

Bimalleolar Equivalent Ankle Fracture Joint Contact: Comparison of Two Stabilization Methods

Reed Smith DPM, John Egdorf DPM, Gabriel Roberts MS-4, Tyler Terhune MS-4, Sean T. Grambart DPM, FACFAS

Introduction

When surgically repairing an ankle fracture one goal is to restore the stability of the ankle joint. The osseous injury that occurs during an ankle fracture can be accompanied by a ligamentous injury, specifically to the deltoid ligament complex. Previous research is conflicting and has not come to a universal conclusion whether there is a need to repair the deltoid ligament with ankle fracture fixation to restore ankle stability¹⁻⁸.

Purpose

The purpose of this study is to evaluate measuring the contact area of the ankle joint with different stabilization medial methods of a bimalleolar equivalent ankle fracture.

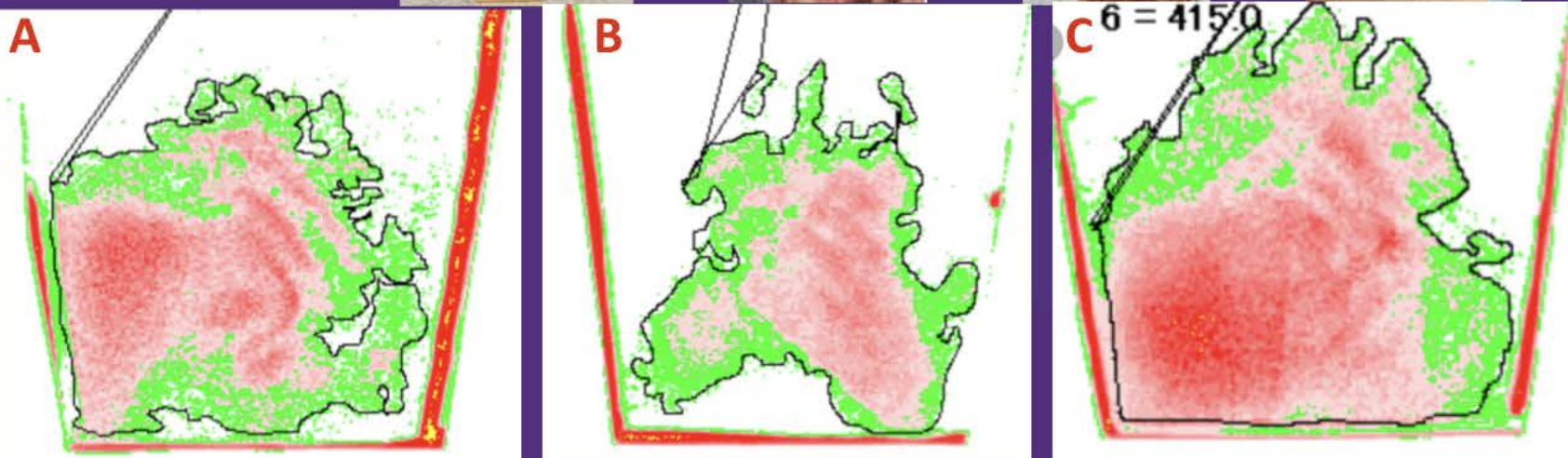
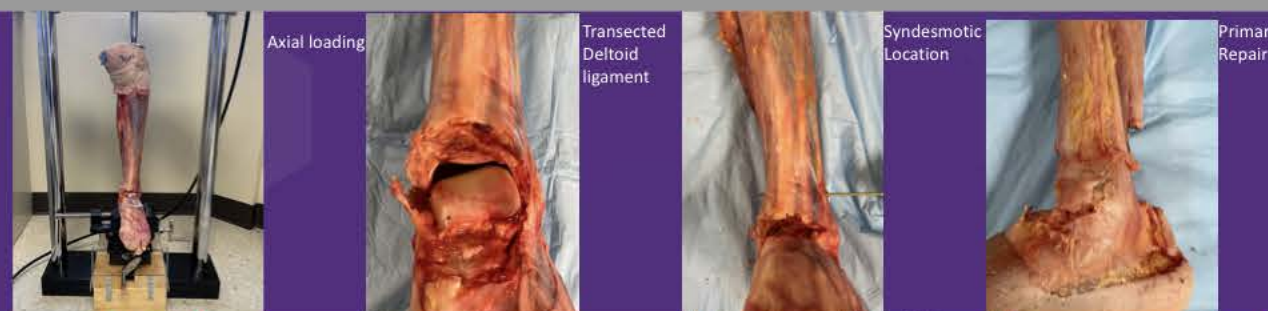
Methods

5 frozen cadavers were utilized for this study. The cadavers were thawed prior to the testing and was dissected to expose the ankle joint with care to preserve the ligamentous structures, fibula, and tibia. Ultra-low contact film was cut to match each of the unique anatomic characteristics of the talus. The film was carefully placed and secured within the ankle joint. An axial load of 100 psi was applied to each ankle under 4 conditions: (1) Normal ankle, (2) transected deltoid ligament off the medial malleolus, (3) transected deltoid ligament off the medial malleolus with a syndesmotic screw through a plate, and (4) direct repair of the deltoid ligament. The ankle joint contact area was tested in the 4 conditions and analyzed using the FujiFilm Pressure Mapping System ©.

Results

Specimen	Average Pressure (Mpa)	Highest Max Pressure (MPa)	Area of High Pressure (areas of red and yellow) (mm2)	Measured Area (mm2)
Intact (Specimen 1)	0.8	3.06	319	477
Intact (Specimen 2)	0.77	2.39	435	513
Intact (Specimen 3)	0.49	1.33	34	106
Intact (Specimen 4)	0.94	3.06	153	229
Intact (Specimen 5)	0.36	0.91	2	61
Intact Specimen Averages	Average Pressure (Mpa): 0.6	Average Max Pressure (Mpa): 2.15	Average Area of High Pressure (mm2): 188.6	Average Measured Area (mm2): 265.2
Syndesmotic screw (Specimen 1)	0.91	3.06	581	802
Syndesmotic screw (Specimen 2)	0.96	3.06	211	327
Syndesmotic screw (Specimen 3)	0.49	1.08	38	108
Syndesmotic screw (Specimen 4)	0.65	2.18	134	252
Syndesmotic screw (Specimen 5)	0.48	1.18	10	47
Syndesmotic Screw Averages	Average Pressure (Mpa): 0.70	Average Max Pressure (Mpa): 2.11	Average Area of High Pressure (mm2): 194.8	Average Partial Measured Area (mm2): 307.2
Direct Repair (Specimen 1)	0.83	2.18	498	685
Direct Repair (Specimen 2)	0.65	1.63	185	350
Direct Repair (Specimen 3)	0.38	1.22	1	50
Direct Repair (Specimen 4)	0.46	1.2	10	79
Direct Repair (Specimen 5)	0.37	0.68	1	34
Direct Repair Averages	Average Pressure (Mpa): 0.54	Average Max Pressure (Mpa): 1.38	Average Area of High Pressure (mm2): 139	Average Partial Measured Area (mm2): 239.6

Figures



Contact Area Pressures
A. Normal Ankle
B. Primary Repair Deltoid Ligament
C. Transsyndesmotic Screw Fixation

Discussion

Much of the recent debates on ankle fracture surgical repair stems around whether or not the direct repair of the deltoid ligament is required or not. While studies that evaluate long-term outcomes do not show a significant difference, studies that evaluated patients in the short-term show favorable patient outcomes with repair of the deltoid. Our study demonstrated that the primary repair of the deltoid ligament more closely represented the average contact pressure of the normal ankle compared to syndesmotic screw placement. The highest maximum pressure was comparable to the normal ankle in the syndesmotic screw placement but the total areas of highest pressure and total area measured were elevated with the syndesmotic screw specimens compared to the normal ankle. The deltoid ligament repair was lower compared to the normal ankle in all of the pressures and areas.

Conclusion

This cadaveric study shows that the contact pressure and areas are elevated with the syndesmotic screw stabilization compared to the normal ankle and the specimens that underwent primary repair of the deltoid ligament. The authors speculate that these elevated pressures can lead to the risk of an increase contact area and potential post-traumatic arthrosis developing. Further research is needed for this widely debated topic.

References

1. Cooper MT. The Role of Deltoid Repair and Arthroscopy in Ankle Fractures. *Clin Sports Med.* 2020; 39(4):733-43.
2. Cavanaugh ZS, Gupta S, Sathe VM, Geaney LE. Initial Fibular Displacement as a Predictor of Medial Clear Space Widening in Weber B Ankle Fractures. *Foot & ankle international.* 2018; 39(2):166-71.
3. van den Bekerom MPJ, Mutsaerts ELAR, van Dijk CN. Evaluation of the integrity of the deltoid ligament in supination external rotation ankle fractures: a systematic review of the literature. *Archives of Orthopaedic and Trauma Surgery.* 2008; 129(2):227-35.
4. Wu K, Lin J, Huang J, Wang Q. Evaluation of Transsyndesmotic Fixation and Primary Deltoid Ligament Repair in Ankle Fractures With Suspected Combined Deltoid Ligament Injury. *J Foot Ankle Surg.* 2018; 57(4):694-700.
5. Butler BA, Hempen EC, Barbosa M, Muriuki M, Havey RM, Nicolay RW, et al. Deltoid ligament repair reduces and stabilizes the talus in unstable ankle fractures. *J Orthop.* 2020; 17:87-90.
6. Li B, Wang S, Zhang Z, Yang H, Li J, Li Q, et al. Transarticular external fixation versus deltoid ligament repair in treating SER IV ankle fractures: a comparative study. *BMC Musculoskelet Disord.* 2019; 20 (1):453.
7. Hsu A, Lareau C, Anderson R. Repair of Acute Superficial Deltoid Complex Avulsion During Ankle Fracture Fixation in National Football League Players. *Foot & ankle international.* 2015; 36(11):1272-6.
8. Guo W, Lin W, Chen W, Pan Y, Zhuang R. Comparison of deltoid ligament repair and non-repair in acute ankle fracture: A meta-analysis of comparative studies. *PLoS One.* 2021 Nov 12;16(11).

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