Impact of Clamp Placement on Reduction of the Ankle Syndesmosis

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Introduction: The ankle syndesmosis is a critical articulation between the distal tibia and fibula and is comprised of the anterior-inferior tibiofibular ligament (AITFL), interosseous ligament (IOL), interosseous membrane, posterior-inferior tibiofibular ligament (PITFL) and inferior transverse ligament (ITL) [1, 2]. The detrimental effects of syndesmotic malreduction have been documented in the literature [3-5]. An item of continued debate is the effect of clamp placement on accuracy of syndesmotic reduction. A previous cadaveric study demonstrated clamp placement in the anatomic axis of the syndesmosis results in the most accurate reduction of the syndesmosis, but clamps were only placed 10 mm from the tibiotalar joint [6]. The purpose of this study was to analyze the effect of clamp placement on syndesmotic reduction with respect to clamp orientation and location above the tibial plafond.

Methods: Thirteen fresh frozen human cadaveric leg specimens were used for testing (mean 63.8 ± 19.6 years). Each specimen was examined externally and with fluoroscopy to verify absence of orthopedic implants or bony trauma. A through knee amputation was performed on each specimen preserving the stability of the proximal tibiofibular joint. Medial and lateral approaches about the ankle were performed prior to testing. The medial dissection was taken down to the level of the medial malleolus, and the deltoid ligament was exposed, but not sectioned. The lateral dissection was taken down to the lateral malleolus, and the AITFL and PITFL/ITL were exposed. Care was taken during these approaches not to damage the nearby tendons and stabilizing ligaments. Small arthrotomies were made medially and laterally to determine accurate clamp placement locations as measured from the tibial plafond. Each specimen was mounted vertically in a custom built frame. Two Schanz pins were used to stabilize the tibia within the frame. The foot was placed in a neutral position and held in place with a Velcro strap over the midfoot/forefoot and two polymethylmethacrylate supports that stabilized the heel. Beneath the foot plate was an X-Y table that allowed for unconstrained movement of the foot in the transverse plane of the leg. Movement of the fibula in relation to the tibia was quantified using an infrared motion capture system (Optotrak Certus, Northern Digital Inc., Ontario, Canada). One set of infrared markers was placed on the tibia and two more independent sets of markers were placed on the fibula. Virtual points were established 1 cm proximal to the plafond to quantify tibial and fibular movement at the level of the syndesmosis. Measurements were taken with Optotrak in the unstressed, native specimen first. The superficial and deep deltoid ligaments, AITFL, IOL, PITFL/ITL, and interosseous membrane were then sectioned to simulate a pronation-external rotation ankle injury. The interosseous membrane was divided from distal to proximal stopping just distal to the proximal tibiofibular joint. Starting 1 cm proximal to the tibial plafond, the tibia and fibula were clamped with a reduction clamp first in the coronal plane and then 30⁰ oblique to the coronal plane. After each clamp placement, static
measurements were obtained with Optotrak for the tibia and fibula. This was repeated at 2, 3, 4, and 5 cm proximal to the tibial plafond. Data reduction was completed using a custom algorithm written in MATLAB (The MathWorks, Inc., Natick, MA). Calculations solved for a vector originating from the center of the tibia and extending to the center of the fibula at the level of the syndesmosis. Then, it resolved the AP and ML components of the difference between the native unstressed state and each stressed state. AP and ML directions were established with respect to the anatomical position of the tibia prior to testing. A two-way analysis of variance compared the clamp placements using Tukey’s HSD for post hoc detection of statistical significance for clamp orientation and proximal distance from the syndesmosis. Significance level was set at p<0.05.

**Results:** There was a significant difference in fibular displacement in the AP direction between oblique and coronal clamping techniques at every level above the plafond (Figure 1). As a group, coronal clamping significantly displaces the fibula posteriorly compared to oblique clamping (p < 0.001). In addition, coronal clamping significantly displaces the fibula posteriorly when compared with oblique clamping at each level above the plafond (p < 0.001, p < 0.001, p < 0.001, p < 0.01, and p < 0.05 at 1, 2, 3, 4, and 5 cm, respectively). There was not a significant difference in coronal plane fibular displacement between coronal and oblique clamping at any individual level above the plafond. However, as a group, the coronal clamping significantly displaces the fibula more laterally when compared with oblique clamping (p < 0.001) (Figure 2).

**Discussion:** We found that oblique placement of reduction clamps provided a more anatomic reduction of the injured syndesmosis. In addition to providing a less anatomic reduction, coronal placement of reduction clamps was also found to produce greater variability in reduction as implied by larger standard deviations; this could lead to less predictable results. We initially hypothesized that clamp placement closer to the tibial plafond would lead to more accurate syndesmotic reduction. However, our results showed no statistically significant difference between clamping at different levels from the tibial plafond. This may be further investigated in the future with a larger sample size. Lastly, we present a unique method for accurately analyzing the syndesmosis using an infrared motion capture system, which may be used in future cadaveric syndesmotic studies.

**Significance:** Oblique placement of reduction clamps 30 degrees from the coronal plane provides a more accurate syndesmotic reduction as compared to clamp placement in the coronal plane regardless of the level as measured from the tibial plafond.
Figure 1. AP translation of the fibula with respect to the tibia using coronal and 30° oblique reduction. Error bars indicate standard deviation. Statistical significance denoted with asterisks for individual levels above the plafond (p < 0.05). (Negative values indicate posterior translation.)
Figure 2. ML translation of the fibula with respect to the tibia using coronal and 30° oblique reduction. Error bars indicate standard deviation. Statistical significance denoted with asterisks for individual levels above the plafond (p < 0.05). (Negative values indicate lateral translation.)