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Anatomical Description of the Spring Ligament Articular Facet

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Abstract

Background: The spring ligament fibrocartilaginous complex (SLFC), which is essential for stabilizing the medial longitudinal arch, features a little-explored fibrocartilaginous facet within its superomedial aspect, articulating with the talar head. This research aimed to provide a detailed anatomical description of this facet, designated as the spring ligament articular facet (SLAF).

Methods: Nine normally aligned cadaveric lower limbs were dissected, approaching the SLFC from a superior direction. Following talus disarticulation, high-resolution images of the ligament complex were captured and analyzed. ImageJ software was used to determine the areas and dimensions of the superomedial calcaneonavicular (SMCN) spring and SLAF.

Results: The fibrocartilage facet exhibited a trapezoid shape in all specimens. The mean area for SMCN spring was 280.39 mm², and for SLAF, it was 200 mm². The proximal-to-distal length for SLAF averaged 11.78 mm at its longest and 5.34 mm at its shortest. Attachment of the SLAF to the calcaneum and the navicular showed robust fibrous structures, with average measurements of 3.75 and 1.75 mm at the medial and lateral calcaneal margins, and 2.75 and 2.98 mm at the medial and lateral navicular margins, respectively.

Conclusion: This study clearly delineated the individual structural components of the SLFC articulating with the talar head and detailed its dimensions, emphasizing the need for more specific anatomical terminology that respects the intricate anatomy of the SLFC.

Level of Evidence: Level III, descriptive study.

Keywords: spring ligament, spring ligament fibrocartilaginous complex, spring ligament articular facet, progressive collapsing foot disorder

Introduction

The medial longitudinal arch is a defining feature of the homo sapiens foot, representing an evolutionary departure from primate ancestors.[8,20] Along with its structural uniqueness, the medial longitudinal arch constitutes a vital component of human foot mechanics providing shock absorption, distribution of body weight across the foot, and a lever for propulsion while walking and running. The spring ligament fibrocartilaginous complex (SLFC) is an essential contributor to the structural integrity and stability

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of the medial longitudinal arch, the failure of which is thought to be implicated in the development of progressive collapsing foot deformity.[1,2,7,9,12,14,17,22,24]

Although significant confusion has historically existed regarding both the nomenclature and the structural components constituting the "spring ligament," contemporary understanding has improved. Our current understanding recognizes the composition of the SLFC as comprising 3 ligamentous components: the superomedial calcaneonavicular ligament (SMCN), the inferior calcaneonavicular ligament, and the medioplantar oblique ligament. Additionally, the SLFC includes a separate smooth tract that accommodates the posterior tibialis tendon planarly, along with a meniscal component referred to as the spring ligament articular facet (SLAF) dorsally, which articulates with the talar head.[5,6,17,21,22]

There are several descriptions of the presence of SLAF. However, to date, no studies have been carried out specifically investigating its extent, measurements, and attachments to its neighboring bones. This study aimed to provide a precise anatomical description of the area of the SLFC that articulates with the talar head through anatomical dissection.

Material and Methods

The study was submitted to the Liverpool University Hospital NHS Foundation Trust research committee and the University of Liverpool ethics committee, gaining approval.

Anatomical Dissection

This element of the study was performed at the Human Anatomy and Resource Centre, University of Liverpool, Liverpool. Cadaveric images used were taken with permission, under the auspices of the Human Tissue Authority license held by the Human Anatomy and Resource Centre.

Nine formalin-embalmed cadaveric foot specimens, each exhibiting apparently well-developed longitudinal arches and no observable deformities, were available for dissection. All had been amputated at the level of the mid tibia and all feet were dissected in the same sequence. First, the tibia and fibula were removed at the level of the upper ankle, leaving the talus in situ. The talus was then mobilized from lateral to medial by releasing it from surrounding soft tissue. The SLFC and the bed of the subtalar joint were exposed by dorsally reflecting the talus. Before detaching the talus medially, the deltoid insertion to SMCN was identified and delineated. The talus was then dissected at the level of that insertion. Figure 1 illustrates the initial dissection to preserve the SLFC during talus elevation. Figure 2 demonstrates advanced dissection to expose the acetabulum pedis. High-resolution, calibrated digital images were captured of the dorsal aspect of the exposed SLFC. Subsequently, thorough analysis and precise measurements were performed on these images using ImageJ Plugin (Java NIH & LOCI, University of Wisconsin).[18]

Figure 1. An image illustrating the initial stages of dissection prior to elevation of the talus from lateral to medial to preserve the spring ligament complex.

Definitions and Observational Anatomy

The SLAF, which represents the meniscal area of the SLFC, was discerned by manually delineating the distinct, clearly visible shiny cartilaginous margin articulating with the talar head. The term "SMCN spring" was used to describe the component of the SLFC that encompasses both the SMCN and medioplantar oblique ligamentous components as identified in the specimens. The attachment of the SLAF to the calcaneum proximally and the navicular distally was ascertained by the presence of distinctly less shiny, thick fibroligamentous insertion (SLAF-FLI).

Measurements

The proximal-to-distal length of the SLAF was measured at 3 positions: the medial, middle, and lateral thirds of the medial to lateral ligament span. Similarly, the length of the SLAF-FLI was measured both proximally and distally at their insertions into the calcaneum and navicular, respectively. Figure 3 illustrates the length measurements of the SLAF at these 3 positions and the SLAF-FLI at their respective insertions.

The surface area of both the SLAF and SMCN spring were calculated (surface area of SMCN spring = surface area of SLAF + surface area of SLAF-FLI).

Results

In all specimens, the SLAF exhibited a consistent trapezoid shape. Furthermore, its shiny cartilaginous consistency was visibly evident across all anatomically dissected specimens.

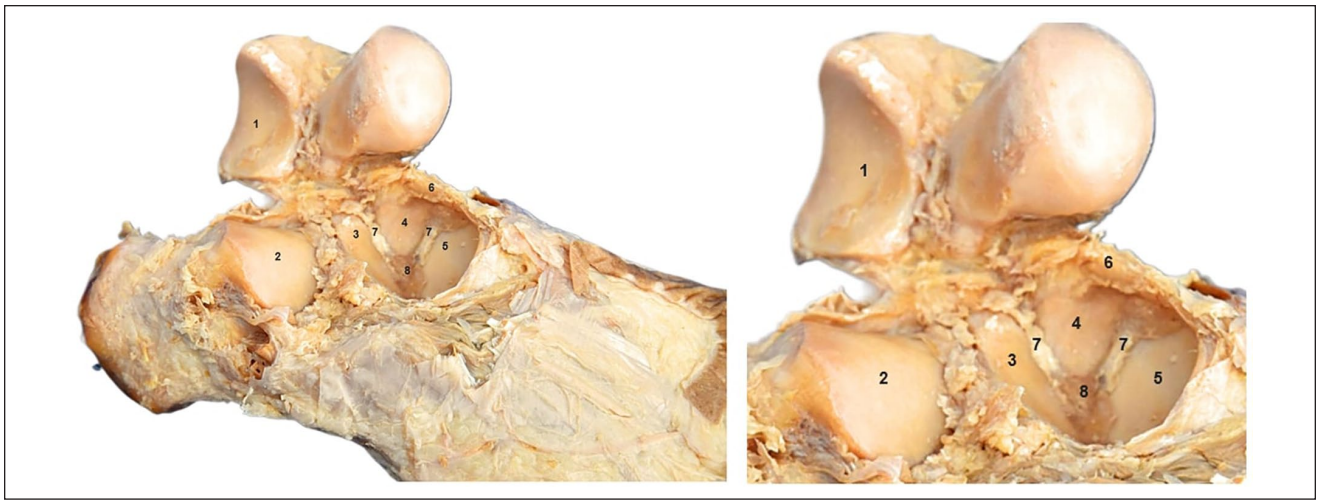

Figure 2. An image illustrating further dissection to expose the acetabula pedis with clear demonstration of the articular surfaces of the posterior facet of the calcaneus (2), medial facet of the calcaneus (3) and proximal articular surface of the navicular (5). The SMCN Spring encompasses both the SLAF (4) and its attachments (SLAF-FLI) to the calcaneus proximally and the navicular distally (7). Also visible are the medioplantar oblique ligament (8) lateral to the SLAF, the tibiospring elements of the deltoid (6) medial to the SLAF, as well as the talus (1). FLI, fibroligamentous insertion; SLAF, spring ligament articular facet; SMCN, superomedial calcaneonavicular ligament.

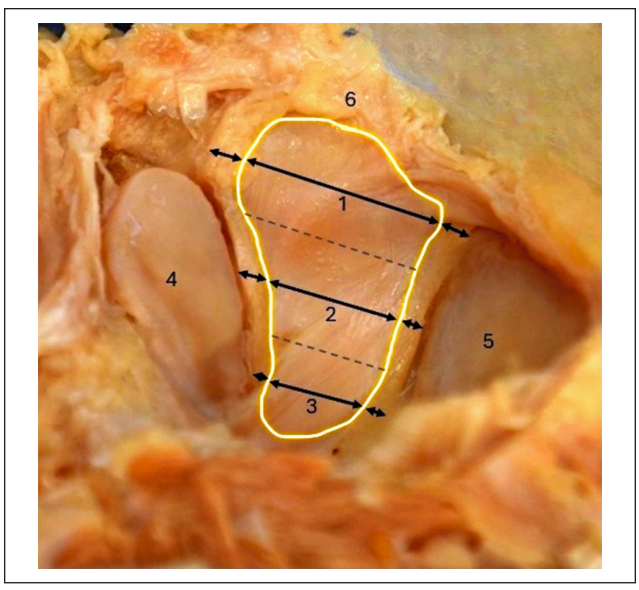

Figure 3. An image illustrating the proximal-to-distal length measurements of SLAF at the medial (1), middle (2), and lateral (3) thirds of the ligament's span and the length measurements of the SLAF-FLI at their respective proximal and distal insertion sites on the middle/sustentacular facet of the calcaneum (4) and proximal articular facet of the navicular (5). Tibiospring elements of the deltoid (6). FLI, fibroligamentous insertion; SLAF, spring ligament articular facet.

The insertion of the SLAF with calcaneum and navicular articular surface were defined by a distinct thick fibroligamentous structure (the SLAF-FLI).

Measurements

Dimensions. The measurements of the SLAF were as follows: the average longest proximal to distal length of the SLAF was determined to be 11.78 mm (95% CI: 10.12-13.44), whereas the shortest lateral margin was 5.34 mm (95% CI: 3.90-6.52). The length of the attachment (SLAF-FLI) proximally averaged 3.75 mm (95% CI: 2.65-4.85) at its medial margin and 1.75 mm (95% CI: 1.43-2.08) at its lateral margin. Distally, it averaged 2.75 mm (95% CI: 1.76-3.74) at its medial margin and 2.98 mm (95% CI: 2.20-3.98) at its lateral margin.

Area. The surface area of the SMCN spring ranged between 198.63 and 417.34 mm^2 with an average of 280.39 mm^2 (95% CI: 235.61-319.13). In addition, the surface area of the SLAF ranged between 115.69 and 254.54 mm^2 with an average of 200 mm^2 (95% CI: 177.33-221.67). Table 1 documents the measurements and surface area for SLAF, SLAF-FLI, and SMCN spring.

Discussion

The term "spring ligament" has been a source of inconsistency and confusion since its introduction in Cunningham's Textbook of Anatomy.[3,6,13,16] Histologic investigations have supplied evidence supporting the absence of elastin as a structural component of the spring ligament, effectively refuting the theory that originally led to its nomenclature.[5,10] The term "spring ligament fibrocartilaginous complex" serves as a comprehensive designation that accurately encompasses the

Table 1. Measurements of the SLAF and Proximal and Distal SLAF-FLI Taken at the Medial, Middle, and Lateral Locations, Including the Surface Areas of the SMCN Spring and SLAF.

	SLAF, mm			Proximal Ligament, mm			Distal Ligament, mm			Surface Area, mm^2	
Specimen	Medial	Middle	Lateral	Medial	Middle	Lateral	Medial	Middle	Lateral	SMCN Spring	SLAF
1	13.61	10.71	6.32	5.02	2.44	2.75	6.22	2.48	3.26	306.19	210.75
2	9.15	6.2	3.77	8.11	1.3	2.32	3.24	1.79	3.12	296.28	203.07
3	11.46	8.7	3.29	6.71	1.2	1.97	2.91	2.57	3.01	261.69	206.20
4	13.34	9.51	5.97	2.57	1.67	2.3	1.22	1.91	2.5	291.37	204.83
5	13.16	10.1	7.44	3.13	1.69	1.14	1.83	1.04	1.68	305.24	254.54
6	10.53	5.91	2.92	1.03	0.8	1.33	3.04	2.35	3.22	223.08	213.65
7	11.09	7.1	4.32	1.88	1.75	1.06	2.4	2.1	5.44	223.69	188.27
8	14.06	11.1	8.3	3.08	1.67	1.77	2.85	1.81	2.9	417.34	202.00
9	9.58	6.38	5.76	2.21	1.02	1.1	1.07	1.05	1.7	198.63	115.70
Mean	11.78	8.41	5.34	3.75	1.5	1.75	2.75	1.9	2.98	280.39	200

Abbreviations: FLI, fibroligamentous insertion; SLAF, spring ligament articular facet; SMCN, superomedial calcaneonavicular ligament.

intricate nature of the structure, incorporating both its ligamentous and fibrocartilaginous components.

Despite the thorough investigation of the ligamentous components within the SLFC by numerous researchers, the meniscal component has received relatively limited attention in the literature. This study represents the first comprehensive analysis delineating the individual structural components of the SLFC articulating with the talar head, accompanied by measurements of each of its individual components.

Our observations revealed that the shape of the SLAF is more trapezoidal in nature, deviating from the previously described triangular morphology.[5]

In their detailed histologic investigation, Davis et al[5] observed gradual blending of the SLAF with the underlying dense collagen bundles with lack of clear demarcation to the underlying ligamentous components. This tight connection between the SLAF and the ligamentous components may pose challenges in visually differentiating between cartilage and ligament, particularly in the middle area of the SLFC. Such an intricate relationship might have also contributed to the discrepancies in terminology usage regarding the "spring ligament" among clinicians and anatomists.[6]

Davis et al[5] also demonstrated that the SLFC exhibits peripheral vascularization, in contrast to the avascular meniscal area. Our findings reveal a distinct attachment of the SLAF, closely resembling a thick ligament that connects the SLAF to the surrounding calcaneus and navicular, which we have termed SLAF-FLI. We propose that this peripheral tissue differentiation aligns with the differentiated vascularity pattern observed at the histologic level.

Various reconstructive procedures for addressing the attenuated SLFC in progressive collapsing foot deformity have been described, including imbrication, autograft or allograft reconstruction, and synthetic bracing options.[1,4,11,15,19,23,25] However, there is no consensus on the indications and techniques for reconstructing the SLFC.[25] Furthermore, none of these techniques address, or mention, the importance or position of the SLAF. We believe that a thorough understanding of the intricate anatomy of SLFC, and thereby the SLAF, is essential, as it should be taken into consideration in the development of reconstruction techniques that accurately reflect and accommodate the specific anatomical characteristics.

Our study has limitations. Although this study used standardized calibration methods, it was limited by the absence of standardized image acquisition methodologies in addition to the small specimen sample size. Nevertheless, it has provided anatomical baselines for the measurement of the SLAF, SLAF-FLI, and SMCN spring.

Conclusions

This study provides a detailed examination of the SLAF, a distinct articular area within the SLFC, incorporating measurements of its dimensions and surface area. Considering these findings, the authors advocate for a departure from traditional terminology toward a unified and more structurally specific nomenclature.

Ethical Approval

Ethical approval for this study was obtained from the Liverpool University Hospital NHS Foundation Trust research committee and the University of Liverpool ethics committee.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. Disclosure forms for all authors are available online.

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