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Anatomical Investigation of the Flexor Retinaculum Covering the Tarsal Tunnel in Formaldehyde-Fixed Cadavers

Formaldehit Fikse Kadavralarda Tarsal Tüneli Kaplayan Retinaculum Flexorum'un Anatomik Olarak İncelenmesi

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ABSTRACT

Aim: The flexor retinaculum lies between the medial malleolus of the tibia and the medial process of the calcaneus. It converts grooves on the tibia and calcaneus into the tarsal tunnel. The aim of this study was to analyze the morphometry, the course, and the shape of the flexor retinaculum covering the tarsal tunnel in formaldehyde-fixed cadavers.
Material and Methods: Six lower extremities of four formaldehyde-fixed cadavers (four right sides, and 2 left sides) were examined to evaluate the morphometry of the flexor retinaculum. The cadavers were two females and two males with an age range of 60-89 years. A digital caliper (150 mm) and a light microscope were used for measuring parameters. The central length, proximal, midpoint, and distal width, thickness, course, and shape of the flexor retinaculum were examined in this study.
Results: The mean central length of the flexor retinaculum was found 42.26±5.18 mm. The mean proximal, midpoint, and distal width of the flexor retinaculum were 29.29±7.29 mm, 29.92±3.66 mm, and 29.76±8.13 mm, respectively. The mean of the thickness was measured at 234.94 µm. The flexor retinaculum coursed vertically in four extremities and coursed obliquely in two extremities. The shape of the retinaculum was triangular in five extremities and quadrangular in only one extremity.
Conclusion: The morphometric data obtained from this study can help surgeons during the operations of the tarsal tunnel syndrome. To our knowledge, the width and course of the flexor retinaculum were examined for the first time in this study.
Keywords: Flexor retinaculum; ankle joint; tarsal tunnel syndrome; morphometry.

ÖZ

Amaç: Retinaculum flexorum, tibia'nın malleolus medialis'i ile calcaneus'un processus medialis'i arasında uzanır. Retinaculum flexorum, tibia ve calcaneus üzerindeki olukları tarsal tünele dönüştürür. Bu çalışmanın amacı, formaldehit fikse kadavralarda tarsal tüneli kaplayan retinaculum flexorum'un morfometrisini, seyrini ve şeklini incelemektir.
Gereç ve Yöntemler: Dört formaldehit fikse kadavraya ait olan altı adet alt ekstremite (dört sağ taraf ve iki sol taraf), retinaculum flexorum morfometrisini değerlendirmek için incelendi. Yaş aralığı 60-89 yıl arasında olan kadavraların ikisi kadın ve ikisi ise erkek idi. Parametrelerin ölçümü için bir dijital kumpas (150 mm) ve bir ışık mikroskobu kullanıldı. Bu çalışmada retinaculum flexorum'un santral uzunluğu, proksimal, orta nokta ve distal genişliği ile kalınlığı, seyri ve şekli incelendi.
Bulgular: Retinaculum flexorum'un ortalama santral uzunluğu 42,26±5,18 mm olarak bulundu. Retinaculum flexorum'un proksimal, orta nokta ve distal ortalama genişliği ise sırasıyla 29,29±7,29 mm, 29,92±3,66 mm ve 29,76±8,13 mm olarak ölçüldü. Retinaculum flexorum'un kalınlığı ortalama olarak 234,94 µm olarak bulundu. Retinaculum flexorum'un seyri, dört ekstremitede dikey ve iki ekstremitede ise oblik olarak bulundu. Retinaculum'un şekli beş ekstremitede üçgen ve sadece bir ekstremitede ise dörtgen idi.
Sonuç: Bu çalışmadan elde edilen morfometrik veriler tarsal tünel sendromu ameliyatları sırasında cerrahlara yardımcı olacaktır. Bildiğimiz kadarıyla retinaculum flexorum'un genişliği ve seyri ilk kez bu çalışmada incelenmiştir.
Anahtar kelimeler: Retinaculum flexorum; articulatio talocruralis; tarsal tünel sendromu; morfometri.

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INTRODUCTION

The flexor retinaculum lies between the medial malleolus of the tibia and the medial process of the calcaneus bone. Proximally, there is no obvious boundary between its border and the deep fascia of the leg (1-4). Distally, its border is continuous with the plantar aponeurosis. Fibres of the abductor hallucis muscle are attached to the distal border of the flexor retinaculum. The flexor retinaculum converts grooves on the tibia and calcaneus into the tarsal tunnel (2). The structures pass through the tarsal tunnel from medial to lateral are the tibialis posterior muscle, flexor digitorum longus muscle, posterior tibial artery/vein, tibial nerve, and flexor hallucis longus muscle (2,5). The main function of the flexor retinaculum is to prevent dislocation of the flexor digitorum longus and the tibialis posterior tendons over the medial malleolus edge during ankle joint movements (6).

The tibial nerve may be compressed at the level of the tarsal tunnel as the nerve passes under the flexor retinaculum (2,7,8). This pathologic nerve entrapment is called "tarsal tunnel syndrome" (4,9). This syndrome was initially described by Kopell and Thompson in 1960 (10). The tibial nerve compression can occur by trauma, repetitive stress, external compression by osseous prominences, edema, perineural fibrosis, pseudoaneurysms, accessory muscles, ganglion cysts, and tumors (5,7,8,11-16). The most common symptoms of tarsal tunnel syndrome are burning, tingling, and shooting pain along the heel and medial aspect of the ankle joint (5,11,17).

The flexor retinaculum is a thin structure composed of three layers: the inner one is a smooth layer to enable gliding; a thick middle layer that contains collagen bundles, fibroblasts, and elastin fibers supports; and the outer layer that contains vascular channels covers the other two layers (1,18). This retinaculum is a broad, narrow collagen structure that reinforces the crural fascia inferiorly and posteriorly (18).

The aim of this study was to analyze the morphometry, the course, and the shape of the flexor retinaculum covering the tarsal tunnel in formaldehyde-fixed cadavers.

MATERIAL AND METHODS

Seven lower extremities of four formaldehyde-fixed cadavers were dissected carefully to evaluate the morphometry of the flexor retinaculum. In one extremity, the borders of the flexor retinaculum could not be distinguished from the crural fascia, and this extremity was excluded from the study. The cadavers included in this study were two females and two males with an age range of 60-89 years. Six lower extremities (four right, and two left sides) were examined for this study. All lower extremities were free from pathology, trauma, surgical incision, or deformity. Dissections were made in the gross anatomy dissection laboratory of Hacettepe University. Ethical approval for this study was obtained from the ethics committee of our institution (June 20, 2023; 11-36). The study was conducted following the Declaration of Helsinki.

A digital caliper (150 mm) was used for measuring the length and width of the flexor retinaculum. Before each measurement, correction of the caliper was done. The light microscope was used for measuring the thickness. The parameters evaluated in this study were as follows: i) the central length (Figure 1), ii) the proximal, iii) the midpoint, iv) the distal width (Figure 2), v) the thickness (Figure 3), vi) the course, and vii) the shape of the flexor retinaculum.

Statistical Analysis

Descriptive statistics analyses were performed using the IBM SPSS Statistics v.23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) program. The descriptive statistics of parameters were summarized as the mean, standard deviation, minimum, and maximum values.

RESULTS

Six formaldehyde-fixed lower extremities (four right sides, and two left sides) were examined to evaluate the morphometry of the flexor retinaculum. It was difficult to identify the proximal and distal borders of the flexor retinaculum since the flexor retinaculum was a contiguity with the deep crural fascia. However, fine and careful dissection was performed starting from the middle part of the leg. Skin and crural fascia were dissected slowly. During fascia dissection, it was observed that the flexor retinaculum was thicker than the fascia on the medial side of the ankle joint. After the borders of the flexor retinaculum were determined by the decision of three anatomists, measurements were done. In one extremity, the borders of the flexor retinaculum could not be distinguished from the crural fascia, so this extremity was excluded from the study.

The mean central length of the flexor retinaculum was found 42.26±5.18 mm in general. The mean proximal, midpoint, and distal width of the flexor retinaculum were measured at 29.29±7.29 mm, 29.92±3.66 mm, and 29.76±8.13 mm, respectively. The thickness of the flexor retinaculum was measured from different regions using with light microscope and its mean value was found to be 234.94 (min-max: 225.60-241.95) μm. Measurements of the flexor retinaculum were summarized in Table 1.

After measuring the length, width, and thickness of the flexor retinaculum, we examined the course and shape of the retinaculum. The flexor retinaculum coursed vertically in four extremities and coursed obliquely in two extremities. The shape of the retinaculum was found to be triangular in five extremities and quadrangular in only one extremity.

Table 1. Morphometric measurements of the flexor retinaculum

Flexor Retinaculum Measurements	Right Side (mm)	Left Side (mm)	General (mm)
Central Length (AB)	43.34±2.94	40.09±9.69	42.26±5.18
Proximal Width (CD)	30.18±9.19	27.52±1.63	29.29±7.29
Midpoint Width (EF)	31.07±1.42	27.61±6.70	29.92±3.66
Distal Width (GH)	29.40±7.08	30.49±13.35	29.76±8.13

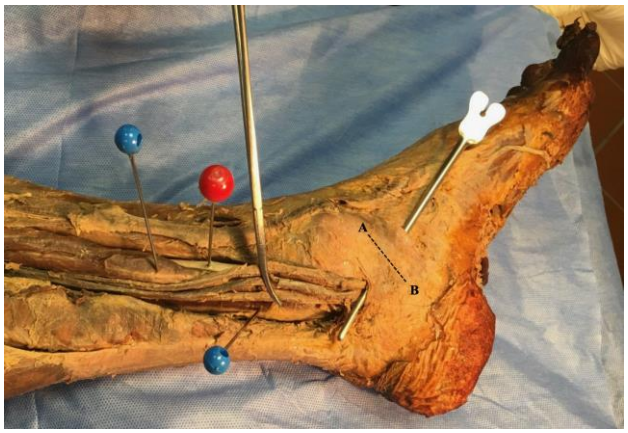

Figure 1. The central length of the flexor retinaculum (AB)

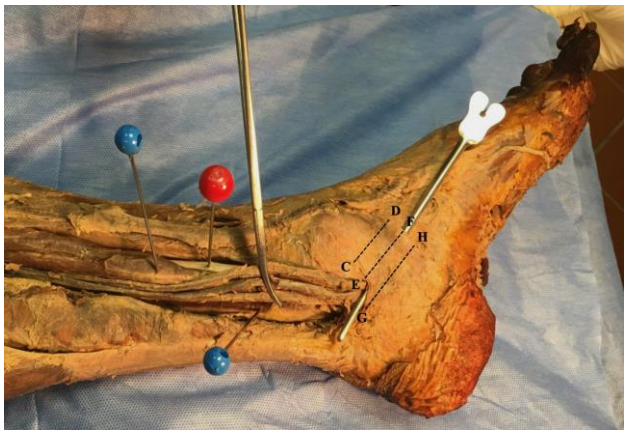

Figure 2. The proximal (CD), midpoint (EF), and distal width (GH) of the flexor retinaculum

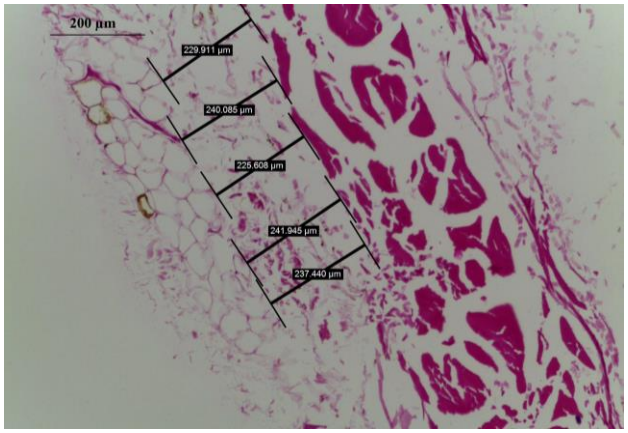

Figure 3. The thickness of the flexor retinaculum

DISCUSSION

The flexor retinaculum is placed on the medial side of the ankle joint and encloses the tarsal tunnel. It has a roughly triangular shape and extends from the medial malleolus of the tibial bone to the posterosuperior aspect of the calcaneus (1).

Mattos et al. (17) dissected 40 lower extremities, but only 9 specimens showed a denser consistency of flexor retinaculum. They measured the mean length of the flexor retinaculum 51.9 (min-max: 43-62) mm in 9 specimens. They found that the flexor retinaculum was an undistinguished extension of the crural fascia in 31 specimens. El Shazly et al. (7) dissected 12 intact adult lower limb specimens (seven left feet specimens, five right feet specimens) and they measured the length of the flexor retinaculum 29.58±1.88 (min-max: 26-32) mm. In our study, we found the central length of the flexor retinaculum 42.26±5.18 mm, higher than El Shazly et al.'s (7) study, but lower than Mattos et al.'s (17) study. The difference between our result and the literature was thought to be due to ethnic differences. These ethnic differences should be taken into consideration in surgical interventions to the medial side of the ankle joint.

Numkarunarunrote et al. (1) evaluated the flexor retinaculum on 10 fresh foot and ankle specimens using 1.5-T with magnetic resonance imaging (MRI). While they measured the thickness of the flexor retinaculum as 0.9 (min-max: 0.7-1.0) mm, they could not evaluate the shape of the flexor retinaculum in their study because of its very thin structure. Stecco et al. (6) analyzed MRI images of 7 voluntary subjects, 17 subjects with ankle sprain and 3 amputated legs. They measured the thickness of the flexor retinaculum as 1.15±0.16 mm around the Achilles tendon and as 1.4±0.22 mm on the tarsal tunnel. El Shazly et al. (7) performed an ultrasonographic study on 10 patients (11 feet) and 14 normal volunteers (28 feet) to examine the flexor retinaculum. They measured the thickness of the flexor retinaculum at 0.81±0.09 mm in the patients group and at 0.64±0.04 mm in the healthy subjects group. They found that there was a statistically significant difference in the thickness of the retinaculum between these two groups. In the present study, we measured the thickness of the flexor retinaculum as 234.94 µm (0.23 mm), lower than the other studies in the literature. This difference may be because of the use of different examination techniques. The other studies in the literature (1,6,7) used MRI and ultrasonographic methods to measure the thickness. However, we performed cadaveric dissections and measured the thickness using a light microscope.

The shape of the flexor retinaculum was described as roughly triangular in most studies in the literature (1,18). In our study, we found the shape of the flexor retinaculum triangular in most cadavers, which was consistent with the literature.

The structure of the lower extremity is generally affected by the body's characteristics such as height/weight and body type, but in our laboratory these properties of cadavers are unknown. Because of this, we couldn't evaluate these parameters. This is the limitation of our study. Maybe, further studies will be planned to evaluate these properties.

CONCLUSION

The flexor retinaculum is an important structure for the stable ankle joint. To our knowledge, the width and course of the flexor retinaculum were examined for the first time in our study. The morphometric data obtained from this study can help surgeons during the operations of the tarsal tunnel syndrome. The results of our study should serve as a foundation for future investigations dealing with pathologic conditions of the flexor retinaculum.

Ethics Committee Approval: The study was approved by the Non-invasive Clinical Research Ethics Committee of Hacettepe University (20.06.2023, 11-36).

Conflict of Interest: None declared by the authors.

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