

Brief communication (original)

Open access

Unusual accessory peroneal muscles, peroneus quartus, peroneus digiti quinti, and their association with peroneus brevis tendon tear

Pimpimol Dangintawat¹, Jirun Apinun², Thanasil Huanmanop¹, Sithiporn Agthong¹,
Prim Akkarawanit¹, Vilai Chentanez^{1,*}

Abstract

Background: Anatomic variation and supernumerary contents in the superior peroneal tunnel, and the prominence of the retrotrochlear eminence and peroneal tubercle are related to peroneal tendon disorders.

Objectives: To investigate the prevalence, origin, and insertion of accessory peroneal muscles, the prominence of the retrotrochlear eminence and peroneal tubercle, and their association with peroneal tendon tears.

Methods: We examined 109 formalin-embalmed legs of cadavers from Thai donors. Accessory peroneal muscles and peroneal tendon tears were noted. Associations with peroneal tendon tears were evaluated using a χ^2 test.

Results: We found 48 accessory peroneal muscles comprising 13 peroneus quartus (PQ), 33 peroneus digiti quinti (PDQ), and 2 unusual muscles. All PDQ originated from the PB tendon and inserted on various parts of the 5th toe. The PQ originated mostly from the PB muscle belly and less from the tendinous part with various insertions on the retrotrochlear eminence, peroneal tubercle, cuboid, and dorsolateral surface of the 5th metatarsal base. Two unusual accessory muscles were identified, 1 coexisting with the PQ. A PB tendon tear was found in 13% of specimens. We found no association between the peroneal tendon tears and the accessory peroneal muscles, or prominence of the retrotrochlear eminence or peroneal tubercle.

Conclusions: The prevalence of PQ, PDQ, and unusual accessory peroneal muscles was concordant with previous findings. We noted a new type of unusual accessory peroneal muscle coexisting with the PQ. No association was found between peroneal tendon tears and the PQ, PDQ, or prominence of the retrotrochlear eminence or peroneal tubercle.

Keywords: foot; leg injuries; metatarsal bone; muscle; peroneal; skeletal; tendon injuries; trochlear


There are various types of peroneal tendon injuries including tear, subluxation, and dislocation of peroneus brevis (PB) and peroneus longus (PL) tendons [1–3]. These injuries decrease performance in walking, running, and sport [1, 4–6].

The pathomechanics of peroneal tendon tear are related to an immediate eccentric contraction in dorsiflexion, while the foot is in contact with the ground. The mechanism of the injury is similar to that for lateral ankle sprain [7, 8].

*Correspondence to: Vilai Chentanez, Department of Anatomy, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand, e-mail: vilai.ch@chula.ac.th

¹Department of Anatomy, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand

²Department of Orthopedics, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand

Open Access. © 2018 P. Dangintawat et al., published by Sciendo.  This work is licensed under the Creative Commons Attribution NonCommercial-NoDerivatives 4.0 License.

Therefore, only 60% of the patients with peroneal tendon injuries are correctly diagnosed when first evaluated [9, 10]. There are several factors associated with peroneal tendon disorders, in particular anatomic variation and supernumerary contents of the superior peroneal tunnel [11–13]. The prominence of the retrotrochlear eminence and the thinning of the superior peroneal retinaculum (SPR) are considered to be associated with peroneal tendon tears [14]. Moreover, the presence of a peroneus quartus (PQ) muscle has the potential to create attrition or tear of the peroneal tendon at the retromalleolar groove [2, 15, 16].

Supernumerary peroneal muscles have been reported including the PQ and peroneus digiti quinti (PDQ). However, other unusual peroneal muscles are also reported [17, 18]. Therefore, the present study focused on anatomic variation of the accessory peroneal muscles and the association between these muscles and peroneal tendon tear. In addition, any possible association between these muscles and the prominence of the retrotrochlear eminence and peroneal tubercle was also investigated.

Materials and methods

This cadaveric study was approved by Institutional Review Board (IRB), Faculty of Medicine, Chulalongkorn University (IRB No. 110/61; certificate of approval No. 007/2018). We retracted legs from 109 formaldehyde-embalmed cadavers from Thai donors (55 male and 54 female) while the specimens were prone. The average age of cadaver donors at death was $77.44 \pm$ (standard deviation, SD) 12.91 years (range from 34 to 94 years), and were obtained from the Department of Anatomy, Faculty of Medicine, Chulalongkorn University. After removing the skin, the sural nerve and small saphenous vein were distracted anteriorly. The SPR was then identified and incised to expose the superior peroneal tunnel. The presence of accessory muscles, for example, PQ and PDQ, was identified. The origin and insertion of these muscles were described. The presence of any peroneal tendon tear (Grade III or IV as described by Sobel et al.) was noted [2, 19].

Statistical analyses

Statistical analyses were conducted using IBM SPSS Statistics for Windows (version 22.0). Epidemiology of legs with each accessory peroneal muscle was descriptive statistics. The association of the peroneal tendon tear with the presence of peroneal accessory muscles, prominence of the retrotrochlear eminence, and peroneal tubercle was determined using

either a χ^2 test (parametric) or Kolmogorov–Smirnov sign test (nonparametric).

Results

Accessory peroneal muscles were found in 48 of 109 cases (44%). Coexistence of the PQ and an unusual accessory peroneal muscle was present in one male cadaver. We found 13 (12%) PQ, 33 (30%) PDQ, and 2 (2%) unusual peroneal muscles.

The most frequent accessory peroneal muscle was the PDQ (**Figure 1**). The PDQ was found bilaterally in 12 (36%) cadavers (6 male and 6 female). All of these muscles originated from the PB tendon, but their insertions were varied as summarized in **Table 1**. On the dorsum of the foot, almost all of the PDQ were tendinous in structure, except for one that consisted of muscle fibers (**Figure 1**). Most of the PQ originated from the PB muscle belly and less frequently from the PB tendon. The PQ inserted on various sites including retrotrochlear eminence, peroneal tubercle, cuboid, and dorsolateral surface of the base of the 5th metatarsal as described in **Table 1** and **Figure 2**. The PQ was found bilaterally in 2 (15%) cases (1 male and 1 female).

Unusual accessory peroneal muscles were observed in 2 specimens (1 male, 1 female). In one, an unusual accessory peroneus muscle originated from the PL muscle and inserted on the peroneal tubercle (**Figure 3**). The other had 2 heads of origin: one from the PL tendon and the other from the lower part of the PB muscle at the distal end of fibula. Both parts united and coursed over the PL tendon at the lateral malleolus before splitting into 2 tendons. One tendon inserted on the retrotrochlear eminence and the other on the talus and peroneal tubercle (**Figure 4**). The PQ coexisted and inserted at retrotrochlear eminence (**Figure 4**).

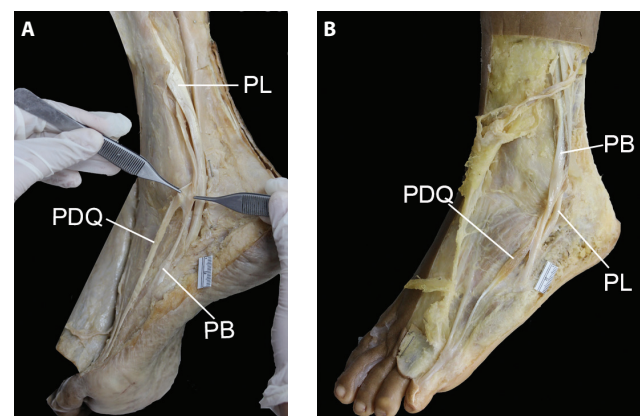


Figure 1. PDQ tendon (A) and muscle (B) on the dorsal surface of foot PB tendon, peroneus brevis tendon; PDQ, peroneus digiti quinti; PL tendon, peroneus longus tendon; scale represents 2 cm

Table 1. Prevalence of accessory peroneal muscles, and their origin and insertion

	Male (n = 55)	Female (n = 54)	Total (N = 109)		
PQ	8 (7%)	5 (5%)	13 (12%)	PB muscle belly (9) PB tendon (3) PL tendon (1)	Retrotrochlear eminence of calcaneus (9) Base of 5th metatarsal (1) Cuboid (1) Peroneal tubercle (2)
PDQ	17 (16%)	16 (15%)	33 (30%)	PB tendon (33) Single tendon (32) Muscle fiber (1)	Base of 5th proximal phalanx (26) Base of 5th middle phalanx (1) PDQ tendon merged with extensor digitorum longus and inserted at the base of 5th distal phalanx (4) Shaft of 5th metatarsal (2)
Unusual accessory peroneal	1 (1%)	1 (1%)	2 (2%)	PL muscle (1) PL tendon and PB muscle (1)	Peroneal tubercle between the inferior peroneal retinaculum septum (1) Tendon bifurcated, one inserted at the talus and peroneal tubercle and the other at the retrotrochlear eminence (1)

PB, peroneus brevis; PDQ, peroneus digiti quinti; PL, peroneus longus; PQ, peroneus quartus

Evidence of a PB tendon tear was found in 14 of 109 cases (13%; **Figure 5**). However, there was no PL tendon tear in any case. The peroneal tubercle was found in 51 (47%) cases and retrotrochlear eminence was found in 87 (80%). All tendon tears were asymmetrical. No significant association was found between the presence of accessory peroneal muscles (either PQ or PDQ) and the prominence of the retrotrochlear eminence or peroneal tubercle (**Tables 2 and 3**). Moreover, there was no significant association between PB tendon tears and prominence of the retrotrochlear eminence or peroneal tubercle (**Table 4**). There was no coexistence of PQ and PB tendon tears in any case. PB tendon tears coexisted with a PDQ in 6 (43%) cases. However, there was no significant association between PB tendon tears and the presence of either a PQ or PDQ (**Table 5**).

Discussion

In the present study, we found 44% prevalence of accessory peroneal muscles in cadavers of Thai individuals. These muscles were PDQ, PQ, and unusual accessory peroneal muscles. The prevalence of PDQ was 30%, which is similar to that found previously (30%–50%) [20, 21]. The PDQ was commonly found bilaterally and predominantly in men [22]. By contrast, the prevalence of bilateral PDQ in an Indian population was only 5% [20]. The PDQ separates from the PB tendon as a slender tendon [20, 21]. In the present study, we found one PDQ with muscle fibers. Most of the PDQ inserted on the different parts of the 5th toe including shaft of metatarsal and bases of proximal, middle, and distal phalanges. Moreover, the

PDQ tendon merged with that of the extensor digitorum longus and inserted at the base of distal phalanx in 3 cases. Demir et al. described the insertion pattern of the PDQ as having 2 different types: a single tendon attached to the 5th metatarsal bone and 2 separated tendons attached to different parts of the 5th metatarsal bone [21]. Moreover, dual insertion of PDQ on the 4th and 5th metatarsals was reported in 3% of PDQ cases [20]. In the present study, all PDQ had a single tendon.

The prevalence of the PQ in this study was 12% and predominantly found in male cadavers in accordance with previous studies (5%–22%) [12, 14, 22–24]. The PQ muscle arose only from the PB muscle belly and its tendon, and not from the distal shaft of the fibula or posterior intermuscular septum as previously described [22–24]. The PQ had a single tendon and inserted at various sites including retrotrochlear eminence, peroneal tubercle, base of 5th metatarsal, and cuboid. However, Bilgili et al. reported the case of a PQ with 2 separated tendons that inserted at different points. In that case, the PQ tendon was bifurcated and coursed above and beneath the PB tendon to insert at the retrotrochlear eminence and cuboid bone [23]. The PQ is reported to coexist with hypertrophy of the peroneal tubercle or retrotrochlear eminence [15, 25]. In the present study, only 7 of 51 cases with a prominent peroneal tubercle and 12 of 87 cases with a prominent retrotrochlear eminence were found to have this coexistence (**Table 2**). Therefore, the association between the prominence of the retrotrochlear eminence or peroneal tubercle and the presence of the PQ was not significant. Moreover, the hypertrophy of a peroneal tubercle and a prominent retrotrochlear eminence was present in an asymptomatic ankle without the presence of a PQ in accordance with previous findings [14, 26].

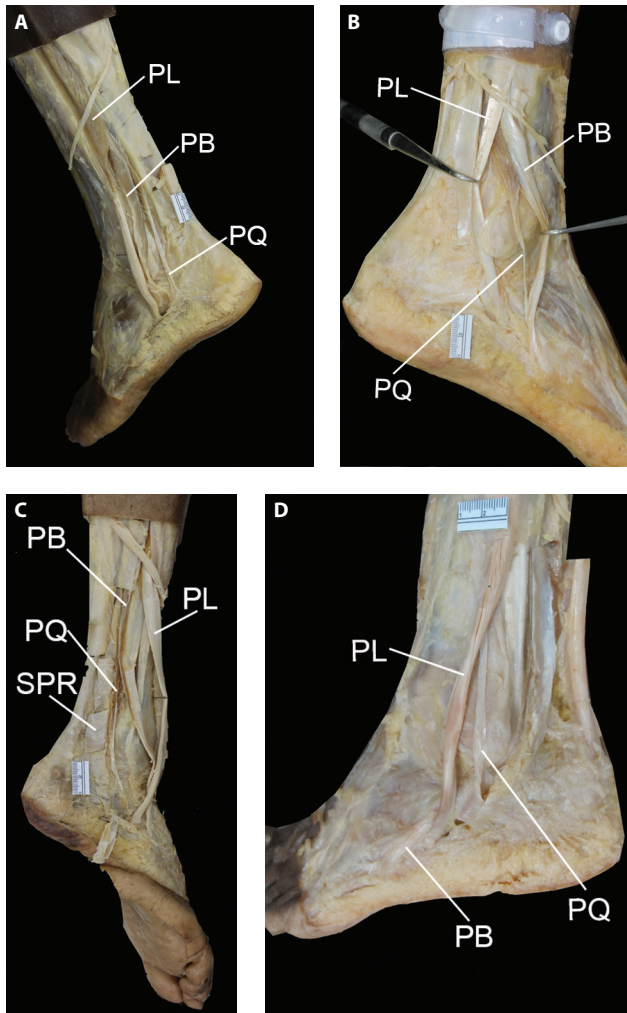


Figure 2. PQ insertion: (A) retrotrochlear eminence, (B) 5th metatarsal, (C) cuboid, (D) peroneal tubercle
PB tendon, peroneus brevis tendon; PL tendon, peroneus longus tendon; PQ, peroneus quartus; SPR, superior peroneal retinaculum; scale represents 2 cm

Tubbs et al. reported an unusual accessory muscle called the peroneotalocalcaneus muscle. This muscle originated from the anterior intermuscular septum and PL muscle and inserted on the superior surface of the talus and calcaneus [17]. Moreover, Fabrizio reported an anomalous fibularis (peroneal) muscle. This muscle arose from the muscle belly of the PL muscle in the proximal half and gave rise to a long slender tendon, which coursed posteriorly to lateral malleolus, and inserted on the superficial aspect of inferior peroneal retinaculum [18]. In the present study, unusual accessory peroneal muscles were found in 1 instance in each sex (2%). One of these muscles arose from the PL and inserted at the peroneal tubercle between the inferior peroneal retinaculum septum. The other arose from the PL tendon and PB muscle and gave rise to 2 tendons inserted at different points. One tendon inserted on the talus and peroneal tubercle, while the other inserted on the retrotrochlear eminence.

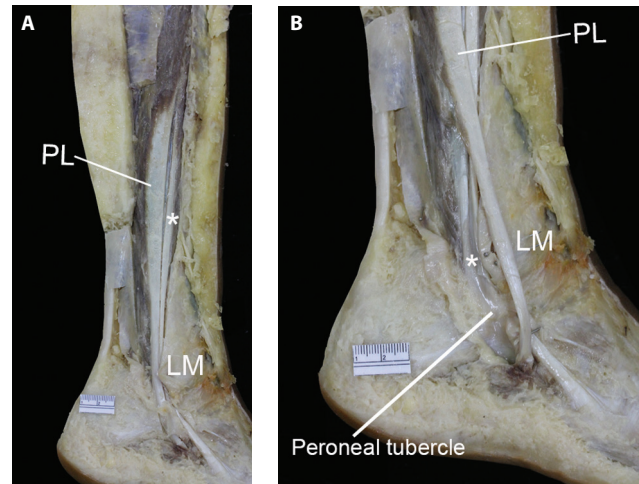


Figure 3. Unusual accessory peroneal muscle (*) (A) arose from PL muscle (B) inserted at peroneal tubercle
LM, lateral malleolus; PB muscle, peroneus brevis muscle; PL, peroneus longus; scale represents 2 cm

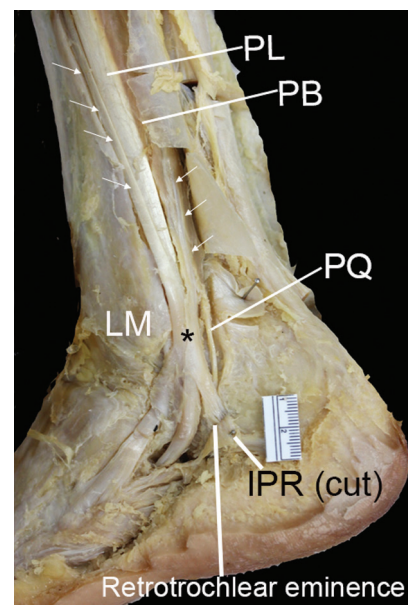


Figure 4. Unusual accessory peroneal muscle (*) which coexisted with PQ muscle; the origin of unusual accessory peroneal muscle (arrows) from PL and PB
IPR, inferior peroneal retinaculum; LM, lateral malleolus; PB tendon, peroneus brevis tendon; PL tendon, peroneus longus tendon; PQ, peroneus quartus; scale represents 2 cm

A peroneal tendon tear or attrition was reported as a consequence of acute mechanical or the repetitive injury such as trauma, mechanical irritation, or attrition within the retromalleolar groove, subluxation of the SPR, incompetent SPR, and ankle instability [4, 9, 14]. Zammit and Singh stated that there were several anatomical factors associated with peroneal tendon tears, such as the prominence

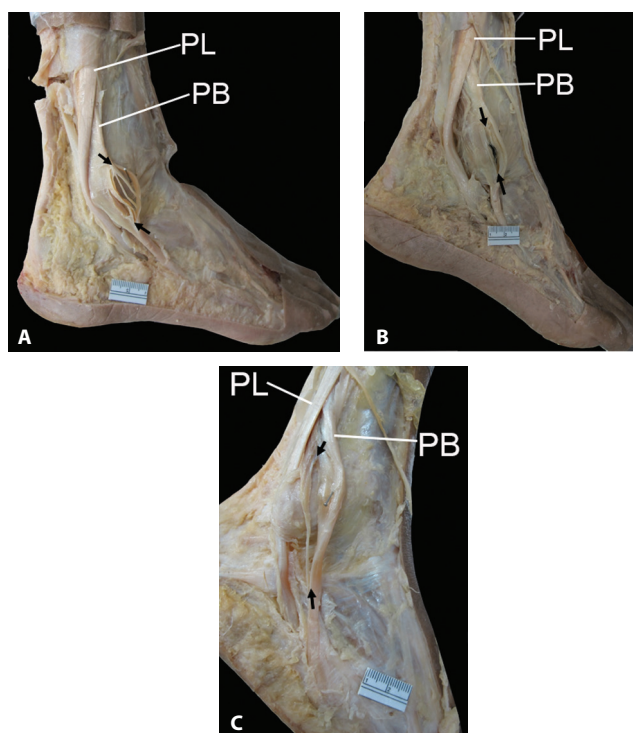


Figure 5. Grade IV of PQ tendon tear (arrows)
PB tendon, peroneus brevis tendon; PL tendon, peroneus longus tendon; PQ, peroneus quartus; scale represents 2 cm

Table 2. Association between PQ and the prominence of a retrotrochlear eminence or peroneal tubercle

		PQ		Total	χ^2 test
		Present	Absent		
Prominent retrotrochlear eminence	Present	12	75	87	$P = 0.23$
	Absent	1	21	22	
Prominent peroneal tubercle	Present	7	44	51	$P = 0.58$
	Absent	6	52	58	

PQ, peroneus quartus

Table 3. Association between PDQ and the prominence of a retrotrochlear eminence or peroneal tubercle

		PDQ		Total	χ^2 test
		Present	Absent		
Prominent retrotrochlear eminence	Present	27	60	87	$P = 0.73$
	Absent	6	16	22	
Prominent peroneal tubercle	Present	17	34	51	$P = 0.52$
	Absent	16	42	58	

PDQ, peroneus digiti quinti

of the retrotrochlear eminence and the thinning or laxity of the SPR [14]. In the present study, only 13 of 87 specimens with a prominent retrotrochlear eminence coexisted with a PB tendon tear. Therefore, no significant association was found. Previous studies had reported that the presence of a PQ has the potential to create attrition or a tear of the peroneal tendon at the retromalleolar groove [2, 15, 16]. However, none of the cases of PB tendon tear in the present study coexisted with the presence of a PQ. Moreover, the presence of a PDQ in the present study was not significantly associated with a PB tendon tear (**Table 5**).

Conclusions

The prevalence of PQ, PDQ, and unusual accessory peroneal muscle in Thai specimens in the present study was in agreement with previous findings in other populations. Coexistence of a PQ and an unusual accessory peroneal muscle was found in one male specimen. There was no association between PQ or PDQ and the prominence of either the retrotrochlear eminence or peroneal tubercle. Moreover, the PB tendon tears were not significantly associated with the presence of an accessory peroneal muscle or the prominence of either the retrotrochlear eminence or peroneal tubercle.

Table 4. Association between PB tendon tears and the prominence of a retrotrochlear eminence or peroneal tubercle

		PB tendon tear		Total	χ^2 test
		Present	Absent		
Prominent retrotrochlear eminence	Present	13	74	87	$P = 0.19$
	Absent	1	21	22	
Prominent peroneal tubercle	Present	7	44	51	$P = 0.80$
	Absent	7	51	58	

PB, peroneus brevis

Table 5. Association between PB tendon tears and the presence of a PQ or PDQ

		PB tendon tear		Total	χ^2 test
		Present	Absent		
PQ	Present	0	13	13	$P = 0.14$
	Absent	14	82	96	
PDQ	Present	6	27	33	$P = 0.27$
	Absent	8	68	76	

PB, peroneus brevis; PDQ, peroneus digiti quinti; PQ, peroneus quartus

Author contributions. PD, JA, TH, SA, and VC conceived and designed this study. All the authors dissected specimens and collected the data. PD and VC analyzed and interpreted the data. All the authors critically drafted, read, and revised the manuscript, approved the final version submitted for publication, and take responsibility for the statements made in the published article.

Acknowledgments. The authors appreciate the contributions of Dr. Somjet Tosamran and Amornrat Tothonglor in the dissection and data collection and specially thank the technical staff of the Department of Anatomy, Faculty of Medicine, Chulalongkorn University, for their support in cadaveric management. We did not receive any specific grant for this research from any funding agency in the public, commercial, or not-for-profit sectors. The present work was presented in part as a poster at the 41st Annual Conference of the Anatomy Association of Thailand (AAT41), 2018 May 23–25, Cha-am, Phetchaburi, Thailand. Pimpimol Dangintawat, Jirun Apinun, Thanasil Huanmanop, Sithiporn Agthong, Prim Akkarawanit, Vilai Chentanez. Unusual accessory peroneal muscles, peroneus quartus, peroneus digiti quinti and their association with peroneus brevis tendon tear [PP 30, AAT97].

Conflict of interest statement. The authors have each completed and submitted an International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. None of the authors have any conflict of interest to disclose.

References

- [1] Cho J, Kim JY, Song DG, Lee WC. Comparison of outcome after retinaculum repair with and without fibular groove deepening for recurrent dislocation of the peroneal tendons. *Foot Ankle Int.* 2014; 35:683–9.
- [2] Sobel M, Bohne WH, Levy ME. Longitudinal attrition of the peroneus brevis tendon in the fibular groove: an anatomic study. *Foot Ankle.* 1990; 11:124–8.
- [3] Sobel M, DiCarlo EF, Bohne WH, Collins L. Longitudinal splitting of the peroneus brevis tendon: an anatomic and histologic study of cadaveric material. *Foot Ankle.* 1991; 12:165–70.
- [4] Coughlin MJ, Schon LC. Disorders of tendon. Chapter 24. In: Coughlin MJ, Saltzman C, Anderson RB, editors. *Mann's surgery of the foot and ankle. Volume I, Part VI. Arthritis, postural disorders, and tendon disorders.* 9th ed. Philadelphia: Elsevier; 2014. p. 1232–75.
- [5] Maffulli N, Ferran NA, Oliva F, Testa V. Recurrent subluxation of the peroneal tendons. *Am J Sports Med.* 2006; 34:986–92.
- [6] Karlsson J, Wiger P. Longitudinal split of the peroneus brevis tendon and lateral ankle instability: treatment of concomitant lesions. *J Athl Train.* 2002; 37:463–6.
- [7] Roth JA, Taylor WC, Whalen J. Peroneal tendon subluxation: the other lateral ankle injury. *Br J Sports Med.* 2010; 44:1047–53.
- [8] van Dijk PA, Gianakos AL, Kerkhoffs GM, Kennedy JG. Return to sports and clinical outcomes in patients treated for peroneal tendon dislocation: a systematic review. *Knee Surg Sports Traumatol Arthrosc.* 2016; 24:1155–64.
- [9] Dombek MF, Lamm BM, Saltrick K, Mendicino RW, Catanzariti AR. Peroneal tendon tears: a retrospective review. *J Foot Ankle Surg.* 2003; 42:250–8.
- [10] Oliva F, Saxena A, Ferran NA, Maffulli N. Peroneal tendinopathy. In: Saxena A, editor. *Sports medicine and arthroscopic surgery of the foot and ankle.* Palo Alto: Springer; 2013. p. 187–212.
- [11] Lotito G, Pruvost J, Collado H, Coudreuse JM, Bensoussan L, Curvale G, et al. Peroneus quartus and functional ankle instability. *Ann Phys Rehabil Med.* 2011; 54:282–92. [article in English, French]
- [12] Athavale SA, Swathi, Vangara SV. Anatomy of the superior peroneal tunnel. *J Bone Joint Surg Am.* 2011; 93:564–71.
- [13] Galli MM, Protzman NM, Mandelker EM, Malhotra AD, Schwartz E, Brigido SA. An examination of anatomic variants and incidental peroneal tendon pathologic features: a comprehensive MRI review of asymptomatic lateral ankles. *J Foot Ankle Surg.* 2015; 54:164–72.
- [14] Zammit J, Singh D. The peroneus quartus muscle. Anatomy and clinical relevance. *J Bone Joint Surg Br.* 2003; 85:1134–7.
- [15] Sobel M, Levy ME, Bohne WH. Congenital variations of the peroneus quartus muscle: an anatomic study. *Foot Ankle.* 1990; 11:81–9.
- [16] Unlu MC, Bilgili M, Akgun I, Kaynak G, Ogut T, Uzun I. Abnormal proximal musculotendinous junction of the peroneus brevis muscle as a cause of peroneus brevis tendon tears: a cadaveric study. *J Foot Ankle Surg.* 2010; 49:537–40.
- [17] Tubbs RS, May WR, Shoja MM, Loukas M, Salter EG, Oakes WJ. Peroneotalocalcaneus muscle. *Anat Sci Int.* 2008; 83:280–2.
- [18] Fabrizio PA. Unusual fibularis (peroneus) muscle. *Surg Radiol Anat.* 2015; 37:997–9.
- [19] Davis WH, Sobel M, Deland J, Bohne WH, Patel MB. The superior peroneal retinaculum: an anatomic study. *Foot Ankle Int.* 1994; 15:271–5.
- [20] Jadhav SD, Gosavi SN, Zambare BR. Study of peroneus digiti minimi quinti in Indian population: a cadaveric study. *Rev Arg Anat Clin.* 2013; 5:67–72.
- [21] Demir BT, Gümmüşalan Y, Üzel M, Cevik HB. The variations of peroneus digiti quinti muscle and its contribution to the extension of the fifth toe. A cadaveric study. *Saudi Med J.* 2015; 36:1285–9.
- [22] Yammine K. The accessory peroneal (fibular) muscles: peroneus quartus and peroneus digiti quinti. A systematic review and meta-analysis. *Surg Radiol Anat.* 2015; 37:617–27.
- [23] Bilgili MG, Kaynak G, Botanlioglu H, Basaran SH, Ercin E, Baca E, et al. Peroneus quartus: prevalence and clinical importance. *Arch Orthop Trauma Surg.* 2014; 134:481–7.
- [24] Athavale SA, Gupta V, Kotgirwar S, Singh V. The peroneus quartus muscle: clinical correlation with evolutionary importance. *Anat Sci Int.* 2012; 87:106–10.
- [25] Wang XT, Rosenberg ZS, Mechlin MB, Schweitzer ME. Normal variants and diseases of the peroneal tendons and superior peroneal retinaculum: MR imaging features. *Radiographics.* 2005; 25:587–602.
- [26] 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; 242:509–17.