Ideal angle of Upper and Lower Syndesmotic Fixation Based on Weightbearing CT imaging in Uninjured Ankles

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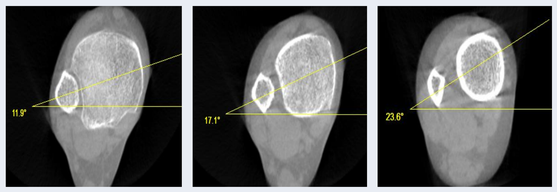
STATEMENT OF PURPOSE

Ankle fractures are Common in the U.S and roughly 10% of ankle fractures lead to syndesmotic injury. (1, 2) Ankle fractures that require fixation have been shown to have increased incidence of syndesmotic injury. (3) The syndesmosis is crucial for stability of the ankle joint, stabilizing the fibula relative to the tibia. (4) Minimal lateral displacement of the talus has shown to decrease tibiotalar articulation by 42%. (5). When instability is noted, surgical reconstruction is usually indicated. Fixation after the syndesmosis is reduced can be done in numerous ways including screws, k-wires, and interosseous sutures. With the fibula residing posterior to the tibia anatomically, fixation has historically been described as 30° in the anteromedial direction. (6) The present study took into consideration the anatomic relationship of tibia/ fibular overlap at 2 cm vs. 3.5 cm above the ankle joint line, which would suggest that the ideal angle for upper and lower fixation devices are not both 30 ° since the fibula is progressively more posterior at the proximal location due to narrowing of the tibia. This study is intended to assess the ideal angle of the syndesmosis at two different levels of fixation based on digital measurement of weightbearing CT imaging of uninjured ankles.

METHODOLOGY & PROCEDURE

Retrospective review was done on 30 weightbearing (WB) CT scans in patients without history of ankle or syndesmotic injury. WB CT scans were analyzed at 2 cm and 3.5 cm proximal to the tibial plafond to measure the degree of angulation for ideal fixation placement bisecting the fibula and medial tibia. Measurements were obtained modeling the technique used to assess femoral anteversion with the long axis of the calcaneus as a reference for long axis of the foot. The axial slice with the best view of the lateral aspect of the calcaneus was utilized. The calcaneal horizontal angle (CHA) was calculated using a 90° tangential to the long axis of the calcaneus compared to the horizontal plane of the CT image (Figure 2). This angle was then added or subtracted to the Tib / fib Bisection Angle (Figure 3) to account for internal or external rotation of the leg which we refer to as the Adjusted Syndesmotic Fixation Angle (ASFA). Statistical significance was calculated using the T-Test for 2 Independent Means.

Figure 1. Ideal angle of syndesmotic fixation increases from distal to proximal due to variation in tibial anatomy

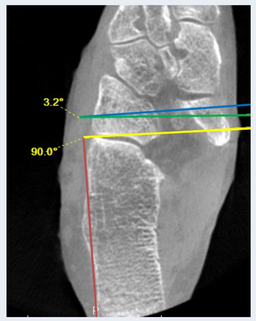


Cross sectional anatomy of the same patient at (a) 1 cm, (b) 2.0 cm, and (c) 3.5 cm proximal to the tibiotalar joint. Note how the tibia becomes more narrow from distal to proximal requiring greater angulation of fixation at the 3.5cm level to avoid being too posterior in the tibia.

Table 1. Measurement technique based on weight bearing CT studies on uninjured ankles

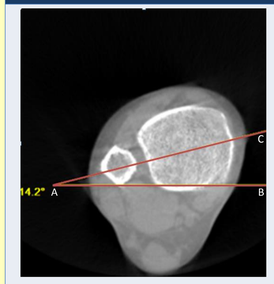
1. Select the axial image that best demonstrates the long axis of the calcaneus
2. Calculate the Calcaneal-Horizontal Angle (CHA) **(Figure 2)**
3. Measure the Tib / fib Bisection Angle at 2.0 cm and 3.5 cm proximal to the ankle joint line **(Figures 3 and 4)**
4. Calculate the Adjusted Syndesmotic Fixation Angle (ASFA) relative to the long axis of the calcaneus at the 2.0 cm and 3.5 cm levels **(Figure 5)**

Figure 2. Measuring the Calcaneal Horizontal Angle (CHA)



The CHA is measured using the lateral aspect of the calcaneus on axial CT as a reference for long axis of the foot. The Yellow line is drawn 90 ° to the long axis of the calcaneus (red line). The green line is drawn parallel to the horizontal plane of the CT image. Next, the blue line is drawn parallel to the 90° yellow line. The CHA represents the rotation of the extremity to the horizontal plane (+3.2 ° here) which was then added or subtracted to the tib/fib bisection angle at 2.0 and 3.5 cm.

Figure 3: Measuring the Tib / fib Bisection Angle



Line AB represents the horizontal plane of the CT image while line AC is the bisection of the tibia and fibula at 2.0cm above the ankle joint. The 14.2° measurement represents the angle of fixation placement prior to adjusting internally or externally to compensate for rotation of the leg that naturally occurs during CT imaging.

Figure 4. Tib / fib Bisection Angles were obtained at 2.0 cm and 3.5 cm proximal to the ankle joint line to represent typical levels of syndesmotic fixation

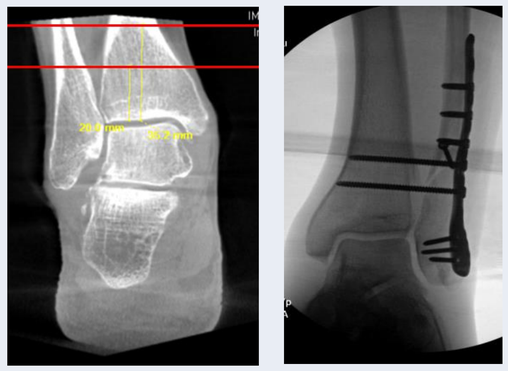
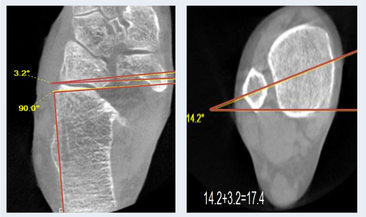


Figure 5. Calculating the Adjusted Syndesmotic Fixation Angle (ASFA) relative to the long axis of the calcaneus

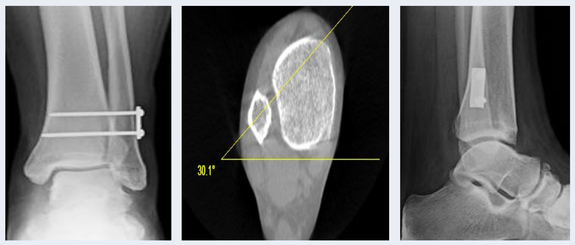


The (a) Calcaneal Horizontal Angle (+3.2°) is added to the (b) Tib / fib Bisection Angle (14.2°) to account for external rotation of the extremity during CT imaging. ASFA is therefore 14.2 + 3.2 = 17.4°.

Figure 6: Using the lateral wall of the calcaneus as a reference point in surgery

The surgeon can use the lateral wall of the calcaneus as a reference when placing syndesmotic fixation. The foot should be held in neutral position at 90 ° of DF when drilling or inserting screws.

Figure 7. Limitations of intra-operative C-arm imaging when placing syndesmotic fixation



(a) Intra-operative AP and mortise C-arm imaging is useful for height, depth, and angle of the drill in the coronal plane when placing syndesmotic fixation but does not account for axial plane angular position which requires the surgeon to estimate the desired angle of fixation. The longstanding assumption that 30 ° is the desired angle could lead to (b) improper placement in a high percentage of patients. (c) Lateral imaging allows assessment of screw position in the axial plane. Note how the upper screw looks posterior in the tibia due to narrowing from anterior to posterior at the 3.5 cm level.

Table 2. Patient Characteristics

	Mean ± SD	Range (min. – max.)
Age (Years)	52.1 ± 15.2	15 – 77
Gender		
Males	14/30	46.7%
Female	16/30	53.3%

RESULTS

Patient characteristics are depicted in Table 2. A total of 30 WBCT were evaluated in uninjured ankles. The Adjusted Syndesmotic Fixation Angle (ASFA) in reference to the calcaneus was found to be 17.41° (8-31°) at 2 cm and 21.56° (14-38.1) at 3.5 cm above the plafond. As depicted in Table 3, these values were statistically significant.

Table 3. Comparison of Adjusted Syndesmotic Fixation Angle

Level	ASFA (Ave.)	Range (min - max)	Difference compared to standard of 30 °	P Value
2 cm	17.41°	8° to 31°	12.59°	.01
3.5 cm	21.56°	14° to 31°	8.44°	.01

ANALYSIS AND DISCUSSION

The recommended angle of syndesmotic fixation has historically been cited as 30° for decades which is rarely debated (8). Our hypothesis was true in that the ideal angle for upper and lower placement of syndesmotic fixation (ASFA) is not equal at the 2.0 and 3.5 cm levels and in fact our results contradict the historically cited angle of 30°. Our measurements correspond with Park et al. who found the syndesmotic angle to be 18.8± 5.6° in CT scans of calcaneal fractures (7). While the ideal angles for upper and lower fixation were not significantly different, the ideal angles of fixation demonstrated here is significantly lower than the historical recommended value. Surgical implications are obvious and surgeons should be mindful of variable anatomy. Divergent fixation also has clinical utility which is potentially beneficial for stability of the syndesmotic. Limitations of this study include a relatively small sample size of 30 patients. The protocol for measurement is also complex and subject to human error although measurements were taken by one author. Our research concludes that the historically cited 30 ° angle is frequently not the ideal angle for syndesmotic fixation. Further, evaluating the 2.0cm and 3.5cm levels separately can aide surgeons in proper fixation placement.

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