Anatomy of Ligamentous Structures in the Tarsal Sinus and Canal

Tsuyoshi Jotoku, M.D.; Mitsuo Kinoshita, M.D.; Ryuzo Okuda, M.D.; Muneaki Abe, M.D.
Takatsuki, Osaka, Japan

ABSTRACT

Background: The descriptive morphology of the interosseous talocalcaneal ligament and other structures in the tarsal sinus and canal vary. An anatomical investigation of the ligamentous structures in the tarsal sinus and canal identified two distinct ligaments, the interosseous talocalcaneal ligament and the anterior capsular ligament, and three components of the medial root of the inferior extensor retinaculum. Methods: Forty embalmed cadaver feet were examined. After disarticulation of the ankle joint, the posterior half of the talus was removed. The length, width, and thickness of the two ligaments and the three components of the extensor retinaculum in the tarsal canal and sinus were measured with calipers. Anatomical variations were recorded. Results: The interosseous talocalcaneal ligament was band-like in 92.5% (38 of 40) of examined specimens, and the anterior capsular ligament was present in 95% (39 of 40) of specimens. The interosseous talocalcaneal ligament, the medial component of the inferior extensor retinaculum, and the talar component of the inferior extensor retinaculum had one or two distinct anatomical variations of morphology and attachments. The interosseous talocalcaneal ligament and the medial component of the extensor retinaculum formed a V shape in the tarsal sinus and canal. Conclusion and Clinical Relevance: We demonstrated the morphology and dimensions of the ligaments and components of the extensor retinaculum in the tarsal sinus and canal. Precise anatomy of the structures in the tarsal sinus and canal will strengthen our understanding of their function in the motion or stabilization of the subtalar joint. There may be a functional link between the medial component of the inferior extensor retinaculum and the interosseous talocalcaneal ligament.

Key Words: Anatomy; Tarsal Sinus; Tarsal Canal

INTRODUCTION

The tarsal sinus and tarsal canal are located in the subtalar joint anteriorly between the neck of the talus and the anterosuperior surface of the calcaneus. This area is described as funnel-shaped, with the larger tarsal sinus opening laterally and the stem-like tarsal canal extending medially posterior to the sustentaculum tali. The tarsal sinus and canal contain the interosseous talocalcaneal ligament (ITCL), the anterior capsular ligament (ACaL), and the three components of the medial root of the inferior extensor retinaculum. The ITCL has been described as a stabilizer of the subtalar joint.1,5,8,11,16,17,21,23 Therefore, many anatomical studies of the subtalar joint as well as studies of inflammatory and traumatic clinical conditions have described these structures, especially the ITCL.5,9—11,14,17,23

There are several inconsistencies in the descriptions of the structures in the tarsal sinus and canal. Several different shapes have been described for the ITCL, including a V shape,2,3,13,24 an inverted Y,15 a veil extending across the tarsal canal,14 an oblique band,1,16,21 and a two-layered structure.25 The ACaL was clearly identified in a seminal study by Sarrafian16 but not noted by other investigators.2,3,13,15,16,21,25,26 The differences in the reported anatomy of these ligaments may be explained by the anatomical variations in their shapes and their presence or absence. Additionally, some techniques dissected and freed the ligamentous structures from the calcaneus in the tarsal sinus and canal,6,13,14 while other studies used different techniques of exposure, such as vertical cuts with a band saw in frozen specimens and examination from a cross-sectional view.1,21 None of these studies discussed anatomic variations within the specimens.

The bands of the inferior extensor retinaculum that are attached to the tarsal bones enter the tarsal sinus and canal. The inferior extensor retinaculum is a band-like structure. On the lateral aspect of the midfoot, this retinaculum is composed of three roots: the lateral, intermediate, and medial. The lateral root attaches to the lateral aspect of the tarsal sinus and blends with the inferior peroneal retinaculum.
at the superolateral border of the calcaneus. The intermediate root attaches just medial to this. The medial root diverges from the inferior extensor retinaculum and enters the depths of the tarsal sinus and anterolateral aspect of the tarsal canal branching into the medial, lateral, and talar components.\textsuperscript{1,4,7,18,20,21} However, little else is known about the morphology of the most medial component of the medial root of the inferior extensor retinaculum.

The anatomy of the inferior extensor retinaculum must be understood before its function is determined. The function of the inferior extensor retinaculum is to serve as a pulley for the extensor tendons. However, the inferior extensor retinaculum may have a direct effect on the motion of the extensor tendons.\textsuperscript{12,22} These moments and the stability that these dynamic forces offer the midfoot are transmitted through the extensor muscles to the tarsal bones by the pulley system of the inferior extensor retinaculum. However, because of a paucity of research on its anatomy, the function of the extensor retinaculum in relation to the tarsal bones remains unclear.

The dimension of the ligaments may be the result of the functional requirements. The dimensions of the ITCL or the ACaL are not reported in any functional, arthroscopic, MRI, or surgical studies. Furthermore, little information is available on the dimensions and the variations of the medial root of the inferior extensor retinaculum.\textsuperscript{1,4,16,21} In addition, several investigators have noted that reconstruction of the ligaments of the subtalar joint is based on vague anatomical findings.\textsuperscript{8,9,15,19}

Because the literature does not include the dimensions and variations of the ligamentous structures in the tarsal sinus and canal, there is need for further investigation. The purpose of this study was to clarify the precise anatomy, especially the anatomical variations and dimensions, of the ligaments and ligamentous structures in the tarsal sinus and canal.

**MATERIALS AND METHODS**

Forty embalmed cadaver feet were examined (21 right and 19 left, 19 male and 21 female). The average age of the donors was 77 (range 49 to 98) years. All specimens were embalmed with formalin, with the ankle slightly plantarflexed and the foot inverted. No specimen had any evidence of trauma, surgery, or deformity of the lower limb, ankle, or foot.

After the skin, subcutaneous tissue, tendons and neurovascular bundles were removed, the feet were disarticulated at the talocrural joint, leaving the inferior extensor retinaculum intact.

To avoid damaging the soft tissues in the tarsal sinus and canal, the posterior half of the talus was carefully removed piece-by-piece with a rongeur to expose the tarsal sinus and canal (Figure 1). The dimensions of the individual structures were noted and photographic records were made. All dimensions were measured by calipers accurate to 0.05 mm and were taken by one investigator (TJ) to decrease the possibility of interuser variability. Each measurement was performed three times, and the mean values were documented. An intraclass correlation coefficient (ICC) was calculated to test the reliability of these measurements. Measurements were taken without visible deformation of the soft tissue to avoid potential artifacts caused by deformation of the ligamentous structures by the calipers. The width and thickness were measured in the central aspect of the ligament and retinacular root. The length of each ligament was measured from the talar insertion site to the calcaneal insertion site. The lengths of the components of the root of the inferior extensor retinaculum were defined as the length between the divergent point from the retinaculum and the insertion onto the bone. During measurements, the subtalar joint was positioned in neutral without any force that would elongate the ligaments and retinaculum.

**RESULTS**

Two ligaments and the three component bands of the medial root diverging from the inferior extensor retinaculum were identified in the tarsal sinus and canal. Anatomical variations were found. The dimensions of each ligament and components of the medial root, in millimeters, were recorded (Tables 1 and 2). The repeatability of the measurements for all structures was tested with the intraclass correlation coefficients (ICC), which ranged from 0.905 to 1.000 (Tables 1 and 2).

Several types of morphological variations of the interosseous talocalcaneal ligament (ITCL) were observed (Figure 2). Because there was only one specimen with an ITCL with a “multiple type” morphology and one value in thickness of the ITCL with a “fan type” morphology, it was not possible to
calculate the ICC for those morphologies. For the remaining morphologies of the ITCL, the total ICC was 0.961, 0.909 and 0.979 for the length, width, and thickness, respectively.

The Ligaments

Anterior Capsular Ligament (ACaL)

The ACaL was found in 95% of the feet examined (n = 38). This flat and thin ligament was defined as the thickened segment of the anterior aspect of the joint capsule of the posterior talocalcaneal facet. The ACaL originated at the anterior border of the posterior facet of the talus and ran vertically across the subtalar joint before attaching to the calcaneus. There were no appreciable differences in the dimensions or running patterns of other structures in the tarsal sinus and canal between the specimens with the ACaL and without the ACaL, therefore they were not categorized.

Interosseous Talocalcaneal Ligament (ITCL)

The ITCL was identified in 100% of the feet (n = 40) (Figure 2). Relative to the ACaL, this ligament was located in the anteromedial portion of the tarsal sinus and canal. The space between the ITCL and the ACaL was filled by adipose tissue; therefore, the ACaL and the ITCL were clearly

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**Table 1:** Measurements and intraclass correlation coefficients (ICC) of the ligaments in the tarsal sinus and canal (mean ± SD in mm).

<table>
<thead>
<tr>
<th>Ligament</th>
<th>Length (ICC)</th>
<th>Width (ICC)</th>
<th>Thickness (ICC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACaL (n = 38)</td>
<td>8.3 ± 1.6(0.999)</td>
<td>8.3 ± 1.7(0.997)</td>
<td>1.4 ± 0.4(0.911)</td>
</tr>
<tr>
<td>ITCL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band (n = 37)</td>
<td>10.0 ± 3.5(0.959)</td>
<td>8.5 ± 2.7(0.905)</td>
<td>2.3 ± 0.7(0.978)</td>
</tr>
<tr>
<td>Fan (n = 2)</td>
<td>7.5 ± 2.1(0.998)</td>
<td>11.0 ± 1.3(0.978)</td>
<td>3.0 ± 0.0 (N.A.)</td>
</tr>
<tr>
<td>Multiple (n = 1)</td>
<td>7(N.A.)</td>
<td>8.5(N.A.)</td>
<td>3(N.A.)</td>
</tr>
</tbody>
</table>

ACaL = Anterior Capsular Ligament, ITCL = Interosseous Talocalcaneal Ligament. band = band shaped type of the ITCL, fan = fan shaped type of the ITCL, multiple = multiple type of the ITCL. N.A. = not available.

<table>
<thead>
<tr>
<th>Component</th>
<th>Length (ICC)</th>
<th>Width (ICC)</th>
<th>Thickness (ICC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCC (n = 40)</td>
<td>19.0 ± 2.9(0.988)</td>
<td>8.3 ± 3.0(0.999)</td>
<td>2.5 ± 0.7(0.951)</td>
</tr>
<tr>
<td>MCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band (n = 38)</td>
<td>17.5 ± 3.1(0.998)</td>
<td>4.5 ± 2.1(0.997)</td>
<td>1.5 ± 0.6(0.979)</td>
</tr>
<tr>
<td>Fan (n = 2)</td>
<td>18.6 ± 1.8(0.991)</td>
<td>4.7 ± 0.4(0.946)</td>
<td>1.5 ± 0.1(1.000)</td>
</tr>
<tr>
<td>TC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type1 (n = 33)</td>
<td>15.9 ± 4.2(0.998)</td>
<td>5.2 ± 3.0(0.998)</td>
<td>1.5 ± 0.4(0.973)</td>
</tr>
<tr>
<td>Type2 (n = 3)</td>
<td>1.5 ± 0.5(0.999)</td>
<td>3.8 ± 1.0(0.990)</td>
<td>1.5 ± 0.9(0.991)</td>
</tr>
</tbody>
</table>

LCC = Lateral Calcaneal Component of the Medial Root, MCC = Medial Calcaneal Component of the Medial Root, TC = Talar Component of the Medial Root, band = band shaped type of the Medial Calcaneal Component of the Medial Root, fan = fan shaped type of Medial Calcaneal Component of the Medial Root, type 1 = Talar Component of the Medial Root originated from the Lateral Calcaneal Component of the Medial Root, type 2 = Talar Component of the Medial Root originated from the Medial Calcaneal Component of the Medial Root.

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**Fig. 2:** Interosseous talocalcaneal ligament and lateral calcaneal component of the medial root (posterior view). s = Posterior facet of the calcaneus, M = medial, L = lateral, ITCL = Interosseous talocalcaneal ligament, LCC = lateral calcaneal component of the medial root.
separated from each other. This ligament originated from the most medial area of the tarsal canal and ran obliquely from the talus toward the calcaneus, inserting on the broad area of the calcaneus (Figure 3).

The ITCL blended with the fibers of the medial component of the medial root of the inferior extensor retinaculum at the insertion on the calcaneus, which formed a V-shape (Figure 4). The ITCL was classified according to its shape into three categories: the band type, fan type, and multiple type. The band type was a flat, thick, band-like ligament. The band type was observed in 92.5% of the feet \(n = 37\) (Figure 4, A). The fan type ligament originated from a broad area of the tarsal canal, ran obliquely toward the calcaneus, decreased in width and inserted on the tarsal canal of the calcaneus (Figure 4, B). This was observed in 5% of the feet \(n = 2\). The multiple type with three distinct bands was observed in 2.5% of the feet \(n = 1\) (Figure 4, C). The dimensions of the three bundles combined were recorded.

**The Medial Root of the Inferior Extensor Retinaculum**

The medial root of the inferior extensor retinaculum was attached to the neck of the talus near the insertion of the anterior talofibular ligament. It entered the tarsal sinus and canal diverging into the medial, lateral, and talar components.

**Lateral Calcaneal Component of the Medial Root (LCC)**

The most lateral branch of the medial root (LCC) was identified in 100% of the feet \(n = 40\). The LCC diverged from the inferior extensor retinaculum, ran almost vertically toward the calcaneus, and inserted on lateral border of the tarsal sinus (Figures 2 and 4).

**Medial Calcaneal Component of the Medial Root (MCC)**

The MCC diverged from the medial root at the lateral aspect of the talar neck, ran obliquely into the tarsal sinus, and inserted onto the calcaneus. The MCC blended with the fibers of the ITCL at its insertion on the calcaneus;

**Talar Component of the Medial Root (TC)**

The TC was defined as the branch of the medial root attached to the talus. The TC was identified in 90% of the feet \(n = 36\). It was classified according to its origin into two categories: type 1 originating from the LCC and type 2 originating from the MCC. Type 1 was observed in 92% of the feet with the TC \(n = 33\). This component ran obliquely or transversely and inserted on the talus. The insertion of this component was adjacent to the insertion of the ITCL (Figure 4). Type 2 was observed in 8% of the feet with a TC
(n = 3). This component ran transversely and inserted on the talus adjacent to insertion of the ITCL (Figure 5).

**DISCUSSION**

The aim of this study was to elucidate the precise anatomy of the ligamentous structures in the tarsal sinus and canal, especially the interosseous talocalcaneal ligament (ITCL), which has been described with several different morphologies.\(^2\),\(^3\),\(^13\),\(^15\),\(^16\),\(^21\),\(^24\),\(^25\) The inconsistencies of morphologies of the ITCL may be attributable to different methods used or the existence of anatomical variations. The present study demonstrated that more than 90% of examined feet had an ITCL with a band-like shape. This result concurred with those reported by Smith,\(^1\) Cahill,\(^1\) and Sarrafian.\(^16\) A V-shaped or layered type of ITCL also has been reported.\(^2\),\(^3\),\(^13\),\(^24\),\(^25\) Although anatomical variations (i.e., the fan type and multiple type with three distinct bands) in this study were observed in 7.5% of specimens, they were not seen in previously reported anatomic variations.\(^2\),\(^13\),\(^14\),\(^24\),\(^25\) The ITCL may have been described as a V-shaped ligament\(^2\),\(^3\),\(^13\),\(^24\),\(^25\) because the ITCL and the MCC had similar insertions on the calcaneus, and the proximal part of the medial root was attached to the neck of the talus (Figure 4).\(^16\) Additionally, the present study demonstrated that the ITCL, MCC, and ACaL, reported as the thickest part of the capsule of the posterior talocalcaneal joint,\(^16\) created a layered structure. Therefore, if an investigator observed them after the talus was freed from the calcaneus, the ITCL might look like a layered structure. Because the present study showed that the ACaL had a different insertion and running pattern from that of the ITCL, the conclusion was that the ACaL and ITCL should be considered two distinct ligaments.

The mean dimensions of the ITCL in five specimens have been reported to be 15 mm in length, 5.6 mm in width, and 1.6 mm in thickness.\(^1\) In this study, the dimensions of the ITCL were relatively shorter, wider, and thicker than those reported (Table 1). This leads us to believe that we measured the dimensions of the ligament without applying tension. Additionally, the repeatability of measurements was excellent as evidenced by the intraclass correlation coefficients (ICC: 0.905–1.000). This study had a significantly larger sample size, which suggests that our results give a more accurate representation of the average dimensions.

The dimensions of ligaments are important factors that define their mechanical properties and may be the results of functional requirements. The ACaL was thinner than the ITCL (Table 1). These findings may indicate that the ITCL is loaded with larger stress than ACaL. Moreover, in the specimens without an ACaL, there were no appreciable differences in the dimensions of the other structures from those specimens with an ACaL. From a clinical point of view, these results led us to believe that the ITCL has a more important role in subtalar joint stability than the ACaL.

Several authors reported the anatomy of the medial root of the inferior extensor retinaculum (MCC). However, they did not examine the components of the medial root.\(^1\),\(^4\),\(^7\),\(^18\),\(^20\),\(^21\) We confirmed that the medial root of the inferior extensor retinaculum has three components. These findings concurred with those reported by Sarrafian.\(^16\) Furthermore, the medial component of the medial root of the inferior extensor retinaculum (MCC) and the talar component of the medial root of the inferior extensor retinaculum (TC) had distinct anatomical variations in their shape and attachments. This information may be useful in future investigations focused on function of the inferior extensor retinaculum.

The inferior extensor retinaculum is considered to be the pulley for the extensor tendons, (i.e., the anterior tibial, extensor hallucis longus, extensor digitorum longus and peroneus tertius).\(^16\) However, several investigators have reported other functions of the inferior extensor retinaculum.\(^12\),\(^22\) Kuhlmann et al.\(^12\) stated that the roots of the inferior extensor retinaculum had direct effects on the talus and the calcaneus, which induces valgus motion of the tarsus by transmitting the force of the extensors to the tarsal bones and contributes to the stability of the ankle and the foot.\(^12\) Stephens and Sammarco\(^22\) found that the lateral root of the inferior extensor retinaculum contributes to subtalar stability with the foot in neutral and dorsiflexion.\(^22\)

No studies report the function of the medial root of the inferior extensor retinaculum. The present study clearly identified the MCC. Furthermore, one of its components shares its insertion with the ITCL on the calcaneus. This component blends with the fibers of the ITCL at the insertion, and the MCC and ITCL form a V-shape in the tarsal sinus and canal (Figure 4). These anatomical findings indicate that the MCC may transmit the force of the extensors to the ITCL, or the MCC, and the ITCL may have complementary functions. For example, when the calcaneus shifts to the valgus position relative to the talus, the MCC will be relaxed while the ITCL is tensioned. Although further biomechanical studies are needed to clarify the function of these complicated structures, the ligaments and components of the extensor

![Fig. 5: Talar component of the medial root diverged from MCC.](Image)

\(^*\) = Posterior facet of the calcaneus, M = medial, L = lateral, ITCL = interosseous talocalcaneal ligament, MCC = medial calcaneal component, LCC = lateral calcaneal component, TC = talar component.
retinaculum in the tarsal sinus and canal may need to be considered as one mechanical complex.

This study was limited by the fact that we could not exclude degenerative changes with aging and the effect of minor trauma, even though we confirmed that the specimens had no traumatic changes in the foot and ankle. The shrinkage or decrease in elasticity of the structures from embalming may have affected the dimensions and orientations. However, this study was able to provide a more accurate knowledge of the anatomy of ligamentous structures in the tarsal sinus and canal.

REFERENCES