CT Characterizing the Anatomy of Uninjured Ankle Syndesmosis

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**Abstract**

Although it is expert opinion that transsyndesmotic screws are placed obliquely 30° from posterolateral to anteromedial in the transverse plane, this has not been formally studied, and there is inconsistency regarding the congruency of the distal tibiofibular joint. Thirty-eight computed tomography (CT) scans of the lower extremity were used to examine the rotational profile of the axis of the syndesmotic joint in relation to the femoral transepicondylar axis and to describe the congruency of this joint. The axis of the distal tibiofibular joint was 32°±6° externally rotated in relation to the transepicondylar axis. The average anterior, central, and posterior widths of the syndesmotic joint space 10 mm superior to the joint line were statistically significantly different: 1.7±0.9 mm, 1.7±0.6 mm, and 2.3±1.1 mm, respectively (P=.004). This study demonstrates that the axis of the uninjured distal tibiofibular joint is approximately 30° externally rotated in relation to the transepicondylar axis. Therefore, reduction clamps and screws should be placed at this angle to avoid malreduction of the syndesmosis. The posterior joint space width is significantly wider than the anterior and central joint spaces. This study’s results provide a description of the anatomy of the uninjured distal tibiofibular joint to guide reduction maneuvers and establish a baseline for evaluation of postreduction CT scans.

**Figure:** Drawing showing measurement of the angle between the syndesmatic joint axis and the transepicondylar axis.
A syndesmotic injury occurs in up to 13% of all ankle fractures\(^1,2\) and in 20% of patients requiring internal fixation.\(^3,4\) Closed reduction of the distal tibiofibular joint results in malreduction in 16% to 52% of patients.\(^5,6\) Patients with malreduction of the syndesmotic joint have inferior clinical outcomes compared with patients with an anatomic reduction.\(^7\)

Although the restoration of anatomic alignment of the distal tibiofibular joint is both difficult to achieve and important for optimal clinical outcomes, little attention has been devoted to the anatomy of the uninjured syndesmotic joint.\(^8-11\) Although it is expert opinion that transsyndesmotic screws are placed obliquely 30° from posterolateral to anteromedial in the transverse plane, this has not been formally studied.\(^12\) In addition, the proper placement of reduction tenaculums is necessary to achieve an anatomic reduction. A recent study reported that reduction clamps must be placed perpendicular to the syndesmotic joint because clamps that are placed diagonally reproducibly result in malreduction.\(^13\) However, the study did not describe how to achieve or confirm perpendicular clamp placement. Moreover, inconsistency exists in the literature regarding the relative widths of the anterior and posterior portions of the uninjured distal tibiofibular joint.\(^11,14\)

The 2 goals of this study were to describe the rotational profile of the syndesmotic joint with respect to the transepicondylar axis and to describe the congruency of the joint as determined by the varying joint space widths.

**Materials and Methods**

Prior to initiation of the study, institutional review board approval was obtained. All consecutive computed tomography (CT) angiograms of the lower extremity ordered by the Harbor-UCLA Vascular Service between July 1, 2010, and April 30, 2011, were included in the study. Most CT angiograms were performed to evaluate for chronic vascular disease in patients who had not sustained an acute injury. Each limb was scanned by taking anatomically true axial cuts; therefore, all images were parallel to the tibial plafond. Computed tomography scans had to include the distal femur through the ankle and be performed with thin cuts (1.5-mm-thick sections or less). All scans were obtained with a GE ProSpeed CT scanner (General Electric, Milwaukee, Wisconsin) using a bone algorithm. Contiguous 0.5- to 1.5-mm-thick sections from the mid-thigh through the ankle were examined using a high-resolution monitor. Each CT scan was reviewed for an acute or chronic osseous injury. If any injury was suspected, then that patient was excluded from the study. All measurements were performed using standard digital imaging calipers that were adjusted for variability in magnification.

**Measuring the Rotational Profile of the Syndesmotic Joint**

A line was drawn between the most prominent points of the lateral and medial femoral epicondyles to establish the transepicondylar axis (Figure 1). The rotation of the distal tibiofibular joint was established by drawing a perpendicular line bisecting the joint (Figure 2). The transepicondylar axis was superimposed on the axis of the syndesmotic joint, and the difference between the 2 was measured (Figure 3).

**Syndesmotic Joint Width Measurements**

The width of the syndesmotic joint was measured 10 mm superior to the joint line. The anterior, central, and posterior widths were measured for comparison. First, the center of the joint was established and the width measured. Next, the most peripheral points of the joint anteriorly and posteriorly were marked. At the halfway point between the central mark and the most pe-
Peripheral marks, the anterior and posterior joint spaces were measured. Therefore, the anterior measurement was taken at the junction of the anterior 2 quartiles and the posterior measurement at the junction of the posterior 2 quartiles (Figure 4).

**Statistical Analysis**

Student’s t test was used for comparison of the syndesmotic joint rotational profile between the right and left lower extremity in patients with bilateral imaging. Analysis of variance test was used to compare differences between the anterior, central, and posterior joint width.

**RESULTS**

**Demographic Characteristics**

Forty-five consecutive thin-cut CT scans of the lower extremity met the inclusion criteria. Seven CT scans were excluded for 2 reasons: motion artifact (n=4) and bony injury to the lower extremity (n=3). There was 1 chronic tibia plateau fracture, 1 acute distal femur fracture, and 1 acute gunshot wound to the proximal tibia. In 17 patients, bilateral lower extremities were imaged, and in 4 patients, only 1 lower extremity was imaged, for a total of 38 studies. The study cohort comprised 16 men and 5 women with an average age of 51. There were 17 right lower extremity scans and 21 left lower extremity scans.

**Syndesmotic Joint Rotational Profile**

The axis of the syndesmotic joint was $32^\circ\pm 6^\circ$ externally rotated in relation to the transepicondylar axis. In patients with bilateral CT scans, the axis of the syndesmotic joint was $30^\circ\pm 6^\circ$ externally rotated in relation to the transepicondylar axis and was not statistically significantly different from the left lower extremity ($30^\circ\pm 5^\circ$) ($P=.9$).

**Syndesmotic Joint Space Width**

Average anterior, central, and posterior widths of the syndesmotic joint space were statistically significantly different: 1.7±0.9 mm, 1.7±0.6 mm, and 2.3±1.1 mm, respectively ($P=.004$).

**DISCUSSION**

The current study is the first to confirm that the distal tibiofibular joint axis is approximately $30^\circ$ externally rotated in relation to the femoral transepicondylar axis. Understanding the normal rotation of the syndesmosis is important because tenaculums must be placed perpendicular to the syndesmosis to achieve an accurate reduction. When the clamp is placed obliquely to the joint, compressive forces are converted to sheer forces, resulting in fibular translation and/or rotation. If the clamp is placed in internal rotation, then the fibula translates posteriorly and/or internally rotates. The converse is true with an externally rotated clamp, producing anterior subluxation of the fibula and/or external rotation (Figure 5). Inaccurate clamp placement is probably the cause of the high incidence of syndesmotic joint malreduction when a closed reduction is attempted. Similarly, transsyndesmotic screws should be oriented approximately $30^\circ$ externally rotated from the horizontal axis to avoid malreduction.

The accuracy of reduction of the distal tibiofibular joint cannot be determined using plain radiographs. Therefore, CT scans are now frequently used to evaluate reduction of this joint. It is important to understand the anatomy of the uninjured syndesmotic joint to provide a baseline for postoperative evaluation. The current study found that the normal distal tibiofibular joint is significantly wider posteriorly than anteriorly. This is in agreement with the results of a study by Elgafy et
which found that the average anterior and posterior joint space was 2 mm and 4 mm, respectively. Conversely, Pelton et al found the anterior and posterior width of the joint to be equal and suggested that the syndesmosis ratio is 1 in normal individuals. The variability in that study may be explained by the fact that the measurements were obtained with a CT scanner using 3-mm axial slices from 9 to 12 mm proximal to the joint, whereas in the current study, the majority of the images were obtained with 1-mm axial slices 10 mm proximal to the joint.

This study has some limitations. Its conclusion is based on the assumption that the femoral transepicondylar axis is the best landmark for neutral rotation of the limb. Other landmarks that may have been used are the tibial condylar axis or the tibial tubercle, but in a pilot study these landmarks were not reliable. Because the current authors’ rotational alignment was determined proximal to the knee, it is possible that rotation may occur through the knee, especially if ligamentous injury or laxity is present, introducing a source of measurement error. Computed tomography scans were evaluated for evidence of acute and prior ligamentous and osseous injury, but the former is more difficult to ascertain.

**CONCLUSION**

In accordance with expert opinion, the axis of the distal tibiofibular joint is approximately 30° externally rotated in relation to the transepicondylar plane. Therefore, the reduction tenaculums and transsyndesmotic screws should be placed at this angle to avoid malreduction of the joint. The posterior joint space width is significantly wider than the anterior and central joint spaces. This should be taken into account when using postoperative CT scans to evaluate the accuracy of syndesmotic joint reduction.

**REFERENCES**


