ORIGINAL ARTICLE

CONTENTS

Change of the anterior talus-fibular ligament length of asymptomatic patients during inversion stress test

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ABSTRACT

Aim: To study the ATFL length among asymptomatic population of young patients on both joints by using the method of ultrasound examination of the ankle joint and applying the inversion stress test.

Materials and Methods: the length of the ATFL was measured among 60 boys and 60 girls during the research. Sonography was performed on both joints, in each of the two studied positions, three times per position in order to obtain the average ligament length. A total of 720 examinations were conducted.

Results: According to the results of sonographic research, the average length of the ATFL of the right ankle joint of young men in a neutral position was 19,08±0,3 mm, of the left one – 19,08±0,31 mm. During the inversion stress test, the length of the ligament increased on the right up to 19,65±0,3 mm, on the left – up to 19,63±0,3 mm. The average length of the ATFL of the right ankle joint of girls in neutral position was 16,92±0,2 mm, of the left one – 16,9±0,19 mm. During the inversion stress test, the length of the ligament increased on the right up to 17,37±0,2 mm, on the left – up to 17,36±0,20 mm. Statistical difference of the length of the ATFL of both joints between the neutral position and the stress test was at the level p<0,001 among boys and girls.

Conclusions: Comparison of the length of the anterior talus-fibular ligament of boys and girls in different positions during testing of both joints indicates a statistically significant difference at the level (P <0,001).

KEY WORDS: ankle joint, anterior talus-fibular ligament, inversion stress test, stress sonography

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INTRODUCTION

Trauma of ligaments of the ankle joint belongs to the most common injuries, both in everyday life and in sports. It is the reason for requests for urgent medical help in 20% of cases, however, total number of these injuries is much higher, since less than half of all people with ligament damage of this specified localization seek qualified medical assistance [1].

Patients with ligament damage are usually young and physically active people between 14 and 24 years old. [2]. More than 65% of cases are isolated injuries of the anterior talus-fibular ligament (ATFL). Interest in this ligament is due to the fact that it is considered the main means of protection against injuries, associated with ankle joint inversion combined with plantar flexion [3].

The consequences of ligament damage can lead to a number of chronic residual symptoms, which are diagnosed among from 40% to 50% of patients and include injury recurrence, chronic pain, chronic instability, osteoarthritis, adverse psychological effects [4].

The diagnosis of ligament damage is established on the basis of the patient's complaints, the mechanism of trauma occurrence, study of the local status, conducting of diagnostic tests and use of additional diagnostic methods. It is well known that there is limited evidence of the use of many specific orthopedic tests, which are widely used at injuries of ankle joint ligaments [5].

Among the non-invasive instrumental methods of diagnosis, they most often use stress radiography and magnetic resonance tomography. Stress radiography is often not informative enough to establish a final diagnosis [6]. Magnetic resonance imaging is the most accurate diagnostic method for assessing ligament damage, considering its high resolution and accuracy, however, its use in case of an acute injury of the specified location is not considered appropriate [7].

In order to improve the results of diagnostics, sophisticated devices and structures are introduced, but they are unlikely to be widely used in everyday practice during study of the state of the ATFL [8, 9].

Today, sonography is becoming increasingly important for the assessment of the ligamentous system of the ankle joint because of low cost, speed, availability and absence of ionizing radiation [10]. Unlike MR- images, it allows to perform dynamic maneuvers, which increses the level of visualization of intact ligaments and improves localization of their injuries [11-13].

Dynamic sonography has a high potential for detecting ankle joint ligament instability, but the parameters of the normative values of change of the length of the anterior talus-fibular ligament during stress tests in different age groups have not been fully determined.

AIM

To study changes of the anterior talus-fibular ligament length among asymptomatic population of young patients by using the device and the method of ultrasound examination of the ankle joint during applying the inversion stress test on both ankle joints.

MATERIALS AND METHODS

The research was conducted using an ultrasound console Acuson Antares (Siemens) applying a high-frequency broadband linear sensor with the operating frequency 7–12 MHz and using a standard acoustic gel.

The researcher visualized and measured the length of the anterior talus-fibular ligament of all examined persons in two positions, three times per position, in order to obtain the average length of the ligament. The examined persons relaxed the lower limb in the intervals between measurements, in order to avoid possible distortions of motion range due to the development of muscle contracture.

In the first position (position A), the examined persons were lying on the couch, the examined lower limb was placed on the device for ultrasound examination of the ankle joint in the position of bending in the knee joint at an angle 45°, and the area of the ankle joint hung freely in the position of plantar flexion at the angle 20° (Fig. 1. A.). This position was defined as the neutral resting position and as the baseline value for each subsequent measurement of the ATFL length.

The sonographic sensor was placed in accordance with the anatomical localization of the ATFL almost parallel to the sole of the foot (Fig. 1. B.)

A. Neutral position of the examined lower limb, the lower leg is placed on the ultrasound device. B. Location of the sonographic sensor for sonography of the anterior talus-fibular ligament in a neutral position.

During the sonographic examination, the distance from the anterolateral edge of the lateral bone was measured, which corresponds to the beginning of the ATFL, to the anterolateral corner of the lateral surface of the talus, which corresponds to the anatomical location of ligament fixation. The length of the anterior talus-fibular ligament was determined as a straight line between these two bony reference points, and was measured on a longitudinal ultrasound image made along the course of its fibers (Fig. 2. A, B).

In the second position (position B, of maximum inversion): examined persons were lying on the examination table, in the standard starting position. The researcher performed maximum inversion in the ankle joint till tissue resistance began.

The length of the anterior talus-fibular ligament in the position of the inversion stress test was defined as a straight line between the bone reference points described above, and measured on a longitudinal ultrasound image, which was performed along the course of its fibers (Fig. 3. A, B).

STATISTICAL ANALYSIS

Statistical analysis was performed using the software Statistica 8.0. Results were presented as average values with 95% confidence intervals. The Shapiro-Wilk test was used to confirm whether the data were normally distributed. Student's criterion was used to compare the continuous data. A Wilcoxon signed-rank test was performed to compare ultrasound results for the right and the left ankle.

RESULTS

The research was conducted in 2022-2023. The students of Ternopil National Medical University voluntarily participated in it. We examined the ankle joints of both limbs of 60 boys and 60 girls. The sample did not include persons with a medical history including injury of ligament of the ankle joint, operative interventions of the specified area, positive tests for joint hypermobility syndrome. All enrolled subjects signed a consent form prior to participating in the study.

Sonography was performed three times in a neutral position and during the inversion stress test. The average length of the anterior talus-fibular ligament of the right and the left ankle joint in each position was included in the protocol. In total 720 tests were carried out.

The morphometric characteristics of the examined persons is given in the Table 1.

According to the results of sonographic research, average length of the anterior talus-fibular ligament

Fig. 1. Neutral position for examining the length of the anterior talus-fibular ligament.

Table 1. Morphometric characteristics of the examined persons

Parameters	Boys	Girls
Age, years	22,63±0,11	22,54±0,12
Height, cm	181,42±0,74	168,68±0,69
Foot length, size cm	42,87±0,15	37,97±0,16
Body weight, kg	76,38±1,22	59,63±0,92
Body weight index, conventional unit	21,14±0,28	18,05±0,25

Table 2. The length of the anterior talus-fibular ligament of the ankle joint of the examined persons in different test positions

Group	Test state	The length of the anterior talus-fibular ligament, the right ankle joint	The length of the anterior talus-fibular ligament, the left ankle joint	Statistical difference between the ligaments of the right and the left joint, P	Statistical difference of ligament length in different positions, the right joint, P	Statistical difference of ligament length in different positions, the left joint, P
Boys	Neutral position, mm	19,08±0,3	19,08±0,31	>0,05	<0,001	<0,001
	Stress test, mm	19,65±0,3	19,63±0,3	>0,05		
	Difference of ligament length, mm	0,57	0,56	>0,05		
Girls	Neutral position, mm	16,92±0,2	16,9±0,19	>0,05	<0,001	<0,001
	Stress test, mm	17,37±0,2	17,36±0,2	>0,05		
	Difference of ligament length, mm	0,45	0,45	>0,05		

of the right ankle joint of young men in a neutral position was 19,08±0,3 mm (Table II). The length of the ligament increased up to 19,65±0,3 mm during maximum inversion stress test. The difference of

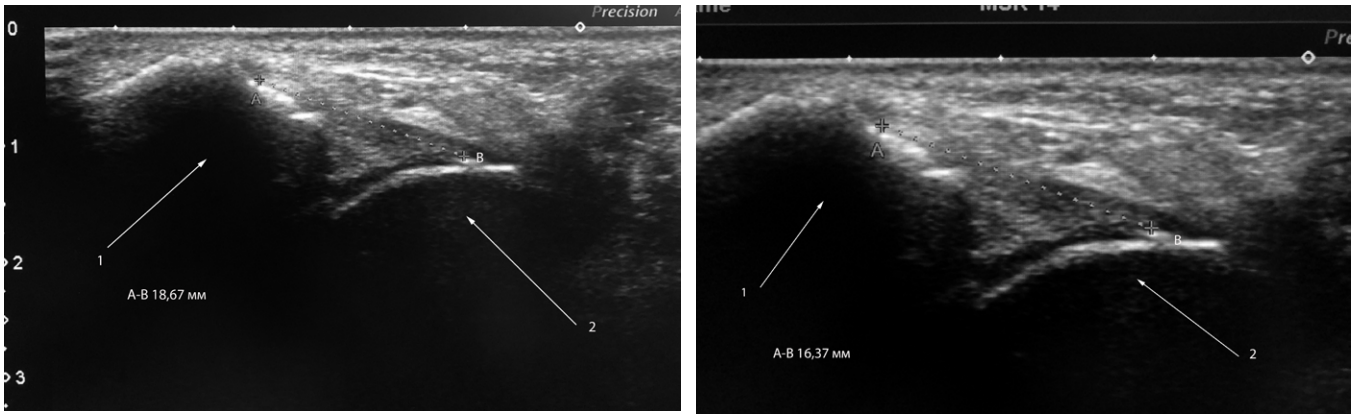

Fig. 2. Length measurement of the anterior talus-fibular ligament (ATFL) in a neutral position during sonography.
A. Dimensions of the anterior talus-fibular ligament in a neutral position of the examined person, male (A-B measurement points of the anterior talus-fibular ligament in a neutral position, 1 – splintbone; 2 – talus).
B. Dimensions of the anterior talus-fibular ligament in a neutral position of the examined person, female (A-B measurement points of the anterior talus-fibular ligament in a neutral position, 1 – splintbone; 2 – talus).

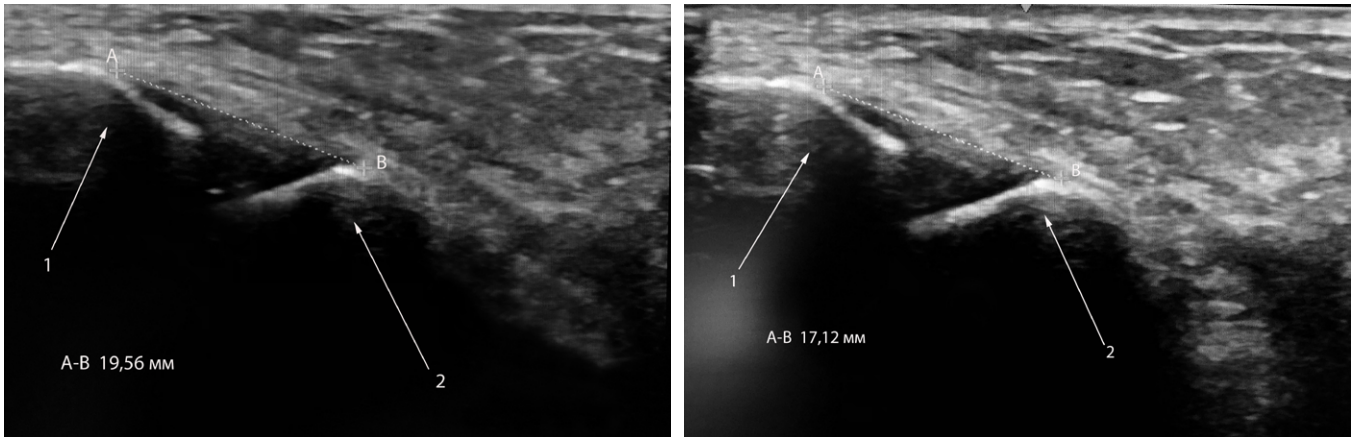

Fig. 3. Length measurement of the anterior talus-fibular ligament in the position of the inversion stress test during sonography.
A. Dimensions of the anterior talus-fibular ligament in a maximum position of the inversion stress test of the examined person, male (A-B measurement points of the anterior talus-fibular ligament, 1 – splintbone; 2 – talus).
B. Dimensions of the anterior talus-fibular ligament in a maximum position of the inversion stress test of the examined person, female (A-B measurement points of the anterior talus-fibular ligament, 1 – splintbone; 2 – talus).

the ligament length between neutral position and maximum inversion was 0,57 mm. 95% DI in the neutral position was 0,078 mm (19,01-19,16 mm), and during the inversion stress test – 0,078 mm (19,58-19,73 mm). ATFL extension in percentage terms was 2,99%. Statistical difference of the length of the anterior talus-fibular ligament of the right ankle joint between the neutral position and the stress test was at the level of $p<0,001$.

As for girls, average length of the anterior talus-fibular ligament of the right ankle joint in a neutral position was 16,92±0,2 mm (Table 2). At maximum inversion it increased up to 17,37±0,2 мм. 95% DI amounts 0,05 mm in both positions: in a neutral position within 16,87-16,97 mm, and during the stress test – 17,32-17,42 mm. The difference of the ligament length between neutral position and maximum inversion was 0,45 mm. In percentage terms it was 2,67%. As for girls, statistical difference of the length of the anterior talus-fibular ligament of the right ankle joint between the neutral position and the stress test was at the level of $p<0,001$.

Sonographic research of the ATFL the left ankle joint of girls showed that in the neutral position its length was 16,9±0,19 mm, and during the inversion stress test – 17,36±0,20 mm. 95% DI (confidence interval) in both positions was 0.05 mm: in neutral position it was within the limits 16,85-16,95 mm, and during the inversion stress test – 17,31-17,42 mm. The difference of the ligament length between neutral position and maximum inversion was 0,45 mm, and in percentage terms it was 2,66%. As for girls, statistical difference of the length of the anterior talus-fibular ligament of the left ankle joint between the neutral position and the stress test was at the level of $p<0,001$.

Our research shows that statistically significant difference between the parameters of the ATFL ligament of the right and the left ankle joint is absent in the group of boys and girls, both in the neutral position and during the inversion stress test (P>0,05).

Length comparison of the ATFL of boys and girls in different positions during testing of both joints indicates a statistically significant difference between the parameters of boys and girls at the level of p<0,001

Difference of the ligament length of the right ankle joint of boys is 0,57 mm, and of girls – 0,45 mm. A similar situation is observed with the length of the anterior talus-fibular ligament of the left ankle joint in different positions: 0,56 and 0,45 mm.

DISCUSSION

With increasing the evidence of efficiency and accuracy of sonography of the musculoskeletal system, more and more attention is paid to ultrasound methods of diagnosing injuries of the anterior talus-fibular ligament (ATFL). So, Oae K. et. al. Informed about the high accuracy of using longitudinal ultrasound examination of ATFL at identification of morphological changes indicating its damage [14]. Study of ligament dimensions was carried out both on cadaveric material and by instrumental methods. Inchai C.et al., while studying fresh-frozen cadavers with ages at death ranging from 25 to 90 years old [15] established, that average dimensions of the anterior talus-fibular ligament were 19,54±2,96 mm. During MRI studies, the average length of ATFL was from 21,5±0,5 mm to 24,5±3,3 mm and significant differences in size between its one- and two-bundle structure were not found [16].

Longitudinal sonographic measurement between bony attachment ATFL showed that its visible length varies in the neutral position from 16,1±3,63 mm to 21,73±2,67 mm [17]. With inversion load, it can increase up to 23,14±2,49 mm [18].

The results of our research show that the average length of the right of the ATFL of boys in the neutral position was 19,08±0,3 mm. Average length values increased to 19,65±0,3 mm during the maximum inversion stress test. Average length of the left anterior talus-fibular ligament of boys in the neutral position was 19,08±0,31 mm. It increased to 19,63±0,3 mm during maximum inversion. Average values of the length of both the right and the left left anterior talus-fibular ligament of girls in the neutral position were 16,92±0,2 mm for the right ankle joint and 16,9±0,19 mm for the left ankle joint. It increases to 17,37±0,2 mm та 17,36±0,2 mm accordingly during the inversion stress test. Thus, the average length of the ATFL of both boys and girls according to the results of our research corresponds with the data obtained by Mizrahi D.J et. al. [19]. Extension of the ATFL of boys in percentage terms it was 2,99% for the right ankle joint and 2,88% for the left ankle joint. Extension of the ligament of girls accordingly was 2,67% and 2,66%. These results correspond with the data obtained by Jeys L. et al. [20], which indicate that change of the ATFL length during movement is less than 5%.

The results of our research regarding the definition of the average length of ATFL of boys and girls in neutral position and during inversion are within the limits reported by Croy et al. for neutral position and inversion, 18,6±1,5 mm and 19,9±2,3 mm respectively [21]. The length of the anterior talus-fibular ligament both in the neutral position and during maximum inversion stress test of boys compared to girls was longer (P <0,001).

Potential limitation of this research was that the exact force applied during manual loading wasn't measured, however, maximal loading in plantar flexion and talar bone inversion can be reproduced in clinical conditions.

CONCLUSIONS

Our research shows that statistically significant difference between the parameters of the ATFL ligament of the right and the left ankle joint is absent in the group of boys and girls, both in the neutral position and during the inversion stress test (P>0,05).

Length comparison of the ATFL of boys and girls in different positions during testing of both joints indicates a statistically significant difference between the parameters of boys and girls at the level of P<0,001

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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