Evaluating Orthopaedic Surgeon Accuracy and Cognitive Effort when Assessing Center-Center Images for Ankle Syndesmosis Fixation

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INTRODUCTION: Surgical fixation of the distal tibiofibular joint, or ankle syndesmosis, has a high incidence of iatrogenic malreduction, with some studies reporting malreduction in as many as 54% of cases [1]. Malreduction (i.e., malalignment of the fibula and tibia) is associated with poor patient outcomes such as pain, osteoarthritis, joint instability, and revision surgery [2,3]. Previous work addressing malreduction has emphasized novel surgical techniques [4,5]. But focusing on surgical technique alone fails to recognize malreduction as a multi-factorial issue with many potential sources of error. One such source of error is image interpretation. For example, the center-center technique requires intraoperatively evaluating an internally rotated lateral x-ray view to determine if the centers of the fibula and tibia align [4]. Drilling through these aligned centers results in a patient-specific fixation axis through the geometric centers of the tibia and fibula [6]. However, to what extent surgeons can accurately assess the centeredness of the fibula, thereby identifying this patient-specific fixation axis is unknown. The primary objective of this study was to evaluate surgeon accuracy when assessing images of center-center alignment. Secondary objectives involved characterizing the effect of training level, cognitive burden, and visual aid on image interpretation accuracy. We tested the hypotheses that higher training level and inclusion of a visual aid are associated with higher accuracy, while increasing levels of cognitive effort are associated with lower accuracy.

METHODS: Twelve attending orthopaedic surgeons (11 male, 1 female, age: 44 ± 9.4 years, surgical experience: 17.5 ± 9.6 years) and eight residents (8 male, age: 29.6 ± 1.8 years, surgical experience: 4 ± 1 years) participated in this IRB-approved study (University of Florida #202001608). To assess surgeon accuracy in image evaluation, two sets of lateral ankle x-ray images were generated. The image sets were identical with the exception that one set contained a visual aid. In each set, tibiofibular malalignment ranged from -40% to 40% in increments of 10% displacement of the fibula from perfectly centered; each displacement was represented 5 times (n = 45 unique images per set). All images were marked with a horizontal line on the tibia to standardize the anatomical location wherein to evaluate alignment (Fig. 1). The image set with a visual aid was additionally marked with a crosshair at the center of the tibia (Fig. 1, left). Participants were tasked with classifying each image as "centered" or "non-centered" at the height of the horizontal line. Image sets and the images within each set were randomized to control for learning effects. Accuracy of image interpretation, time to interpret each image, and blinks per image, a physiological measure of cognitive burden were recorded. Statistical analyses evaluated the effects of training level (resident vs. attending) and presence of visual aid (crosshair vs. no crosshair) on accuracy, time per image, and blinks per image. Accuracy was analyzed using a Fisher's Exact test. Time per image and blinks per image were separately evaluated using one-way ANOVA followed by multiple comparisons using two-sampled t-test assuming unequal variance.

RESULTS: For both attendings and residents, accuracy for center-center image interpretation was nearly perfect for fibula displacements of 20% or greater in either the anterior or posterior directions (Fig. 2). In contrast, both training levels were poor at discerning 10% fibula displacement (r = 0.8, 95% CI 0.62 to 1.57), with results approximating random chance (median accuracy 50%, IQR 25 to 65%). Importantly, provision of a visual aid (i.e., crosshair) centered on the tibia significantly improved accuracy for images of -10% fibula displacement (34% vs 57%, p=0.002).

Time per image was significantly higher in residents versus attendings both with a crosshair added (5.9 s vs. 3.8s, p = 0.049) and without (6.3 s vs. 4.3 s, p = 0.041) (Fig. 3). Addition of a crosshair did not result in significantly different time per image. Blinks per image were not significantly different between training levels, but a crosshair was associated with significantly lower blinks per image for +10% fibula displacement (0.56 vs. 1.78 blinks, p = 0.029).

DISCUSSION: This study demonstrates that although surgeons can accurately evaluate tibiofibular alignment when the fibula is highly displaced, assessing alignment at small magnitudes of fibular displacements is difficult and results in inaccurate assessment. Notably, when classifying tibiofibular alignment at displacements equal to +/-10%, surgeon accuracy is comparable to random chance, or guessing. The increased blinks per image at this magnitude of displacement indicates that surgeons, regardless of training level, find assessing these images cognitively challenging. This study also provides evidence that a simple visual aid, such as a crosshair, can improve image interpretation accuracy. Future work will assess accuracy of identifying smaller magnitudes of malalignments to better understand the limits of visually evaluating center-center images. Future work will also expand this analysis beyond a computer-based task to a surgical simulation lab or operating room in order to evaluate image interpretation in the context of intraoperative psychomotor multi-tasking.

SIGNIFICANCE/CLINICAL RELEVANCE: Prior work has focused on developing novel surgical techniques instead of robustly analyzing sources of error in syndesmotic fixation. Understanding image interpretation as a source of error can directly inform interventions or trainings to improve surgeon accuracy.

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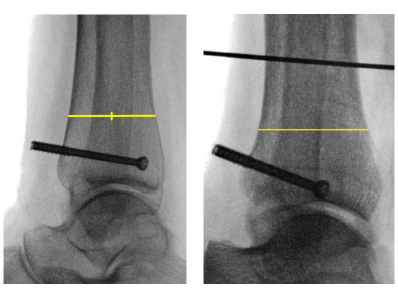

Figure 1. Example of centered (with crosshair, 0% displacement) and non-centered (no crosshair, 40% displacement) x-ray images.

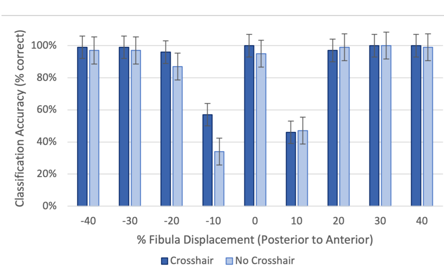

Figure 2. Accuracy of image interpretation with and without visual aid (crosshair) for fibular displacements of -40 to +40%. Error bars are st. error across all participants.

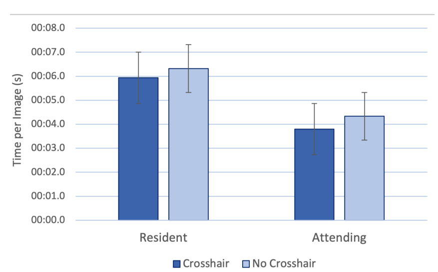

Figure 3. Average time spent interpreting each image by resident and attending surgeons with and without visual aid (crosshair). Error bars are st. error across participants within an image set.