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A computed tomography evaluation of two hundred normal ankles, to ascertain what anatomical landmarks to use when compressing or placing an ankle syndesmosis screw

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ABSTRACT

Classical AO teaching recommends that a syndesmosis screw should be inserted at 25–30 degrees to the coronal plane of the ankle. Accurately judging the 25/30 degree angle can be difficult, resulting in poor operative reduction of syndesmosis injuries.

The CT scans of 200 normal ankles were retrospectively examined. The centroid of the fibula and tibia in the axial plane 15 mm proximal to the talar dome was calculated. A force vector between the centroid of the fibula and the tibia in the axial plane should not displace the fibula relative to the tibia when surfaces are parallel. Therefore, a line connecting the two centroids was postulated to be the ideal syndesmosis line. This line was shown to pass through the fibula within 2.5 mm of the lateral cortical apex of the fibula and the anterior half of the medial malleolus in 100% of the ankles studied.

The results support the concept that in the operatively reduced syndesmosis, the anterior half of the medial malleolus can be used as a reliable guide for aiming the syndesmosis drill hole, provided that the fibular entry point is at/or adjacent to the lateral fibular apex. The screw should also remain parallel to the tibial plafond in the coronal plane.

1. Introduction

Ankle injuries are among the most common of all lower limb orthopaedic trauma related maladies in adults. Fractures involving the ankle are increasing [1,2] and are reported to have an incidence of 107 fractures per 100,000 person-years in a recent Danish study [3]. UK epidemiology studies indicate that ankle fractures are the group of injuries most likely to warrant open reduction and internal fixation in patients between 20 and 65 years old [4].

Syndesmotic disruption can occur in up to 13% of all ankle fractures [5,6]. In those ankle fractures requiring operative fixation the number requiring syndesmosis stabilization approaches 20% [7,8]. Indeed the numbers may be even higher. Jenkinson et al. [9] reported that up to 37% of operatively treated ankle fractures can have undetected syndesmotic instability when examined intraoperatively.

The tibiofibular syndesmosis, which is often referred to as the distal tibiofibular joint, is stabilized by three ligamentous components; the anterior inferior tibiofibular ligament (AITFL), the interosseous tibiofibular ligament (ITFL) and the posterior inferior tibiofibular ligament (PITFL). These ligament supports allow just 1 mm widening of the syndesmosis during normal gait [10]. The bony anatomy comprises of the “incisura fibularis tibiae” or “fibular notch” on the tibial side, against which the fibula abuts (Fig. 1). The size and shape of this notch is significant, often dictating proximal–distal migration and rotatory movements between the tibia and fibula. The anterior tubercle, being larger, prevents forward slipping of the fibula. The diminutive posterior tubercle facilitates backward dislocation. In fibula fractures, the posterior notch often acts as a fulcrum around which the distal fragment spins and rotates. The fibular notch is concave in the majority of ankles, but can be relatively flat in up to 33% of subjects [11].

There have been several papers stressing the importance of achieving an anatomical reduction of the syndesmosis [12–14]. Therefore, the reports of syndesmosis malreduction varying from 12–52% are a cause for further scrutiny [15–18]. It has been previously reported that ankle fractures with concomitant syndesmotic

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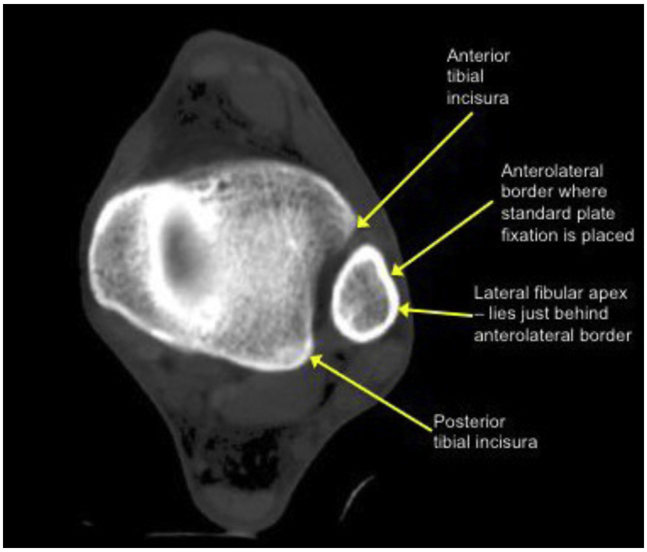

Fig. 1. Anatomical areas referred to written passages.

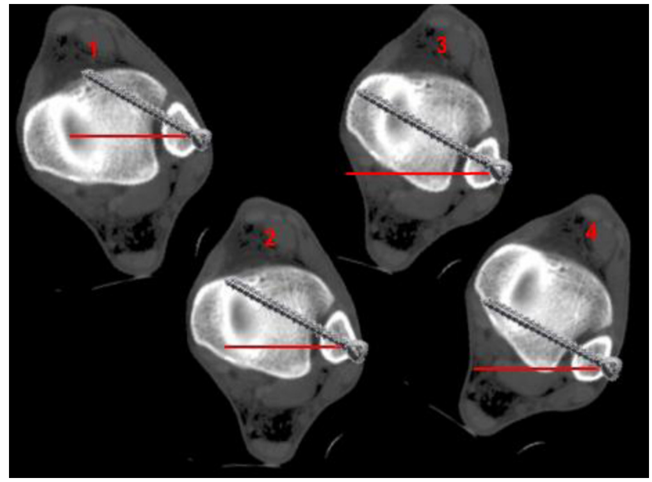

Fig. 2. An axial CT of the ankle syndesmosis replicated four times. Each screw is at a 30 degree angle to the horizontal red line, but minor amounts of internal or external rotation of the ankle can lead to wide variability in the final position of the syndesmosis screw. Interestingly the best screw position appears to be achieved in position number 3 when this particular ankle is externally rotated about 20 degrees.

disruption have more pain and poorer function than those ankle fractures without syndesmotic disruption [7,19]. These reports of poorer outcome related to syndesmotic injuries are likely to have significant correlation to the high malreduction numbers.

It could be postulated that the causes for malreduction have a dual aetiology. The first is the obvious fact that it is necessary to reduce the syndesmosis prior to fixation. The success of this step can be increased by using direct visualization to ensure that the fibula is reduced relative to the incisura fibulae of the tibia [16]. However, as Miller et al. noted in the same paper, this does not guarantee perfect reduction according to their measurement criteria. The second factor that may cause a malreduction is inadvertent compression by the syndesmosis screw or reduction clamp along a non-centroidal axis resulting in possible rotation or translation of the fibula relative to the tibia.

The rationale behind the hypothesis that the centroidal axis would make the ideal vector in which to place a syndesmosis screw, or an intraoperative reduction clamp, is as follows. If a physical object has uniform density, then its centre of mass is the same as the "centroid" of its shape. The line connecting two centroids is called the centroidal axis. The area moment of inertia (I) of any area is defined as the product of the area (A) and the square of the perpendicular distance (d) from the centroid of the area to the moment axis (x) $Ix = Ad2$. Therefore the area moment of inertia through the centroid is neutral as "d" is zero. As such, we can assume that the centroidal axis of the fibula and tibia is the ideal syndesmosis line as there will be a neutral area moment of inertia for a vector passing through this axis.

The current consensus is that when the fixation device is to be used it should be inserted parallel to the tibial plafond in the coronal plane, and thirty degrees relative to the coronal plane of the ankle [20,21]. In practice however, it can be difficult to accurately assess where exactly this 30 degree angle lies while drilling a path for the screw or tight rope device. As demonstrated in Fig. 2, comparatively minor amounts of internal or external rotation of the ankle, can lead to a wide disparity in the final position of syndesmosis screws.

In addition the 30 degree guideline does not take account of the wide individual variation between people's ankles [22].

We thus set out to establish the centroidal axis of the ankle syndesmosis at the transsyndesmotic level relative to easily accessible anatomical landmarks. There has been no study to our knowledge suggesting an alternative to the AO doctrine of the 30 degree guideline when inserting the syndesmosis screw. Similarly, the optimum entry point on the fibula for this screw has not previously been defined.

2. Methods

At our institution CT angiograms of the aorta and distal peripheral arterial tree are used as standard in lieu of intravenous angiograms by the vascular surgery department. These CT angiograms were performed with 2 mm slices from approximately the level of the first lumbar vertebra to the toes. This allowed the opportunity to have a detailed view of normal ankle skeletal anatomy in a large group of people without instigating additional radiation based studies.

One hundred patients who had prior peripheral CT angiograms on their legs were selected, and the CT images from their two ankles used in the study. Patients who had any evidence of ankle pathology or previous trauma were excluded. Two hundred normal ankles were therefore included.

All measurements and image analysis were performed using the Voxar 3D tm, version 5.1, Barco N.V, Build:hoda-0050.

Initially, the ankle to be examined was aligned and synchronized in the coronal, saggital and axial planes. A point 15 mm above, and 3 mm below, the talar dome was measured on the coronal view. The point 15 mm above the talar dome was then viewed in the axial plane and a trapezoidal shape that most closely approximated the area of the tibia in the axial plane was placed over the tibia at this point. The centroid of a trapezoidal or triangular shape can easily be calculated (Fig. 3). The midpoint of the four sides of the trapezoid was then marked at 15 mm above talar dome (Fig. 4). Lines were drawn between the midpoints of opposite sides of the trapezoid. The point where these two lines intersected is adjudged to be the centroid of the trapezoid and thus the centroid of the tibia in that axial plane. The fibula's centroid was similarly obtained with the use of a closely approximating trapezoid (Fig. 4). There were a minority of fibulae whose axial outline was that of a triangle rather than trapezoid, and thus a triangle was drawn around the cortical outline of these fibulae and the centroid of the triangle elicited. This involved drawing a line between the one apex and the midpoint of the opposite side. Where these three lines intersected is the centroid of that triangle. The centroid of the tibia and the fibula were therefore marked on the axial plane (Fig. 5).