A Divergent Screw Orientation is Superior to a Parallel or Convergent Screw Orientation during the Fixation of Vertical Shear Fractures of the Medial Malleolus

Derek F. Amanatullah, Safdar N. Khan, Shane Curtiss, and Philip R. Wolinsky

University of California at Davis School of Medicine, Department of Orthopaedic Surgery, Sacramento, California
derek.amanatullah@ucdmc.ucdavis.edu

Introduction: Vertical shear fractures of the medial malleolus are thought to result from axial loading of the medial malleolus by the talus during a supination-adduction injury. Anatomic reduction and stable internal fixation are essential for the treatment of intra-articular fractures of the ankle. Stable internal fixation allows early motion of the ankle joint, leads to improved functional outcomes, and has diminished the incidence of post-traumatic arthritis. Multiple fixation techniques for vertical shear fracture of the medial malleolus have been described including: two 4.0 mm cortical, cannulated, or malleolar screws; tension band wiring; and anti-glide screw/plate constructs of varying configurations. Despite this cornucopia of fixation methods, the optimal technique and pattern of the internal fixation used for fixation of a vertical shear fracture of the medial malleolus remains ill-defined. There are no clinical studies that compare the clinical outcomes and complications of these different fixation methods. When presented with limited clinical evidence orthopaedic surgeons must use biomechanical studies to guide their choice of fixation for vertical shear fractures of the medial malleolus. In clinical practice, two 4.0 mm partially threaded cancellous screws placed parallel to each other are often used. However, there is no biomechanical data regarding this common fixation method if the screws happen to be placed in a non-parallel orientation.

Significance: This study assesses the stiffness and load at 2 mm of displacement of three different screw configurations used to stabilize a vertical shear osteotomy of the medial malleolus. We initially hypothesized that a divergent screw configuration would have mechanical advantages over parallel screw configurations.

Methods: Identical vertical osteotomies were created in synthetic distal tibiae using a jig. The specimens were randomly assigned to one of the three fixation groups (n = 8 per group): 1) parallel: two 40 mm length, 4.0 mm diameter screws were placed parallel to each other in the transverse plane; 2) convergent: two 40 mm length, 4.0 mm diameter screws were placed 25° convergent to each other in the transverse plane; and 3) divergent: two 40 mm length, 4.0 mm diameter screws were placed 15° divergent to each other in the transverse plane (Figure 1). The specimens were then tested using offset axial loading at 1 mm/sec until 2 mm of displacement occurred.

Results: The average stiffness was 102 ± 51 N/mm for the parallel group, 109 ± 37 N/mm for the convergent group, and 185 ± 73 N/mm for the divergent group (Figure 2A). The average stiffness of the divergent group was significantly greater than either the parallel (p < 0.05) or convergent (p < 0.05) groups. The divergent group was 81.4% more stiff than the parallel group and 69.7% more stiff than the convergent group. The average load at 2 mm of displacement was 324 ± 87 N for the parallel group, 373 ± 95 N for the convergent group, and 512 ± 170 N for the divergent group (Figure 2B). The average load at failure of the divergent group was significantly (p < 0.05) greater than the parallel groups. The divergent group was required 58.0% more force at 2 mm of displacement than the parallel group.

Conclusion: The use of a divergent screw pattern resulted in a stiffer construct that requires more force for 2 mm of displacement when used to stabilize an osteotomy model of vertical medial malleolus fractures.

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