as shown in Fig. 3. For the posterolaterally applied straight plate, an interfragmentary lag screw was placed through the elongated oblong hole as shown in Fig. 2. In this study, all screws were placed at right angles to the plate. In the case of the lateral (neutralization) plates, a custom-made targeting device was used for the placement of the distal locking screws. All the screws used for the attachment of the plates, both to the distal and to the proximal fragment, were 3.5-mm-diameter locking screws. In all cases, screw length was selected to ensure perforation of the opposite cortex of the fibular shaft (proximal fragment). The same applied to the lag screw. Screw length for the distal fragment was selected to ensure attachment of the screw in the opposite cortex without perforating the articular surface.

2.4. Potting and testing

Prior to the potting of the specimens, the osteotomy gap and the parts of the hardware that would subsequently be within the potting cup were covered with an elastic rubber compound. The distal and the proximal ends of the specimens were then placed in cylindrical steel cups matching the jigs of the testing machine, and

Fig. 3. Lateral plate. The construct includes an independent interfragmentary lag screw.