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Research Article

Reliability of the Assessment of Fibular Torsion Relative to Tibia at Syndesmosis using CT Scans

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Abstract

Background: The CT scans were better than X-ray plain in diagnosing injury of distal tibiofibular syndesmosis. At present, there lacks of systematic research on syndesmotic three-dimensional mismatch, especially for the measurement of rotational relationship.

Objective: To measure torsion of fibula relative to tibia at syndesmosis in normal persons using CT scans.

Methods: 21 male and 21 female volunteers were enrolled for measuring the anterior and posterior tibiofibular interval, fibula rotation angle, tibiofibular syndesmosis anterior surface tangent angle and tibiofibular syndesmosis posterior surface tangent angle on axial CT scans.

Results: The anterior tibiofibular interval, posterior tibiofibular interval, fibula rotation angle, tibiofibular syndesmosis anterior tangent angle and posterior tangent angle were 2.10 - 2.25 mm, 4.14 - 4.29 mm, 103.97° - 106.30°, 21.88° - 26.64°, 33.03° - 36.63° in form of 95% confidence interval, respectively. The fibula rotation angle had the smallest coefficient of variance (CV) with minor fluctuation, and was more representative and stable ($p = 0.091$, $CV = 0.035$).

Conclusion: The fibular rotation relative to tibia at syndesmosis was measured on the CT images of 42 healthy ankles. The fibula rotation angle was most reliable comparing to other parameters. It could be helpful for the surgeons to increase the accuracy of tibiofibular syndesmotic reduction in operation.

Keywords: *Ankle Fracture; Syndesmotic Injury; Fibula Position*

Introduction

Ankle injury was one of common injuries, the distal tibiofibular syndesmosis was frequently involved [1,2], which was need to be treated properly. Under traditional intraoperative two-dimensional fluoroscopy, due to the influence of the ankle joint rotation, the malreduction was unable to be diagnosed [3]. So 39% of the patients was found to have the abnormal tibiofibular syndesmosis with postoperative CT scans [4]. Therefore the three-dimensional fluoroscopy was used in clinical practice [5,6]. However, the parameters on CT scans reflecting the malrotation was not studied. In this project, the normal distal tibiofibular syndesmosis was measured using CT scans, some parameters about fibular torsion relative to tibia were investigated and aim to find a more sensitive and reliable parameter.

Materials and Methods

A total of 61 volunteers with age varied from 18 to 56 years were initially enrolled, and 7 volunteers were excluded according to the exclusion criteria: ankle fracture, distal tibiofibular injury, chronic ankle instability, ankle osteoarthritis, ankle sprains, ankle tumors, ankle surgery. The rest were divided into two groups by gender, male group with 28 cases and female group with 26 cases. 21 cases were randomly sampled in each group with average age of 38.3 years. Unilateral ankles were randomly selected for CT scanning, a total of 18 left ankles and 24 right ones.

CT scanning protocol: A 64 multi-sliced CT (GE, LightSpeed VCT) was utilized. The lower limb was positioned laterally with 90° bend of the knee and neutral of the ankle. Scanning was set from 10 cm above the tibial plafond to the distal fibula. All of which were done by the same radiologist. Tube voltage: 120 kvp; tube currency: 200 - 250 mA; FOV: 250 - 350 mm; thickness; 5 mm. The CT images were saved as DICOM 3.0 format.

Imaging post-reconstruction and measurement: The CT images were input into the PACS (Picture Archiving and Communication Systems) in our hospital. All the measurements were done by two orthopedists blindly in 3 different time (5-day interval), and the average value was then calculated. The measurement plane was 1 cm above the tibial plafond with distance and angle accuracy of 0.01 mm and 0.01 degree respectively.

Measurement indexs: P1: anterior tibiofibular interval: the distance from anterior tibial tubercle to adjacent cutting-edge fibula cortex (Figure 1). P2: posterior tibiofibular interval: the distance from posterior tibial tubercle to adjacent cutting-edge fibula cortex (Figure 2). P3: fibula rotation angle: the angle between the anterior tangent of tibia cortex and the axial line of fibula (Figure 3). P4: tibiofibular syndesmosis surface anterior tangent angle: the angle between anterior articular surface tangent and the axial line of the fibula (Figure 4). P5: tibiofibular syndesmosis surface posterior tangent angle: the angle between posterior joint surface tangent and the axial line of the fibula (Figure 5).

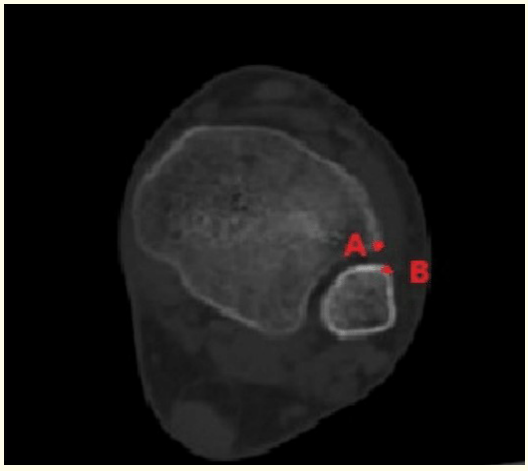

Figure 1: *The anterior tibiofibular interval: the distance between point A and point B. The measurement plane was 1 cm above the tibial plafond.*

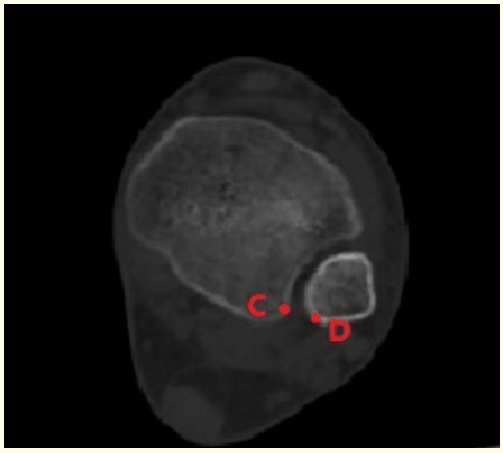

Figure 2: *The posterior tibiofibular interval: the distance between point C and point D. The measurement plane was 1 cm above the tibial plafond.*

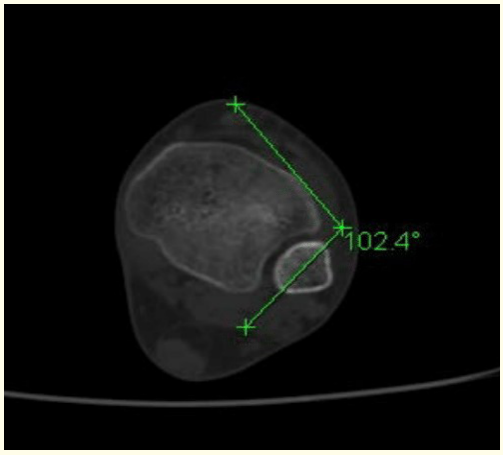

Figure 3: *The fibula rotation angle: the angle between the anterior tangent of tibia cortex and the axial line of fibula.*

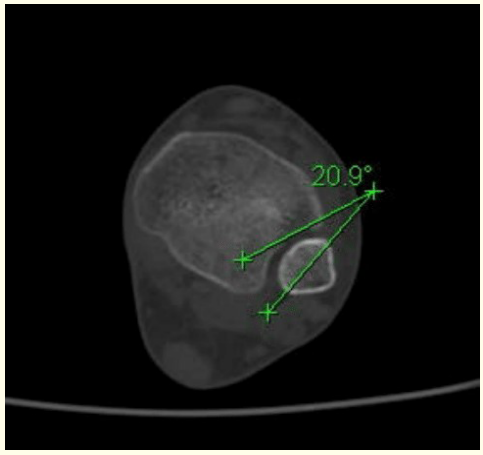

Figure 4: *The tibiofibular syndesmosis surface anterior tangent angle: the angle between anterior articular surface tangent and the axial line of the fibula.*

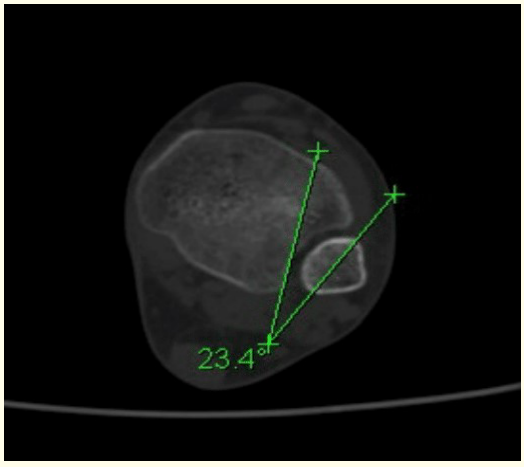

Figure 5: *The tibiofibular syndesmosis surface posterior tangent angle: the angle between posterior joint surface tangent and the axial line of the fibula.*

Reliability evaluation: In order to evaluate the reliability of the measurement, 42 cases of ankle by two independent investigators to determine the appropriate measuring line and completed all the measurement. Three measurement with interval at least two weeks, two investigators were orthopedist and radiologist.

Statistical analysis: All the parameters were tested by t test (x(_)±s, a = 0.05). All the parameters were estimate with 95% confidence interval. The distribution of measurement data was similar to normal distribution. The central tendency was described by the mean number and the discrete trend was described by the standard deviation. Because of the different measurement unit, we used the coefficient of variance (CV) to compare the variability.

Results

54 cases in the 61 volunteers met the study requirements based on the inclusion and exclusion criteria. 42 volunteers included 21 males and 21 females were randomly selected from the 54 cases to complete the experiment and all involved in the result analysis. The average age of the study group was 38.3 years.

The 95% confidence interval of anterior tibiofibular interval, posterior tibiofibular interval, fibula rotation angle, tibiofibular articular anterior surface tangent angle and tibiofibular articular posterior surface tangent angle were 2.10 - 2.25 mm, 4.14 - 4.29 mm, 103.97° - 106.30°, 21.88° - 26.64°, 33.03° - 36.63° respectively (Table 1). Only anterior tibiofibular interval between the male and the female group had significant difference (P = 0.014). The rest of the parameters had no significant difference (P > 0.05) (Table 2). Each coefficient of variation between the indexes were shown in table 3, coefficient of variation of the fibular rotation angle was the smallest, relatively small fluctuation and more representative, followed by subsequent posterior tibiofibular interval, anterior tibiofibular interval, tibiofibular syndesmosis posterior surface tangent angle, tibiofibular syndesmosis anterior surface tangent angle.

Index	Overall	Confidence interval
P1 (mm)	2.17 ± 0.24	2.10 - 2.25
P2 (mm)	4.22 ± 0.25	4.14 - 4.29
P3 (°)	105.14 ± 3.65	103.97 - 106.30
P4 (°)	24.26 ± 7.63	21.88 - 26.64
P5 (°)	34.84 ± 5.79	33.03 - 36.63

Table 1: *95% confidence intervals of indicators of ankle joint.*

P1: Anterior Tibiofibular Interval; P2: Posterior Tibiofibular Interval; P3: Fibula Rotation Angle; P4: Tibiofibular Syndesmosis Anterior Surface Tangent Angle; P5: Tibiofibular Syndesmosis Posterior Surface Tangent Angle

Index	Male	Female	P
P1 (mm)	2.26 ± 0.20	2.08 ± 0.26	0.014
P2 (mm)	4.29 ± 0.25	4.14 ± 0.24	0.061
P3 (°)	105.31 ± 3.55	104.96 ± 3.83	0.091
P4 (°)	24.24 ± 7.25	24.28 ± 8.16	0.989
P5 (°)	35.83 ± 5.83	33.84 ± 5.72	0.272

Table 2: *Comparison of the indicators of ankle joint between male and female patients (x ± s).*

P1: Anterior Tibiofibular Interval; P2: Posterior Tibiofibular Interval; P3: Fibula Rotation Angle; P4: Tibiofibular Syndesmosis Anterior Surface Tangent Angle; P5: Tibiofibular Syndesmosis Posterior Surface Tangent Angle

Index	Overall	Male cv	Female cv
P1 (mm)	0.111	0.088	0.125
P2 (mm)	0.059	0.058	0.058
P3 (°)	0.035	0.034	0.036
P4 (°)	0.303	0.336	0.336
P5 (°)	0.166	0.169	0.156

Table 3: *Variation coefficient of indicators of ankle joint.*

P1: Anterior Tibiofibular Interval; P2: Posterior Tibiofibular Interval; P3: Fibula Rotation Angle; P4: Tibiofibular Syndesmosis Anterior Surface Tangent Angle; P5: Tibiofibular Syndesmosis Posterior Surface Tangent Angle

Discussion

Anatomic reduction of the distal tibiofibular syndesmosis had been reported to improve the functional outcomes of patients who had ankle fracture with instability of the syndesmotic complex [7,8]. The slight fibular dislocation may have substantial influence on the biomechanics of the ankle joint [9,10]. Recently, the cadaver experiments showed that the tibiotalar contact area decreased significantly as displacement increased from 361.1 mm^2 (no displacement) to 162.2 mm^2 (2 mm lateral displacement) and to 82.6 mm^2 (4 mm lateral displacement) [11]. The decreasing of tibiotalar contact area and rupture of syndesmotic complex were the important reasons lead to instability and arthritis of ankle joint [12,13]. Therefore, it was very important to achieve anatomic reduction of tibiofibular syndesmosis. Under traditional two-dimensional radiographs, due to the influence of the ankle joint rotation, the malreduction was unable to be diagnosed [3]. Computed tomography was believed to be the more accurate method for assessment of the rotational profile of distal fibula, and may detect the malreduction not appreciated on two-dimensional radiographs [15].

Zwipp measured the fibula rotation displacement was the most common due to the fact that the distal tibiofibular syndesmotic ligaments were damaged. Zwipp measured the fibula rotation angle compared with the contralateral side but not compared with the ipsilateral side [18]. However, various literatures showed that there was that left and right sides distal tibiofibular syndesmosis may be different [16,17]. The fibular rotation relative to tibia at the syndesmosis on the normal human being instead of cadaver and compared with other parameters of ipsilateral side was performed in our study. The level of measurement and observation depended on the cuts on 1cm above the tibial plafond.

Due to dimension of these indexes were different in the research, the coefficient of variance (CV) was used to access the reliability and accuracy of the five indexes of fibular torsion relative to tibia. According to the study, above all of these measurement indexes could reflect the torsion relationship of fibula relative to tibia in a certain degree. However, the fibula rotation angle was the most stable and reliable, minor data variability. The fibula rotation angle was the angle between tibia cortex former tangent the bisection of the vertical midline of fibula, the 95% confidence interval was 103.97° - 106.30°, in addition, the difference between male and female had no statistical significance. The overall CV of fibula rotation angle was 0.035, the numerical value was the smallest among the five indexes.

The anterior tibiofibular interval was the distance from the anterior nodule adjacent to cutting-edge fibula cortex, and the 95% confidence interval was 2.10 - 2.25 mm. Moreover, the difference between male and female had statistical significance, the overall CV was 0.111. The posterior tibiofibular interval was the distance from the posterior nodule adjacent to cutting-edge fibula cortex, the 95% confidence interval was 4.14 - 4.29 mm and the difference between male and female had no statistical significance, the overall CV of was 0.059. The CV of above two indexes was more than CV of fibula rotation angle.

The tibiofibular articular anterior surface tangent angle was the angle between the anterior joint surface tangent and fibular axial line, the 95% confidence interval was 21.88° - 26.64° and the overall CV was 0.303. The tibiofibular articular posterior surface tangent angle was the posterior joint surface tangent and fibular axial line, the 95% confidence interval was 33.03° - 36.63° and the overall CV was 0.166. The difference between male and female had no statistical significance in the both indexes. Defining the front and back joint surfaces of the deep curved and symmetrical individuals was relative stable. However, delimiting for the tangent was difficult for the shallow curved individuals (Figure 6), because the variation was larger.

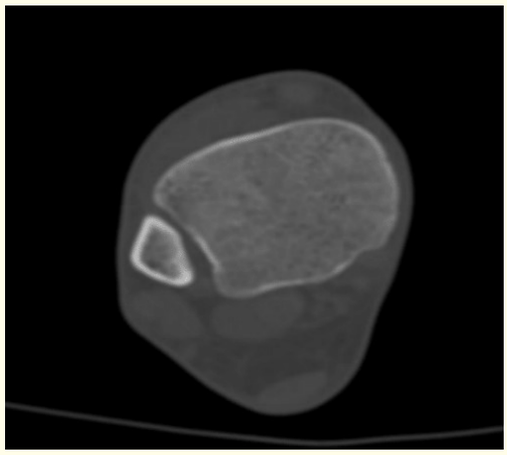

Figure 6: *The distal tibiofibular syndesmosis surface was shallow curved.*

A suitable parameter of distal tibiofibular syndesmosis should be: defining the measurement of anatomical marks was relatively stable, easy to identify; the measurement index was as simple as possible and repeatable strongly. In our study, on the axial CT images, the axial line was the fibula longest meridian and the anterior cortex tangent was the highest point of anterior tibial cortex tangent, which were relatively constant anatomical axis, easy to identify in the process of delimiting and to repeat.

The weakness in the study was the sample size was little and no further compare to the patients with syndesmotic injury. For some patients with syndesmotic injury or ankle fracture were in plaster splint, the position of the ankle was difficult to control. So the measurement outcomes of these patients were not easy to compare with normal people. The anatomical variant of foot and ankle was also not recorded, this might change the measurement outcomes. However, this study provided a series of parameters for diagnosing injuries of tibiofibular syndesmosis, and the fibula rotation angle was most reliable based off CT Scans.

Conclusion

The fibular rotation relative to tibia at syndesmosis were measured on the CT images 42 healthy ankles. The fibula rotation angle was most reliable comparing to other parameters. It could be helpful for the surgeons to increase the accuracy of tibiofibular syndesmotic reduction in operation.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

No authors received financial support for the research.

Ethical Approval

This study had been approved by the local ethics committee.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

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