CHAPTER 5

Stress radiography and stress examination of the talocrural and subtalar joint on helical Computed Tomography

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Foot & Ankle International 1997;18:480-488
Abstract

The main objective of this study was to compare subtalar inversion stress views using the Brodén view with inversion stress views on helical computed tomography (CT). One of the drawbacks of routine radiography is the imaging of three-dimensional structures in a two-dimensional plane. We investigated whether the use of helical CT would lead to a more objective and clearer measurable method to determine the amount of tilt in the subtalar joint. A group of 15 patients with unilateral chronic instability complaints and clinically suspected subtalar instability was examined. The contralateral asymptomatic foot was used as control.

A variable amount of subtalar tilt (range, 4° to 18°) was demonstrated in all cases on stress radiographs, without finding significant difference between the symptomatic and asymptomatic feet. However, contrary to the findings at the talocrural level, subtalar tilt was found in none of the patients using helical CT. Thus, we now doubt that the tilt seen during stress examination using the Brodén view is the true amount of tilt. It may be that the lateral opening, seen on these radiographs, largely results from imaging two planes that has made a translatory and rotatory movement relative to each other in an oblique direction. It is concluded that the Brodén stress examination might not be useful for screening patients with subtalar instability.

Associated anomalies, not visible on the radiographs, were detected by helical CT. In four cases, narrowing of the articular cartilage and irregular and hypertrophic bone formation at the middle facet joint of the subtalar joints were found. It is likely that these changes cause disturbance of function of this joint and it is suggested that the subjective complaint of instability with “giving way” is not only caused by hypermobility, but can be caused by other disturbances of normal motion.
Introduction

Chronic lateral instability of the ankle/foot may be present in as many as 10% to 30% of people who have sustained an injury of the lateral ligament complex [6,8,21]. It is a clinical condition with frequent inversion injuries/sprains, “giving way” sensations, difficulties in walking on uneven ground, and sometimes pain and swelling. Multiple factors are involved. Abnormal or increased motion in the talocrural joint caused by lateral ligamentous damage is believed to be one of these factors [3,14,28]. Damage to the anterior talofibular ligament results in increased motion in the sagittal plane [25,31]. This ligament, with its more horizontal orientation, plays an important part in transmission of motion between the leg and the foot [12,24]. After this ligament is severed, tibiotalar delay will increase markedly [5,12]. The term “anterolateral/internal rotatory instability” has been used to describe the resulting clinical symptoms [1,7,25]. More severe trauma of the lateral ligament complex may cause injury to both: the anterior talofibular and calcaneofibular ligaments. Damage to both of these ligaments results in an increase of varus tilting of the talus within the ankle mortise [25,27]. The calcaneofibular ligament is rarely injured alone, but with or without a combined lesion of the anterior fibular ligament, rupture of this ligament is reported to result in an increase of motion in the subtalar joint [2,10,16,18,20,26,30,32,33,35]. Increase in talocalcaneal movement is found when a lesion of the calcaneofibular ligament is combined with a lesion of the interosseous talocalcaneal ligament [13]. Laxity or elongation of this interosseous ligament has been reported to be a cause of subtalar joint instability [15,34]. Subtalar instability must be considered as a cause of symptoms in chronic lateral instability, particularly if other causes of instability have been excluded [4].

In a previous study, we found that an increase in talar tilt (in the talocrural joint) between two steps of inversion was present in symptomatic feet only [22]. It was suggested that the increase in tilt between these steps might serve to distinguish between normal and pathologically increased tilt. However, because increased tilt was found only once in the subtalar joint, no conclusions could be drawn regarding the use of this method in diagnosing mechanical instability of the subtalar joint. We also concluded that no consensus existed as to the best method and the criteria to be used for evaluation of abnormal motion in the subtalar joint.

In the present study, a further effort is made to objectify a possible subtalar component in a group of 15 patients with unilateral chronic instability complaints. An identical standardized radiographic assessment of talar and simultaneous subtalar tilt was made, using a 40° Brodén view. This time, the same stress examination was also applied using CT imaging.
Patients and methods

Patients
Fifteen patients (12 men and 3 women) with chronic unilateral foot instability were consecutively recruited from the orthopaedic outpatient departments of the Central Military Hospital and the University Hospital of Utrecht. All patients complained of frequent unilateral inversion injuries and instability (with giving way sensations) of the foot. Typically, sprains already occurred when they walked on an uneven surface. Sometimes, a short period of pain and swelling followed such a sprain, but otherwise the patients were without pain. At physical examination, an increase in inversion tilt seemed to be present, and there was strong suspicion of the presence of subtalar instability on the symptomatic side. The asymptomatic feet of these patients served as a control group. The number, age, height, and weight of the subjects are shown in Table 1.

Methods
A detailed description of the standardized radiographic assessment of talar and simultaneous subtalar tilt and of the measurements used in the present study has been given previously [22]. The hinge device to stress the joints in the present study was identical to the one previously described, except that all metal was replaced by other materials to make the apparatus suitable for helical CT or Magnetic Resonance Imaging (MR imaging) (Fig. 1) [22]. The consequence of the use of this apparatus is that inversion stress is applied to the foot as a whole, not to one specific joint of the tarsus, and that it allows the joints to move in a normal fashion. A specific subtalar view (Brodén view) was used under fluoroscopic control, using a Philips (Shelton, CT) Angiodiagnostics 96 apparatus.

Radiographs were made of the feet in neutral position (step 0), after inversion with moderate force until the point of fair restraint (step 1) and after inverting as far as possible to the point of pain or until no further closure of the device was possible (step 2). This

Table 1. Age, height, and weight of the patient group (12 M, 3 F).

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a S.D., Standard deviation.
position was held for 1 minute, to ensure full muscle relaxation, before the third radiograph was made.

The amount of talar tilt (TT) found after step 1 was defined as TT1 and after step 2 as TT2. The corresponding subtalar tilt angles were defined as STT1 and STT2, respectively. The difference/increase in tilt found between (S)TT1 and (S)TT2 was calculated for each foot and defined as TTd and STTd. TTd and STTd were used as parameters for comparison between symptomatic and asymptomatic feet.

In the stress device, CT of the inverted hindfeet was performed with a high resolution technique on a helical CT scanner (Tomoscan SR 7000; Philips Medical Systems, Best, the Netherlands). Stress was gradually increased to compensate for the effect of ligamentotaxis, and the hinge device was closed to the same number of degrees as previously found after step 2. This position was held during a period of 4 minutes, the time required to perform CT scanning. Contiguous axial slices (thickness, 3 mm) from 2 cm above the talocrural joint to the calcaneocuboid joint were obtained. After acquiring the raw data, separate coronal reconstructions were made of the hindfoot using a bone algorithm. Measurements were made analogous to those on the Brodén view.

Statistics

The data were analyzed using SPSS/PC+, version 6.0. P values of 0.05 or less were considered significant. TTd and STTd values of the symptomatic feet were compared with those of the asymptomatic feet using a one-tailed sign test. The same test was used to compare the results obtained with CT imaging.
Results

Results for TT, STT, TTd, STTd, TTct and STTct are summarized in Table 2.

Brodén Stress Examination

Talocrural: An increase in TT was found in seven of the symptomatic feet (range, 2° to 7°) but also in three of the asymptomatic feet. In one case, increased TT was found only in the asymptomatic foot, and in two patients an increase was found in both feet. In 7 of the 15 patients, no increase in TT was seen between step 1 and step 2, either in the symptomatic or in the asymptomatic foot. Regarding the increase in TT (TTd), the difference between symptomatic and asymptomatic feet was found to be statistically significant (P = 0.04).

Subtalar: An increase in subtalar tilt was found in the symptomatic feet of three patients and in both feet of one patient. Differences between the symptomatic and asymptomatic feet were not significant.

CT Stress Examination

Talocrural: Tilting of the talus within the ankle mortise was found in the symptomatic feet of five patients (range, 5° to 12°). A TT of 10° was also found in the asymptomatic foot of one of these patients. The difference in TT (TTct) between the symptomatic and asymptomatic feet was statistically significant (P = 0.03). The five feet with TT during CT stress examination also demonstrated an increase in TT during the Brodén stress examination. In two symptomatic feet, no TT was found during CT examination, whereas these feet did demonstrate an increase in TT during the Brodén stress examination.

Subtalar: Tilting within the subtalar joint was never found using CT stress examination.

Other Findings

Four patients showed changes in the middle facet of the subtalar joints (Fig. 2). Loss of cartilage space and irregular and hypertrophic bone formation is seen, suggesting the existence of a fibrous coalition. One patient had a large posterior calcaneal cyst in the symptomatic foot. No other disorders or signs of osteochondral lesions were found.
Table 2. Results for TT1 and TT2, TTd, STT1 and STT2, STTd, TTct, and STTct.

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Mean 5.63 7.07 1.43 8.33 8.73 0.40 1.700
S.D. 3.72 4.93 2.22 2.81 3.03 0.93 3.620
Range 11.00 18.00 7.00 12.00 14.00 3.00 12.00 0
Min. 0 0 0 4 4 0 0 0
Max. 11 18 7 16 18 3 12 0

S, symptomatic; A, asymptomatic; S.D., standard deviation; Min., minimum; Max., maximum; TT1, talar tilt found after step 1; TT2, talar tilt found after step 2; STT1, subtalar tilt found after step 1; STT2, subtalar tilt found after step 2; TTd, difference in talar tilt; STTd, difference in subtalar tilt; TTct, difference in talar tilt as measured using computed tomography; STTct, difference in subtalar tilt as measured using computed tomography.
Discussion

Talocrural Joint

The association between chronic lateral instability of the foot and mechanical instability (increased mobility as a result of ligamentous damage) is under debate. Although some authors stress the importance of mechanical stability [3,14], there are others who believe that factors like proprioception, muscle control, and balance control are more important [6,29]. Freeman et al and Tropp [6,29] found no correlation between the patient’s subjective complaints, for which the term functional instability was introduced by Freeman et al., and mechanical instability [6]. Obviously, the more importance is attributed to mechanical instability, the more interesting it becomes to be able to differentiate between normal physiological and pathologically increased range of motion of the joints. In a previous study, increase in TT (between step 1 and 2, as also performed in the present study) was only found in symptomatic feet. This was interpreted with the possibility that during the first step the foot is fully inverted and passive structures, such as the ligaments, become increasingly tight until they block further motion. Increasing stress thereafter, as done

Figure 2.
A, On the Brodén stress view, no talocalcaneal coalition can be seen. Only a slight lateral opening suggests minimal motion in this joint.
B, CT examination shows the presence of a fibrous coalition.
during step 2, will only show an increase in tilt in feet with damaged lateral ligamentous structures. It was suggested that this increase might serve as a new parameter in diagnosing mechanical instability of the talocrural joint.

In the present study, a statistically significant difference was found between symptomatic and asymptomatic feet with regard to increase in TT (TTd); however, an increase in tilt was also found in three asymptomatic feet, and in one case a clear TT and increase in TT was found in the asymptomatic foot only (Table 2). The use of increased tilt as a definite parameter has therefore become doubtful. Again, the relation between the radiographic diagnosis of mechanical instability and chronic lateral instability complaints remains questionable. Both mechanical as well as functional instability are involved, and they may be parallel phenomena, as described by Tropp [29]. In our patient group, mechanical instability was not a dominant factor.

To our knowledge, no previous investigation has been published combining stress examination of the foot and CT scanning. One of the drawbacks of routine radiography is the imaging of three-dimensional structures on a two-dimensional plane. When motion takes place in complex geometric structures like the subtalar joint, the articular surfaces lose congruency. It may become a problem to draw the lines that represent the tangents to these surfaces and thus to measure the amount of tilt. This problem does not occur when CT scanning is used.
In only six feet, an angulation was found in the talocrural joint during CT stress examination (Table 2). In five cases, this was in the symptomatic foot, and in these feet it was associated with increased tilt with Brodén stress radiography. In the sixth case, it concerned an asymptomatic foot in which a TT of 11° was found, but no TTD. An increase in tilt is not always associated with a tilt during found with CT scanning. Although explanations can be found for differences in the amount of tilt between the two examinations, we cannot explain why not all feet that exhibit an evident TT with stress radiography also show tilting during CT scanning. It cannot be excluded that slight concessions were made regarding the amount of stress applied during CT examination, although subjectively both the examiner and the subjects experienced the amount of stress and closing of the hinge device to be equal. Another explanation for the difference would be that the talocrural joint was cut in a different plane, but this does not explain why in some feet no tilting at all is seen with CT examination, while they show a TT of 10° and sometimes more. In conclusion, there seems to be some relation between chronic lateral instability, increase in TT, and CT angulation of the talocrural joint during stress examination, but the results are inconsistent, and none of these examinations are found to be more specific for the radiographic assessment of mechanical instability.
Subtalar Joint

A wide range of motion (range, 4° to 18°) of the subtalar joint was found during Brodén stress radiography. These results are comparable to those found in previous studies [9,22,26]. An increase in subtalar tilt was found in only four symptomatic feet and in one asymptomatic foot. This increase was never more than 3°, and what influence any slight “errors” in drawing the lines representing the articular surfaces might have is open to discussion. As mentioned earlier, this can be a problem for the subtalar joint, with its complex geometry. It was hoped that CT scanning would bring clarity and make measurements more reproducible. However, not once was an actual opening of the subtalar joint found on the lateral side. One would have expected similar to findings at the talocrural level in at least one of the patients.

Incongruity occurring between the bones of the tarsus during motion has been noted as early as the second half of the 19th century and has been extensively described by Huson [11,12]. Roentgen-stereophotogrammatic studies have demonstrated translation and rotation of the talus and calcaneus in relation to one another during inversion of the injured foot [19]. As a result, the calcaneus inverts in relation to the talus [17,23]. However, a tilting motion between the two bones is not mentioned. Kjaersgaard-Andersen et al. found an increase in adduction in the talocalcaneal joint to a maximum of 5° after cutting the calcaneofibular ligament [18]. Smaller increases were found after cutting the ligaments of the sinus and canalis tarsi only [17]. The results of a study performed by Heilman et al. [10], in which the calcaneofibular and talocalcaneal ligaments were selectively cut, suggest that this increase is a result of tilting, and Clanton [4], in a review article, concludes that it appears that any loss of parallelism is indicative of instability. In fact, practically all clinical radiographic studies on this matter, including the present study, have focused on finding a subtalar tilt to establish mechanical instability.

We now doubt that the tilt seen during the Brodén stress examination (Fig. 3) is the true amount of tilt. It seems that there is no important tilting in the subtalar joint and that it is erroneous to translate the pattern of motion, as applied to the ankle joint, to this joint. If surfaces have a curved geometry, as drawn in figure 4, some amount of tilt will occur when these planes translate and rotate on each other (Fig. 4B), but the angulation that seems to occur (Fig. 4C) is the result of viewing two planes that make such movements relative to each other in an oblique direction. Obviously, there is a direct relation between the amount of motion and the so-called tilt, but we suggest that determining the amount of translation and rotation in a direct manner might prove to be more helpful in objectifying abnormal motion in the subtalar joint. Recently, Kato [15] described a method to measure anterior displacement of the calcaneus in relation to the talus. This translation is only one
of the components. Harper [9] suggested that the assessment of the rotational component of hindfoot inversion might help to document subtalar instability. Possibly, a combination of both above mentioned components occurs, resulting in anterolateral rotatory instability of the subtalar joint. Further research must be performed to confirm these suggestions.

Finally, CT examination of the hindfoot itself might prove to be helpful in diagnosing problem cases with chronic lateral instability. Unexpectedly, a fibrous talocalcaneal coalition was found in four patients (Fig. 2). In these patients, the subjective complaints seem to be caused by disturbance of the coupling between the foot and the leg (possibly abnormal motion at the talocrural level) as a result of decreased motion in the tarsus rather than hypermobility.

References


