BICORTICAL SCREW FIXATION OF DISTAL FIBULA FRACTURES: AN ANATOMICAL AND BIOMECHANICAL STUDY

*Milner, BF; *Firoozbakhsh, K; ++Mercer, D; *Miller, RA
*University of New Mexico, Albuquerque, NM
dmercer@salud.unm.edu

INTRODUCTION:
Ankle fractures are among the most common injuries seen and treated by orthopedic surgeons. It has been shown that when the distal fibula is involved, anatomic reduction and secure fixation of the lateral malleolus is of key importance to a good outcome. A lateral 1/3 tubular plate and screws are commonly used for fixation of displaced lateral malleolar fractures. Typically, the plate is secured with 3 or 4 bicortical screws in the proximal fragment while at least two screws are placed in the distal fragment in a unicortical manner to avoid intra-articular screw placement into the ankle joint. One disadvantage of this technique is that unicortical screw placement in the primarily cancellous bone of the distal fibula may lead to less than satisfactory fixation, especially when comminution, osteoporosis, or a small distal fragment is present. Because lateral plating is currently one of the most commonly employed and technically easiest method of fixation of distal fibula fractures, and as it is generally recognized that bicortical compared to unicortical screw placement provides stronger fixation, it would be logical to determine if and how bicortical fixation without penetration of the ankle joint can be achieved in the distal fragment with lateral plating of the fibula, which may be advantageous in the treatment of some lateral malleolar fractures. The purpose of this study was to better understand and define the anatomy of the distal fibula, find safe corridors for placement of bicortical screws through a lateral plate in the periaricular region of the distal fibula, determine an improved radiographic view for evaluation of extra-articular screw placement, and determine whether a bicortical screw has a biomechanical advantage over a unicortical screw in this area of the body.

METHODS:
Eight pairs of embalmed and eight pairs of fresh cadaver ankles were used for anatomical consideration. The distal ten centimeters of fibula were dissected and examined. Measurements of articular and non-articular surface area of the medial face were made and three distinct anatomic zones were defined. Another eight pairs of fresh-frozen human cadaver ankles were utilized for biomechanical testing. One specimen from each pair was randomly chosen and 3.5 mm screws were unicortically inserted in the previously identified zone one and zone two using standard technique. In the other specimen from each pair 3.5 mm screws were inserted bicortically along the previously determined safe trajectories. Each specimen was then cemented into a methylmethacrylate mold for mechanical testing. A Bionex model of MTS was used for mechanical testing and the pullout strength was determined at the rate of 1 mm/s. The SAS software package was used for statistical analysis. The paired t-tests was performed to determine statistical differences between unicortical and bicortical screw fixation with p<0.05 considered as significant. The interaction between the cortical factor and the zone factor was also statistically determined. Another pair of cadaver ankles was used for radiographic evaluation of bicortical screw fixation using a lateral malleolus plate. A standard lateral approach was done to the distal fibula, and a four-hole 3.5 mm 1/3 tubular plate was contoured to fit and secured with bicortical screws with one screw in each of the three described zones. The proximal screw hole was left empty. Standard AP, lateral and mortise oblique radiographs were obtained. We also took another AP radiograph with the ankle internally rotated 15 degrees and the x-ray tube angled 45 degrees in a cephalad direction.

RESULTS:
Anatomical Findings: The distal fibula is somewhat spade shaped and the medial border supports the articular surface of the talar-fibular portion of the ankle joint. Unlike most of depictions in many anatomic texts, the articular surface does not make up the majority of the medial distal border of the fibula. In fact, a significant percentage (53.2%) of the surface area of the distal fibula is non-articular cortical bone. It was found that the distal fibula could be divided into three distinct zones based on the geometry of the articulating surface of the medial fibula. Zone I is defined as the distal most 1.5 centimeters of the fibula, the area below the blunt posterior apex of the articular triangle where there is significant non-articular cortical bone posteriorly. Zone II is the next 1 cm of fibula proximal to Zone I, and demarcates the section of bone where the talo-fibular articular cartilage spans nearly the entire anterior to posterior surface of the medial fibula. Zone III is defined as the fibula above the ankle joint, starting at just over 2.5 cm proximal to the tip of the fibula. We were able to define safe trajectories for bicortical screw placement in each of the three zones of the distal fibula. In Zone I, it was found that a screw placed through a plate from the midline lateral surface of the distal fibula and angled posteriorly 10 degrees would miss the articular surface, and terminate in the distal fibular fossa. This was successfully done in 32 out of 32 cadaveric specimens. From anywhere in Zone II, intra-articular screw placement could be avoided by angling the screws at 25 degrees superiorly, and interference with bicortical screws placed in Zone III is avoided by also angling posteriorly 12 degrees. These screws were placed through a midline lateral plate and extra-articular location was confirmed in 32 out of 32 specimens. Bicortical screws in Zone III, defined as proximal to the joint, can be placed directly lateral to medial in the usual manner. Radiographic Findings: It was found that extra-articular placement of these screws in Zone I could be identified using standard ankle radiographs on the AP and mortise views. However, radiographic confirmation of extra-articular placement of the most distal bicortical screw (Zone I) could not be achieved. To assure that none of the screws had violated a neighboring joint space, a new radiographic view was conceived. Specifically, this radiograph of the ankle is taken with the lower extremity internally rotated 15 degrees (similar to the mortise oblique view), and with the x-ray tube angled from caudal to cephalad 45 degrees. In this technique the beam is directly projected up the distal fibular fossa demonstrating positioning of the screw tip within the fossa. Biomechanical Findings: In both zone I and zone II the bicortical screw fixation was significantly stronger than the unicortical screw fixation. In zone I the average pullout strength for the bicortical screw fixation was 2.3 times (250.4 ± 69.6 vs. 108.6 ± 28.4) higher than the unicortical screw fixation (P<0.002). In zone II the average pullout strength for the bicortical screw fixation was 3.3 times (430.7 ± 149.9 vs. 131.3 ± 57.0) higher than the unicortical screw fixation (P<0.0008). Comparing zone I versus zone II for pullout strength, there was statistically no difference between zone I and II for unicortical screw placement (P = 0.426); pullout strength in zone II, however, was significantly higher than in zone I for bicortical screw fixation (P< 0.013). A paired t-test of interaction between cortical factor and zone factor indicated that the difference between the pullout strength of bicortical and unicortical screw fixation is significantly more in zone II than in zone I (P < 0.01).

DISCUSSION:
Complications of lateral plating of distal fibula fractures cited by various authors have included less than satisfactory fixation of the distal fragment. This is likely due to incorrect screw fixation in the mostly cancellous bone of the distal fragment in order to decrease the risk of intra-articular penetration into the ankle joint. This study has shown that bicortical screw fixation is easily and safely obtained with lateral plating of distal fibula fractures, that safe placement of such screws can be readily confirmed via plain radiographs using only one special view in addition to the standard ankle series, and that bicortical screws provide a significant biomechanical advantage over more traditional unicortical distal fibular screws.

ACKNOWLEDGEMENT:
The study was supported by the Dedicated Health Research Funds of the University of New Mexico.