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Research Article

Fibular Groove Morphology and Fibularis Tendon Disorders: A Study Based on Computed Tomography

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Abstract

Background: One important structure that supports the fibularis tendons is the posterior surface groove of the distal fibula. Fibularis tendon diseases like tendinopathy, instability is predisposed by anatomical variations in the groove. As CT provides accurate, high-resolution evaluation of bony structures that may affect peroneal tendon stability, it was utilized to analyze fibular groove morphology and associated anomalies.

Methods: 223 ankle CT scans (219 asymptomatic and 4 with fibularis tendon dislocation from Yan'an Hospital's PACS database were looked at in this retrospective. A clean dataset was produced by applying exclusion criteria, such as age under 18, motion artifacts, fibular fractures and previous fibular surgery. Two anatomical levels were used to assess the concave, convex, flat and irregular morphology of the fibular groove. Groove shape was evaluated independently by two blind reviewers. Cohen's Kappa was used to calculate reliability between and within observers. SPSS v29 was used for statistical analysis to investigate correlations between variations of the peroneal tendon and groove shape.

Results: The most prevalent shape (62.7%) identified by computed tomography of 223 participants was the convex fibular groove, which was followed by flat, irregular and concave forms. Convex grooves and peroneal tendon diseases were shown to be significantly related ($\chi^2(1) = 6.57$, $p = .010$; $\varphi = -0.17$). Moderate inter-rater reliability ($\kappa = .495$) supported groove morphology's consistency and clinical significance.

Conclusion: Fibular groove morphology aids in the stability of the peroneal tendon, but its clinical significance varies. Instead of depending solely on groove morphology, the clinicians should incorporate soft-tissue condition, overcrowded of tendon on the pouch and patient-specific factors.

Keywords: Retro-Malleolar Fibular Groove; Ankle Joint; Computed Tomography; Peroneal Tendon; Anatomy

Level of Evidence: The study design represents Level IV evidence, as it is a retrospective observational analysis without a control group

Introduction

The fibular groove, located on the back of the lower fibula, plays a crucial role in stabilizing the fibularis (peroneal) tendons [1]. These tendons are essential for maintaining lateral ankle stability and enabling foot eversion. The fibularis longus and brevis tendons extend from the leg to the foot, curving around the lateral malleolus the bony bump on the outer ankle [2]. As they navigate this natural pulley system, they pass through a tunnel formed by the surrounding bone and the Superior Peroneal Retinaculum (SPR), which helps secure them within the malleolar groove behind the lateral malleolus [1,3,4]. Despite these stabilizing structures, the tendons can sometimes slip out of place or fully dislocate, with over 90% of such injuries occurring during sports activities and calcaneal fractures [4-6]. Toussaint, et al., reported that peroneal tendon displacement occurred in 28% of calcaneal fracture cases [7]. However, this association was documented in radiology reports in only 10.2% of instances. Certain abnormalities in the shape of the fibular groove such as being shallow, flat or convex have been linked to fibularis tendon issues, including tendinopathy, subluxation and tears [8,9]. These conditions can lead to pain, instability and a noticeable snapping sensation, especially in physically active individuals [1]. While peroneal tendon dislocations are relatively uncommon, they are usually the result of acute trauma, repetitive stress or prior injuries [10].

CT imaging has become an incredibly useful tool for looking at the structure of the fibular groove, especially when it comes to understanding its shape and how it might relate to fibularis tendon issues [11]. While past studies have explored this connection, there's still a need for more in-depth research to establish what's considered normal and to better understand how different groove shapes might contribute to tendon problems. On top of that, newer imaging techniques like dual-energy CT have made it possible to see tendons by detecting the collagen fibers within them [12]. Thanks to these advancements, CT isn't just helpful for looking at bones anymore; it's also becoming a reliable way to diagnose tendon injuries more accurately [4]. All of this can help doctors make better decisions about treatment, whether that's physical therapy or surgery.

This study aims to use CT imaging to analyse the morphology of the fibular groove and its connection to fibularis tendon disorders. Understanding these anatomical variations is especially important for sports physicians and Foot and Ankle Surgeons managing such injuries. In some cases, surgical intervention may be necessary to reconstruct the tunnel that holds the tendons in place [6]. By examining groove shapes and their relationship with tendon abnormalities, this research seeks to provide valuable insights into the structural factors contributing to these disorders and highlight the advantages of CT imaging in diagnosing them.

Materials and Methods

Study Design and Imaging Protocol

This Institutional Review Board-approved (2025-100-01) retrospective study aimed to evaluate the anatomy of the fibular groove using Computed Tomography (CT) and to assess its association with fibularis tendon abnormalities. Between June 2023 and July 2024, CT images were acquired from Yan'an Hospital, which is affiliated to Kunming Medical University, using the PACS system. Ankle CT scans from people with or without a history of lateral ankle pain or suspected disease of the fibularis tendon were included in the study.

In the beginning, 513 CT scans including those from people with and without symptoms-were examined. 132 scans with a history of ankle fractures or lateral ankle surgery were eliminated to maintain a clean dataset. Furthermore, 41 scans impacted by motion artifacts or obtained for the assessment of osteomyelitis, as well as 121 scans from skeletally immature persons under the age of 18 were eliminated. 219 asymptomatic people and 4 verified cases of fibularis tendon dislocation were among the 223 scans that made up the final samples.

Non-lateral ankle or foot pain was the most often reported clinical indication for imaging (57%), followed by injury or sprain (15%), Achilles tendon problems (6%), infection (6%), posterior tibial tendon pathology (9%) and mass examination (6%). A Siemens SOMATOM Definition Flash scanner with a slice thickness of 2.5-3 mm and an interslice gap of 0.6 mm was used to get the CT scans. These settings were selected to minimize radiation exposure, guarantee patient comfort and maximize imaging of delicate osseous structures such as the fibular groove. For groove assessment, two distinct anatomical levels were used: (1) at the level of the syndesmotic ligaments and tibial plafond and (2) one centimeter above the point of the lateral malleolus.

Protocol for Inter-Observer Agreement

- In this retrospective CT study, an inter-observer agreement protocol was established to ensure uniformity and minimize bias. An orthopedic surgeon and a musculoskeletal radiologist independently assessed fibular groove morphology following a calibration session with anonymized cases to define classification criteria:
- Concave: A deep groove with bony walls
- Convex: A dome-shaped groove
- Flat: Minimal contouring
- Irregular: Random shape

Every image was presented in a random order after being anonymized and encrypted. Both the patient's information and each other's assessments were hidden from the observers. On standardized Microsoft Excel sheets, classifications and confidence scores (ranked 1-5) were documented.

Cohen's kappa for paired agreement between observers were used in the statistical study. Variability in mistake patterns and confidence scores was also examined. To reach a final classification, cases that were considered disagreeable were reviewed in a consensus event. Each observer re-scored ten randomly chosen cases two weeks later to evaluate intra-observer reliability. The INFINITT PACS Viewer was used for the imaging review and SPSS (v29) was used for the statistical analyses (Fischer Exact Test). This methodical methodology made sure that the morphological evaluation was accurate and reliable, which strengthened the validity of the research findings (Fig. 1).

Figure 1: Measurement of the distance from the tip of the lateral malleolus to the proximal tip of the lateral malleolar fossa on a coronal CT of the right ankle. Upper Line is drawn perpendicular to the fibular axis; Lower line is a parallel tangential line at the fossa's proximal tip.

Results

In this study, 223 participants' fibular groove shapes were examined (Table 1), with particular focus given to how these shapes differed by gender, body side and other relevant characteristics. At approximately 62 percent of cases, the convex groove was by far the most widespread. Flat grooves (nearly 22.42%), irregular shapes (10.76%) and the least common, concave grooves (just over 4%), came next. Interestingly, males were more inclined to have convex, flat or irregular grooves, whereas females were more likely to have the uncommon concave shape. In general, there were roughly 65% more men than women in the sample, indicating that some groove shapes could have been prominent in one gender than the other (Table 1).

Groove Shape	Total n (%)	Males n (%)	Females n (%)
Concave	9 (4.03%)	3 (33.3%)	6 (66.7%)
Convex	140 (62.7%)	90 (64.28%)	50 (35.71%)
Flat	50 (22.42%)	34 (68.0%)	16 (32.0%)
Irregular	24 (10.76%)	18 (75.0%)	6 (25.0%)
Total	223 (100%)	145 (65.02%)	78 (34.9%)

Table 1: Distribution of Fibular Groove Shapes by Sex (N = 223).

The existence of peroneal tendon problems was shown to be significantly inversely correlated with the shape of the fibular groove in this computed tomography analysis of 223 cases. With a tiny but substantial effect size ($\varphi = -0.17$), statistical analysis using Pearson's chi-square test revealed that the association was significant ($\chi^2(1) = 6.57$, $p = 0.010$).

$$\Phi = \sqrt{\chi 2/ N} = \sqrt{6.57/223} \approx -0.17$$

Additional statistical tests, such as Fisher's exact test ($p = 0.012$) and the continuity-corrected chi-square ($\chi^2(1) = 5.87$, $p = 0.015$), supported this conclusion. Most importantly, the reliability of the results was strengthened by the fact that all statistical assumptions were met, with the smallest expected cell count being 38.13. These results provide credence to the hypothesis that peroneal tendon instability may be influenced by groove morphology (Table 2).

Test	χ^2	*df*	*p-value*	*Effect Size*
Pearson χ^2	6.57	1	0.01	$\varphi = -0.17$
Continuity Correction	5.87	1	0.015	
Fisher's Exact Test			0.012	
Linear-by-Linear	6.54	1	0.011	

Table 2: Chi- Square Test Summary (N=223).

Statistically important moderate agreement between the two independent raters was established by inter-rater reliability analysis using Cohen's Kappa, with $\kappa = .495$, $p < .001$ (Table 3).

	Value	Asymptotic Standard Error	Approximate T	Approximate Significance
Measurement of Kappa Agreement	0.495	0.002	14.933	<0.001
N of Valid Cases	223			

Table 3: Cohen’s Kappa for inter-rater reliability.

Discussion

This study provides valuable insights into the relationship between retro malleolar fibular groove morphology and peroneal tendon disorders. The findings underscore the potential role of a convex fibular groove in contributing to tendon instability, particularly in cases of dislocation, tendinosis and tearing. Notably, all observed cases of peroneal tendon dislocation were associated with a convex groove, regardless of patient age, supporting prior studies that have identified this shape as a possible risk factor for instability [11]. However, the high prevalence of convex grooves among both symptomatic and asymptomatic individuals complicates the interpretation of this finding, suggesting that groove shape alone may not be sufficient to predict pathology [9]. The study also revealed gender-based differences in groove morphology, with males more frequently exhibiting flat or irregular grooves, while females more commonly had concave shapes. This aligns with earlier research indicating that anatomical differences between gender may influence susceptibility to different types of tendon pathology [5]. These observations highlight the need to consider gender-specific anatomical variations when evaluating patients with peroneal tendon complaints. A major strength of this study was the use of Computed Tomography (CT) imaging, which proved highly effective for evaluating bony structures such as the fibular groove. While Magnetic Resonance Imaging (MRI) remains the gold standard for assessing soft tissue injuries, CT provides superior visualization of bone morphology and is especially valuable in detecting subtle anatomical variations that may contribute to tendon instability [9,10,12,13].

Despite extensive research, the significance of groove morphology in peroneal tendon pathology remains debated [9]. Some studies, such as that by Ayanoglu, et al., have suggested that even a concave groove may be associated with tendon tears. In contrast, other investigations, including those by Adachi, et al., and more recent MRI-based studies have found no significant differences in groove shape between patients with and without peroneal tendon dislocation [9]. These inconsistencies indicate that although bony anatomy contributes to tendon pathology, it is likely only one component of a more complex clinical picture.

In addition to osseous morphology, soft tissue structures particularly the Superior Peroneal Retinaculum (SPR) are critical for tendon stability [16-18]. The SPR originates from the posterolateral fibula and inserts onto the calcaneus and Achilles tendon aponeurosis. Damage to the SPR, often resulting from acute ankle inversion injuries and reflexive peroneal muscle contraction, can lead to tendon dislocation or tear [14]. Another core reason for peroneal tendon subluxation is, anatomical variants such as the peroneus quartus muscle which can crowd the retro malleolar space and contribute to frequent instability. Studies have shown that such crowding can compromise the Superior Peroneal Retinaculum (SPR), the primary soft tissue structure responsible for maintaining tendon alignment, thereby predisposing it to tearing or laxity during ankle inversion injuries [14]. Additionally, research by Saragus, et al., Title, et al., Dombek, et al., emphasizes that anatomical anomalies within the retro malleolar region, such as bifid peroneus brevis including peroneus quartus muscle crowding, are frequently observed in patients with recurrent peroneal tendon subluxation and results in peroneal brevis tendon tears where high pressure is established. Therefore, it is reasonable to conclude that variations in fibular morphology influence the depth of the groove [17,19,20].

Research suggests that irregular, convex or flat fibular grooves may increase the risk of tendon dislocation, irritation and tears [11]. However, these variations are also found in more than two-thirds of people without symptoms, making their clinical significance more complex [13]. Other anatomical factors, such as low-lying muscle bellies of the fibularis brevis or the presence of an additional fibularis quartus muscle also known as the peroneal quartus muscle can crowd the retro malleolar space, increasing the likelihood of tendon disorders or injuries to the SPR [8,13]. Additionally, enlarged fibular tubercles or retro-trochlear eminences may contribute to tendon irritation and tenosynovitis. Previous studies have also pointed out that the fibrocartilaginous ridge in this area is only loosely attached to the periosteum, providing minimal support to the SPR [14]. During an injury, the SPR often pulls the periosteum away from the bone, creating a false pouch and further destabilizing the tendons [15]. While several measurements-such as the bowing ratio and angles relative to the bimalleolar axis-have been proposed to analyse the fibular groove, no single metric has proven to reliably predict fibularis tendon tears, even in individuals with symptoms [11]. Although the study sample was limited to a Chinese population, the findings offer important implications for understanding how anatomical variation may influence tendon pathology. Future research should explore diverse populations to assess potential ethnic differences in fibular groove morphology and further clarify its clinical significance. Additionally, longitudinal studies involving symptomatic patients may help establish whether specific groove shapes are predictive of peroneal tendon disorders over time (Fig. 2).

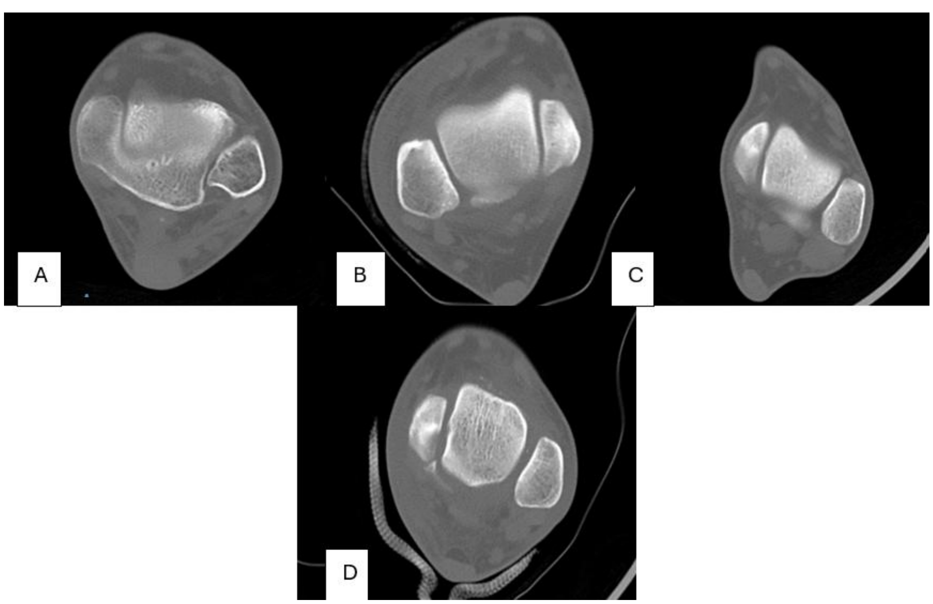

Figure 2: Axial CT scans depicting images of the four most seen fibular groove. A: Concave, B: Irregular, C: Flat, D: Convex.

Limitations

There are certain limitations to this study. Initially, the fibular groove was only assessed at two axial levels, which may not accurately depict its three-dimensional form. Future studies using 3D reconstructions would provide a more comprehensive assessment. Second, there were only four symptomatic cases (n=4) due to the rarity of peroneal tendon dislocation, which lowers the findings' statistical power and generalizability. Third, although we only included Chinese individuals in our research, we do not believe that the shape of their fibular grooves is influenced in any way by their lower average height. A variety of ethnic groups should be included in future research to identify any ethnic discrepancies. Fourth, even though we assessed inter-observer reliability, which was good and used a defined categorization approach, observer bias may still exist. Finally, we employed CT imaging, which is excellent for bone anatomy but does not directly detect soft tissue structures. Nevertheless, when it comes to evaluating the bone morphology of the fibular groove, CT is similar to MRI and our selection of CT was appropriate for the study's goals.

Conclusion

Peroneal tendon problems are significantly influenced by the anatomy of the fibular groove, especially if it is convex. Although convex grooves are frequently found and associated with tendon issues, subluxation cannot be explained only by groove shape. Soft tissue components, like the superior peroneal retinaculum and tendon crowding, are also significant. To elucidate the clinical importance of groove variations, more research is required using sophisticated imaging and bigger, diverse cohorts.

Conflict of Interests

The authors declare that there is no conflict of interest related to this study.

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References

1. Yokoe T, Tajima T, Ouchi K, Yamaguchi N, Morita Y, Chosa E. Differences in retromalleolar fibular groove morphology according to level of axial computed tomography scans. Orthop J Sports Med. 2024;12(3):23259671241237255.
2. Arrowsmith SR, Fleming LL, Allman FL. Traumatic dislocations of the peroneal tendons. The American Journal of Sports Medicine. 1983;11(3):142-6.
3. Ozbag D, Gumusalan Y, Uzel M, Cetinus E. Morphometrical features of the human malleolar groove. Foot and ankle international. 2008;29(1):77-81.
4. Golshani A, Zhu L, Cai C, Beckmann NM. Incidence and association of CT findings of ankle tendon injuries in patients presenting with ankle and hindfoot fractures. American Journal of Roentgenology. 2017;208(2):373-9.
5. Clanton TO. Athletic injuries to the soft tissues of the foot and ankle. Surgery of the Foot and Ankle. 1999:1090-209.
6. Kumai T, Benjamin M. The histological structure of the malleolar groove of the fibula in man: its direct bearing on the displacement of peroneal tendons and their surgical repair. Journal of Anatomy. 2003;203(2):257-62.
7. Toussaint RJ, Lin D, Ehrlichman LK, Ellington JK, Strasser N, Kwon JY. Peroneal tendon displacement accompanying intra-articular calcaneal fractures. JBJS. 2014;96(4):310-5.
8. Saupe N, Mengiardi B, Pfirrmann CW, Vienne P, Seifert B, Zanetti M. Anatomic variants associated with peroneal tendon disorders: MR imaging findings in volunteers with asymptomatic ankles. Radiology. 2007;242(2):509-17.
9. Adachi N, Fukuhara K, Kobayashi T, Nakasa T, Ochi M. Morphologic variations of the fibular malleolar groove with recurrent dislocation of the peroneal tendons. 2009.
10. Tjin A Ton E, Schweitzer M, Karasick D. MR imaging of peroneal tendon disorders. AJR American journal of roentgenology. 1997;168(1):135-40.
11. Wang X-T, Rosenberg ZS, Mechlin MB, Schweitzer ME. Normal variants and diseases of the peroneal tendons and superior peroneal retinaculum: MR imaging features. Radiographics. 2005;25(3):587-602.
12. Deng K, Sun C, Liu C, Ma R. Initial experience with visualizing hand and foot tendons by dual-energy computed tomography. Clinical Imaging. 2009;33(5):384-9.
13. Matcuk GR, Patel DB, Cen S, Heidari KS, Tan EW. Fibular groove morphology and measurements on MRI: correlation with fibularis tendon abnormalities. Surgical and Radiologic Anatomy. 2019;41:75-85.
14. Raikin SM, Elias I, Nazarian LN. Intrasheath subluxation of the peroneal tendons. JBJS. 2008;90(5):992-9.

15. Ogawa BK, Thordarson DB. Current concepts review: peroneal tendon subluxation and dislocation. Foot and ankle international. 2007;28(9):1034-40.
16. Hallinan JTPD, Wang W, Pathria MN, Smitaman E, Huang BK. The peroneus longus muscle and tendon: a review of its anatomy and pathology. Skeletal Radiology. 2019;48:1329-44.
17. Saragas NP, Ferrao PNF, Mayet Z, Eshraghi H. Peroneal tendon dislocation/subluxation-case series and review of the literature. Foot and Ankle Surgery. 2016;22(2):125-30.
18. Maffulli N, Ferran NA, Oliva F, Testa V. Recurrent subluxation of the peroneal tendons. The American Journal of Sports Medicine. 2006;34(6):986-92.
19. Title CI, Jung H-G, Parks BG, Schon LC. The peroneal groove deepening procedure: a biomechanical study of pressure reduction. Foot and ankle international. 2005;26(6):442-8.
20. Dombek MF, Lamm BM, Saltrick K, Mendicino RW, Catanzariti AR. Peroneal tendon tears: a retrospective review. The Journal of foot and ankle surgery. 2003;42(5):250-8.