The Effect of Screw Fixation Height on Syndesmotic Malreduction: A Cadaveric Study Utilizing Weightbearing Computed Tomography

Mohamad Al Masri, Ronit Avadhuta, Justin Luk, Rohith K Ryali, Mohammad Hossein Chegini-Kord, Lercan Aslan, Jaeyoung Kim, Gregory Richard Waryasz, Soheil Ashkani Esfahani, John Y Kwon

INTRODUCTION:

Syndesmotic malreduction is a well-documented problem negatively impacting outcomes, with a reported incidence approaching 52%. Metal screw fixation remains the most common means of syndesmotic stabilization and placement between 1.5 – 6 cm above the tibial plafond has been traditionally advocated. Despite this, the optimal height for screw fixation remains unclear and its potential effects on syndesmotic malreduction poorly examined in the current literature. As more distal placement may theoretically lead to improved reduction given proximity to the osseous constraints of the incisura, screw height placement may be a modifiable variable to improve syndesmotic reduction. This cadaveric study employed weightbearing computed tomography (WBCT) to evaluate the effects of screw fixation height on syndesmotic alignment in a simulated pronation-external rotation (PER) ankle fracture model. We hypothesized that increasing screw fixation height above the tibial plafond correlates with a higher degree of syndesmotic malreduction.

METHODS: Twelve knee-disarticulated cadaveric specimens underwent simulated pronation-external rotation (PER) ankle fracture injuries, including disruption of the deep deltoid ligament, syndesmosis, and creation of a proximal fibula fracture. A 1/3 tubular plate was secured to the distal fibula, and screw fixation was performed incrementally at 1.5 to 6.5 cm above the tibial plafond. Four fellowship-trained orthopedic foot and ankle surgeons manually reduced the syndesmoses using direct thumb pressure and fixed them with quad-cortical, fully threaded metal screws. Screw insertion followed a standardized protocol replicating clinical technique, with surgeons maintaining approximately 30° of "dropped" hand positioning during drilling. Mean screw angulation and range were recorded across trials to confirm consistency. Post-fixation, weightbearing computed tomography (WBCT) was performed after each trial. Syndesmotic alignment was evaluated using both traditional 2D measurements (translation, rotation, cross-sectional area) and 3D volumetric analyses to assess reduction quality across different screw heights.

RESULTS: Syndesmotic diastasis measurements varied significantly with screw fixation height ($p = 0.035$ for posterior diastasis, $p < 0.0001$ for mid-diastasis, and $p = 0.023$ for anterior diastasis). Fibular rotation and translation also demonstrated significant differences depending on screw height ($p < 0.001$). Syndesmotic volume analyses showed no statistically significant difference between fixation levels ($p = 0.054$), indicating that total volume was not strongly influenced by screw height. However, more proximal fixation levels tended to increase syndesmotic volume and resulted in distal widening, supporting a "see-saw" effect with asymmetric distraction. Although no fixation level completely restored the syndesmosis to its pre-injury state, screw placement at 27 mm above the tibial plafond consistently produced measurements closest to the intact condition across both 2D and 3D analyses. Importantly, there was no significant effect of individual surgeon on the incidence or degree of malreduction across trials.

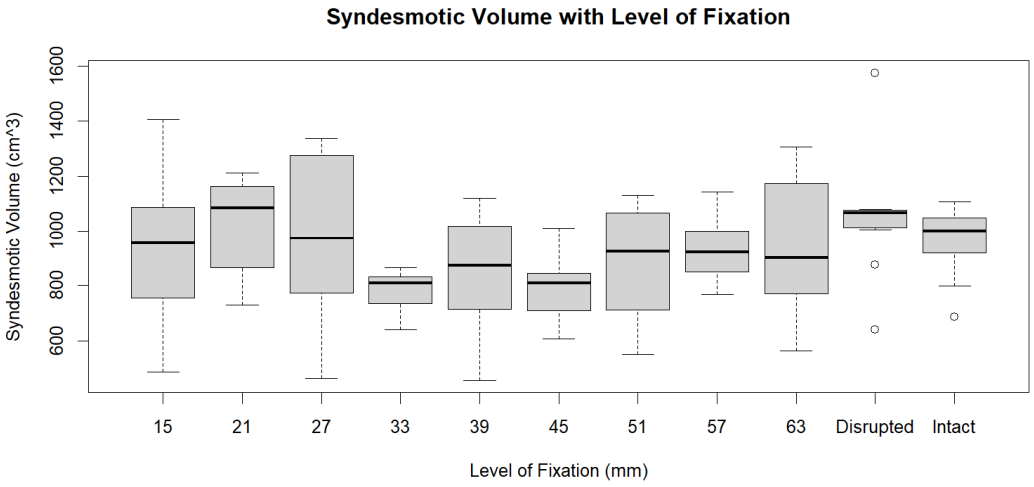
DISCUSSION AND CONCLUSION:

This cadaveric study demonstrates that syndesmotic screw fixation height significantly influences fibular alignment within the tibial incisura. Using a controlled pronation-external rotation injury model and weightbearing CT, we identified progressive malreduction with increasing screw height from 1.5 cm to 6.5 cm above the tibial plafond. Fibular external rotation, anterior translation, and lateral shift all worsened with more proximal fixation, with the highest malreduction rates observed at 5.1 cm and 6.5 cm levels. A fixation height of 2.7 cm most closely restored native alignment across both 2D and 3D metrics.

While prior clinical studies, including those by Yüce et al. and Rooney et al., suggested a relationship between screw height and malreduction, their findings were limited by confounding variables, heterogeneity in fixation constructs, and the absence of within-subject comparison. In contrast, our study isolated screw height as a single variable across identical specimens, using standardized fixation and WBCT imaging to precisely assess syndesmotic position. Moreover, 3D volumetric analysis revealed a “see-saw” effect, in which more proximal fixation acted as a fulcrum, inducing distal syndesmotic widening. This biomechanical insight highlights not only that screw height affects alignment, but also the manner in which malreduction occurs spatially across the syndesmosis.

Importantly, we found that these malreduction patterns were independent of surgeon variability, reinforcing that screw height is a reproducible, modifiable factor. Our data support limiting fixation to within 4 cm of the tibial plafond to reduce the risk of clinically relevant malalignment.

In conclusion, optimal screw height is critical for accurate syndesmotic reduction. Screws placed more than 4 cm above the plafond are associated with increased malreduction due to both angular and translational shifts. When advanced reduction tools such as intraoperative CT or suture button constructs are not available, precise control of screw height offers a simple, cost-neutral strategy to improve alignment and potentially reduce revision rates.


Syndesmotic Volume with Level of Fixation
Syndesmotic Volume (cm^3)
600
800
1000
1200
1400
1600
15
21
27
33
39
45
51
57
63
Disrupted
Intact
Level of Fixation (mm)