Reducing the Syndesmosis Under Direct Vision: Where Should I Look?

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Objectives: To compare the quality of syndesmotic reduction obtained using the incisura versus the ankle articular surface as the visual cue. Secondarily, we evaluated the difference in the anterior to posterior depth of the fibula to the tibia at the joint level and the fibula to the incisura 1 cm above the joint.

Methods: Seven surgeons reduced disrupted syndesmoses of 10 cadaveric ankles using either the anterolateral articular surface of the distal tibia to the anteromedial fibular articular surface or the location of the fibula within the incisura as a visual reference. Malreductions in translation were measured in millimeter from the anatomical position of the fibula. The anterior to posterior distances of the tibia and fibula were also measured at both levels to determine the differences in their depths.

Results: The translational reduction was within 2 mm in 93% (0.7 ± 0.7 mm) of reductions using the articular surface as a reference compared with 80% (1.2 ± 1.0 mm) using the incisura as a reference (P = 0.0001). All surgeons' reductions were better using the joint articular surface as the visual reference. The difference in the fibular and the tibial depth was smaller at the level of the articular surface versus the incisura (2.1 mm vs. 5.9 mm; P = 0.0002).

Conclusions: The articular surface is a significantly more accurate visual landmark for translational reduction of the syndesmosis. This is potentially explained by the larger differences in the fibula and tibial depth at the incisura versus the articular surface.

Key Words: ankle, syndesmosis, reduction, open

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INTRODUCTION

Injuries to syndesmosis occur in 10% of all patients with fractures about the ankle and in 20%–90% of patients with ankle injuries requiring internal fixation.[1–5] Controversy remains regarding the ideal surgical technique for repairing syndesmotic injuries.[7–13] Regardless of surgical technique, reduction of the syndesmosis is considered critical in obtaining the best functional outcomes for patients with unstable ankle injuries.[12–19] Multiple authors have shown that the quality of the reduction is related to the eventual outcomes of patients treated surgically for injuries involving the syndesmosis.[1–21]

Many radiographic methods of reduction have been described in recent years with reported malreduction rates as high as 52%.[22–25] Although fluoroscopic assessments have been proposed as a guide for reduction,[26,27] intraoperative fluoroscopy may fail to detect fixation of the fibula in as much as 30 degrees of external rotation.[28] A retrospective analysis of 253 intraoperative three-dimensional scans made after reduction under fluoroscopy revealed malreduction in 33% of the patients.[29]

To date, little attention has been paid to open techniques, likely because of the lack of well-described landmarks for reduction and anatomical variability. Because the incisural anatomy varies in depth and width, the evaluation of the reduction at this level may be challenging and may lead to anterior or posterior malalignment.[16] Miller et al[25] proposed the use of an open technique with direct visualization of the anterior incisura. However, he found that 16% of distal tibiofibular joints remain malreduced compared with the normal ankle using this open technique.[25]

We theorize that using the anterolateral plafond and anteromedial fibular articular surfaces as a surgical reference, as compared to the location of the fibula within the incisura, would allow for less translational malalignment because the anterior to posterior width of the articular surfaces are matched. The senior author has always used this visual reference for reduction (see **Video, Supplemental Digital Content 1**, http://links.lww.com/JOT/A737).

The 2 aims of this cadaveric study were (1) to compare the quality of the translational syndesmotic reduction obtained using the incisura versus the articular surface at the joint as the visual cue and (2) to evaluate the difference of the anterior to posterior depth of the fibula to the corresponding tibial surface at the level of the ankle articular surface to that at the of the incisura 1 centimeter above the joint.

METHODS

A cadaveric study was undertaken using the left ankles of 10 specimens with intact syndesmoses. Six cadavers were men, 4 were women, and their ages ranged from 78 to 90 years. The skin and musculature were removed to access each

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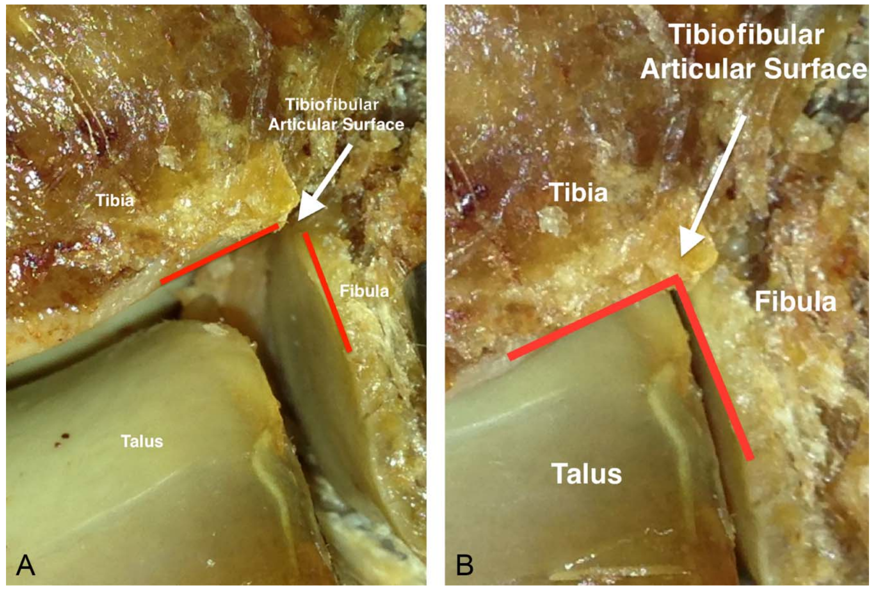

FIGURE 1. A–B, Example of the articular surface reduction method—the arrow points to the location to examine, and the red lines indicate the articular surfaces that are originally separated (A) and then subsequently aligned and reduced (B). **Editor's Note**: A color image accompanies the online version of this article.

ankle and syndesmosis, but the ligaments were not taken down initially.

The anatomical location of the fibula was marked before sectioning the syndesmotic ligaments by driving two 1.6-mm K-wires from lateral to medial immediately adjacent to the anterior and posterior edges of the fibula approximately 1 cm above the ankle joint line. The wires were pulled out medially and were not visible from the lateral side, nor were the holes they went through. These wire locations would later be used as reference points for the evaluation of the anterior to posterior translational reduction.

The syndesmosis was then surgically disrupted from the ankle to a point 1 cm distal to the proximal tibiofibular articulation. The lateral ankle ligaments were also surgically released rendering the distal fibula mobile.

Seven surgeons (2 attending surgeons and 5 chief residents) were asked to anatomically reduce the syndesmosis using 2 different visual references for the reduction. Each surgeon had a random allocation of which technique would be used first with 3 using the incisural technique first and 4 using the articular reduction technique first. No surgeon performed reductions using both techniques on the same ankle on the same day. Each reduction was stabilized by the surgeon driving a K-wire that was prepositioned in the lateral fibula by an independent investigator into the tibia from the fibula to stabilize it for measurement. Each wire was in a different position and for all surgeons for each of their 10 reductions. These K-wires were between 1 and 2 cm above the joint. The purpose of this variation was to create a new trajectory for each wire placed avoiding altering the reduction.

Reductions were performed on each specimen using both the "articular surface" method and the "incisura" method. For each method, green towels were used to mimic the available anterior surgical exposure by covering areas that would not be visible during the approach. For each method, only the anterolateral plafond or the anterior incisura was visualized while the other was covered (Figs. 1 and 2). For the articular surface technique, surgeons were instructed to anatomically reduce the syndesmosis by perfectly aligning the anterolateral plafond cartilage and the anteromedial fibular cartilage. For the incisura method, surgeons were able to see the entire anterior incisura and instructed to anatomically align the fibula within the incisura. If the reduction shifted while they were advancing the K-wire, they were permitted to redo it until they believed that the reduction was anatomical.

The translational accuracy of each syndesmotic reduction obtained by the surgeons was assessed by comparing the location of the "reduced" fibula to that of its anatomical location marked before syndesmotic release. The K-wires that marked the anatomical position of the fibula anteriorly and posteriorly were driven back across, so that one of them stuck out in front or in back of the fibula. This wire was used to assess the anterior or posterior translation of the reduction.

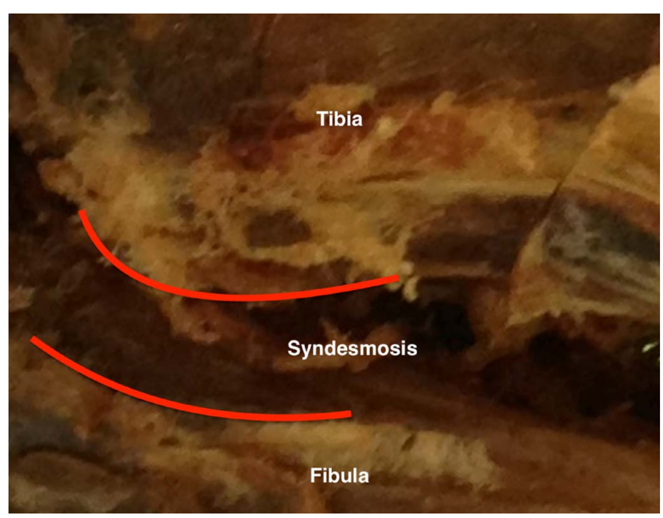

FIGURE 2. Example view of the incisura surgeons used to align the syndesmotic reduction. **Editor's Note**: A color image accompanies the online version of this article.

Measurements were made using digital calipers to the 100th of a millimeter from either the anterior or posterior reference K-wire. For example, if the surgeon over anteriorly translated the fibula during reduction, the posterior anatomical marker (a K-wire) would be visible and used to measure the translation by its distance to the posterior border of the fibula. If the surgeon posteriorly translated the fibula, the anterior marker was visible and used for measurement. For the purpose of the statistical analysis, the absolute values of the displacements were recorded for each reduction.

Reduction quality was assessed using mean and SD of the displacements for each technique. Comparisons of the reduction quality were performed using a paired *t* test with significance set at <0.05.

Malreduction was defined as displacement >2 mm. Comparison of the rate of malreduction was preformed using a Fisher exact test, again with significance set at <0.05.

In the second part of the study, a single investigator measured the anterior to posterior distance of the fibular and tibial articular surfaces at the level of the ankle joint and the anterior to posterior distance of the fibula and the incisura 1 cm above the ankle joint using the digital calipers to determine the differences in the tibial and fibular surfaces at these levels.

RESULTS

Reduction Quality

Syndesmotic reduction using the articular surface method resulted in significantly more accurate reductions than using the incisura technique. The malalignment of the syndesmosis using the articular surface as a visual reference was 0.7 ± 0.7 mm and using the incisura was 1.3 ± 1.0 mm (*P* = 0.0001). The range of malalignment using the joint as a reference was 0.0 mm–2.7 mm and using the incisura was 0.0–4.8 mm (Table 1).

As each surgeon reduced each of the 10 ankles using both techniques on different days, there were 70 comparisons. Of these, 52 (74%) of the reductions were better using the articular surface as a visual reference. All 7 surgeons yielded better average reductions across all specimens using the articular surface than using the incisura as a reference. Malreduction of >2 mm occurred in only 7% of cases using the articular surface method versus 20% of cases using the incisura method (*P* = 0.046).

Anatomical Relationship of Anterior-Posterior Depth

The difference in anterior-posterior depth of the fibula versus the incisura was significantly less at the level of the articular surface than at 1 cm above the ankle joint. The difference in the fibular width and the tibial incisura width was 2.1 ± 1.4 mm at the level of the ankle articular surface and was 5.9 ± 2.1 mm at 1 cm above the joint (*P* = 0.0002). The range of the differences in widths at the level of the articular surface was 0.5–5.0 mm and at 1 cm above the joint was 3.5–9.5 mm (Table 2 and Fig. 3).

TABLE 1. Absolute Distance of Malalignment for Articular Surface Versus Incisura Methods

Malalignment (in mm)	Mean	Range	*P*
Articular surface	0.7 ± 0.7	0.0–2.7	0.0001
Incisura	1.3 ± 1.0	0.0–4.8	

TABLE 2. Width of the Fibula to the Tibial Surface at the Articular Surface Versus the Incisura

Width (in mm)	Mean	Max	*P*
Articular surface	2.1 ± 1.4	0.5–5.0	0.0002
Incisura	5.9 ± 2.1	3.5–9.5	

DISCUSSION

We sought to evaluate the accuracy of 2 visual reference methods for open reduction of the syndesmosis in this cadaver study. Despite the consensus opinion that anatomical reduction of the syndesmosis is necessary for optimal outcomes, malreduction after operative fixation has been shown to be as high as 50%.[22,25,28,30,31] Sagi et al[16] found that at 2-year follow-up, patients exhibiting malreduction had significantly worse outcomes than those with anatomical reduction. In part, these poor malreduction rates are the result of insufficient intraoperative methods for assessment of syndesmotic reduction. Plain radiographs have been shown to be inaccurate in assessing syndesmotic reduction,[32] and although CT scan measurements evaluate the syndesmosis more accurately than the traditional radiographic parameters, they are not available in the operating room at a vast majority of centers.[16,33]

Open techniques including direct visualization through anatomical landmarks offer a potential solution. Miller et al[25] showed that the use of an open technique with direct visualization of the anterior tibiofibular joint reduced malreduction rates (measured as >2 mm displacement) from >50% to

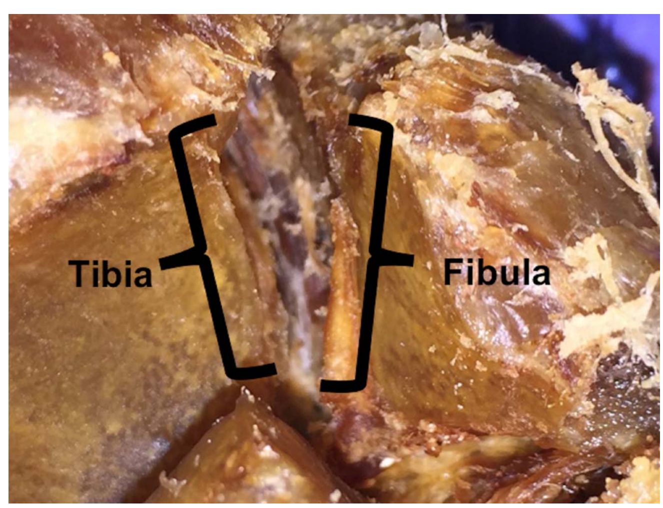

FIGURE 3. The anterior to posterior width of the fibular and tibial articular surfaces. **Editor's Note**: A color image accompanies the online version of this article.

15%. However, syndesmotic anatomical variability including incisura depth and width can make accurate reduction of the distal fibula difficult.[34,35] Cherney et al[34] found that shallow syndesmoses were correlated with anterior fibular malreduction and were less likely to be malrotated, while deep syndesmoses were predisposed to posterior sagittal plane and rotational malalignment.

Lilyquist et al[35] recently performed an anatomical analysis suggesting that there is consistency in the measurements of the anterior inferior tibiofibular ligament and posterior inferior tibiofibular ligament in relation to the distal articular cartilage. As a result, they recommend that the superior margin of the distal articular cartilage could serve as a consistent anatomical landmark for reconstruction but did not study the effectiveness of this method.[35]

The senior surgeon of this trial has long used the articular surface method for open reduction when it is performed. In this study, aligning the articular surface of the anterolateral tibial articular surface and the anteromedial fibular articular surface at the level of the ankle joint when surgically reducing the syndesmosis was significantly more accurate method than using the relationship of the fibula to the incisura above the joint level as a guide.

Measurements of the difference of the fibula and incisural anterior to posterior width at the joint and 1 cm above the joint may provide an explanation for this because there is much closer relationship at the level of the articular surface, which would potentially lead to a better reduction when using this relationship as the visual reference. Since only the anterior reduction is visualized, the smaller difference in the width at the level of the joint would logically lead to more accurate translational alignment. This is consistent with the findings of Lepojarvi et al, who found that at the level of the syndesmosis, there were significant differences between the width of the tibial incisura and fibula between sexes. They also found that the fibula could be found both centrally or anterior translated within the incisura in normal subjects.[36]

Based on our data, we believe that using the relationship of the articular cartilage of the anteromedial fibula to the anterolateral tibia aids in the open reduction of the syndesmosis. Importantly, having chief residents participate in addition to 2 attending surgeons makes this trial more generalizable to surgeons who do not treat a high volume of syndesmotic injuries. These surgeons were able to reduce the syndesmosis within 2 mm in 93% of the cadavers using the articular surface method, which would indicate that this is a reproducible result for lower volume surgeons. Moreover, all surgeons were able to reduce the syndesmosis within 3 mm when using the articular surface method, and Cherney et al[21] have shown that there is no significant difference in functional outcomes at a 1-year follow-up between reduced and malreduced groups at the 1.5-, 2-, and 3-mm thresholds.

The major limitation of this study is that it is a cadaveric study that relies on the ability of the surgeons performing the reduction to use the appropriate visual landmarks. In addition, we chose not to evaluate the reduction of rotation or length because the fibula was intact and attached at the proximal joint. This replicates the clinical scenario in which the fibula is fixed, but does not represent the case of a high fibula fracture that is not fixed. However, in clinical practice, the articular surface would be expected to be a better location to assess length than the incisura with augmentation by fluoroscopy.

In conclusion, using the articular surface as a visual reference during open reduction of the syndesmosis may provide better alignment than relying on the incisura.

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