

New aspect of morphometric study of the superior peroneal retinaculum: pertinent data for surgical repair and reconstruction

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Background: This study was conducted to investigate characteristics, attachments and morphometric parameters of the superior peroneal retinaculum (SPR).

Materials and methods: Morphology and morphometric details including width, length, thickness and angle of alignment of SPR in 109 embalmed cadaveric legs were investigated. The occurrence of peroneal tendon tear was also noted.

Results: Most of SPR originated from the fibrocartilaginous ridge of the lateral malleolus. The SPR might be a single band or split into proximal and distal bands inserted on the posterior intermuscular septum and lateral wall of calcaneus, respectively. Based on the characteristics and insertion patterns, the SPR could be divided into three types: type I (double band with subtype Ia and Ib), type II (single band) and type III (single band) with the prevalence of 56.88% (12.84%, 44.04%), 1.83%, and 41.28%, respectively. The average coordinate (X, Y axis) of the midpoint of width at origin measured from the tip of fibula in all types was 7.26 ± 3.15 and 10.45 ± 4.52 mm. The average coordinate of the midpoint at insertion on the posterior intermuscular septum was 24.06 ± 4.94 and 13.35 ± 5.18 , and those inserted on the lateral wall of calcaneus was 21.45 ± 7.88 and 13.59 ± 6.73 mm. Prevalence of peroneus brevis tendon tear was 12.84% (14 cases) and was associated with SPR type Ib with statistical significance.

Conclusions: Precise information of the characteristics, morphometric data and coordinates of attachment sites of SPR are essential for surgical procedures and reconstruction. (Folia Morphol 2020; 79, 3: 594–603)

Key words: morphometric data, peroneal tendon tear, reconstruction, superior peroneal retinaculum

INTRODUCTION

The superior peroneal retinaculum (SPR) is the primary stabilizer of the peroneal tendons to fit in their alignment at distal fibular level [2, 6]. The space beneath

the SPR is called the superior peroneal tunnel (SP tunnel) [2]. Contents of SP tunnel are peroneus brevis (PB) and peroneus longus (PL) tendons. Additional contents of the SP tunnel including peroneus quartus and unusual

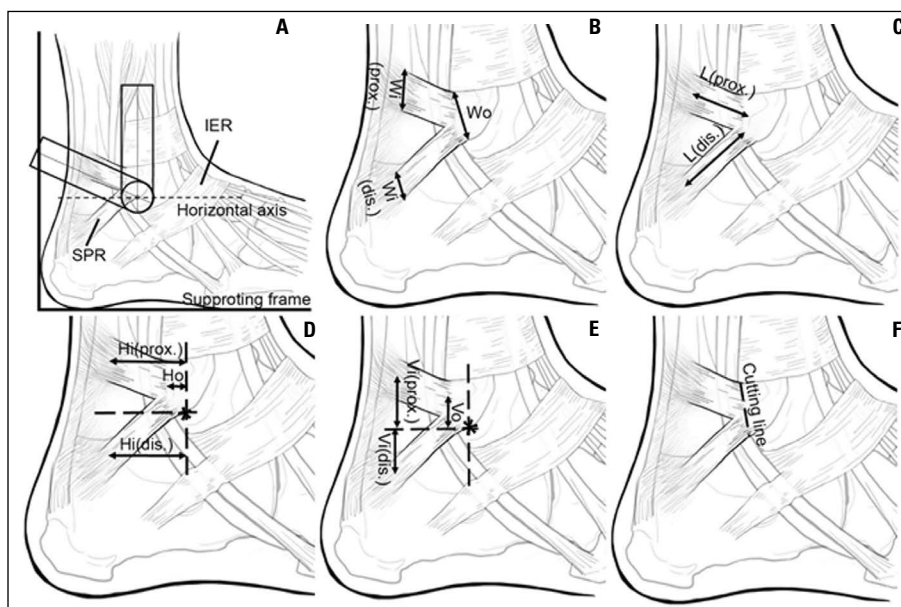


Figure 1. Illustration showing ankle supporting frame to maintain the foot in neutral position and measurement of all parameters in this position; **A.** Angle of the superior peroneal retinaculum (SPR) to the horizontal axis; **B.** The width at the origin and insertion; **C.** The length of the SPR; **D.** The horizontal distance from mid-point of SPR origin and insertion to tip of fibula (*); **E.** The vertical distance from mid-point of SPR origin and insertion to tip of fibula (*); **F.** The cutting line; $W_o(\text{prox.})$ — width at origin of proximal band; $W_i(\text{prox.})$ — width at the insertion of proximal band; $W_i(\text{dis.})$ — width at the insertion of distal band; H_o — horizontal distance from mid-point of origin to tip of fibula; $H_i(\text{prox.})$ — horizontal distance from mid-point of insertion of proximal band to tip of fibula; $H_i(\text{dis.})$ — horizontal distance from mid-point of insertion of distal band to tip of fibula; $L(\text{prox.})$ — length of the SPR proximal band; $L(\text{dis.})$ — length of the SPR distal band; IER — inferior extensor retinaculum.

accessory peroneal muscle were reported [1, 24]. Insufficiency of SPR was claimed to be an associated factor related to peroneal tendon disorders [8, 17, 23]. This pathology caused disabilities in walking, running and sport performances. The anatomic descriptions of SPR are extremely variable in width, thickness and their patterns of insertion [6, 18]. Conservative treatments might not be able to prevent recurrent episodes of dislocation/subluxation of peroneal tendon [13, 18, 25]. Therefore, surgical treatment is required after unsuccessful conservative treatments [19, 22, 23]. Nowadays, several surgical procedures have been described [4, 10]. Maffulli et al. [13] suggested that the key to successful treatment of peroneal tendon dislocation and prevention of recurrent symptom were the reattachment of SPR to its anatomical position [13]. However, knowledge of the precise area for SPR reattachment is still lacking. Therefore, the authors conducted this study to investigate the characteristics, the attachments, the morphometric parameters of SPR including width, length, thickness and angle of alignment. The distance from the attachment to inferior tip of fibula in X and Y axis was measured in order to locate the precise area of attachment. The presence of peroneal tendon tear was also noted. Comparisons of these parameters between genders and sides were determined.

MATERIALS AND METHODS

Formaldehyde-embalmed cadaveric legs with age range of 34–94 years (55 males and 54 females) from the Department of Anatomy, Faculty of Medicine, Chulalongkorn University were investigated. Lower extremities with injury and foot deformities were excluded. All cadaveric legs were dissected and evaluated in prone position. The skin and subcutaneous tissue were removed. Characteristics and attachments of the SPR were identified. The Achilles tendon was released and adjusted to neutral position by a supporting frame (Fig. 1A). The standardised digital Vernier calliper (GuangLu® 0–100 mm; range 100 mm, resolution 0.01 mm) was used to measure each parameter. Width of SPR was measured both in origin at lateral malleolus (W_o) and at insertion (W_i) (Fig. 1B). Horizontal and vertical distances from mid-point of origin and insertion to the inferior tip of fibula were measured from X and Y axis (Fig. 1D, E). Length of the SPR band was also measured (Fig. 1C). The angle of the alignment of the SPR to the horizontal axis was evaluated by standard goniometer (BASELINE™_{MCE}) (Fig. 1A). The axis of rotation was the inferior tip of fibula. The origin of SPR was cut (Fig. 1F) and its thickness was measured at its middle part. The presence of the

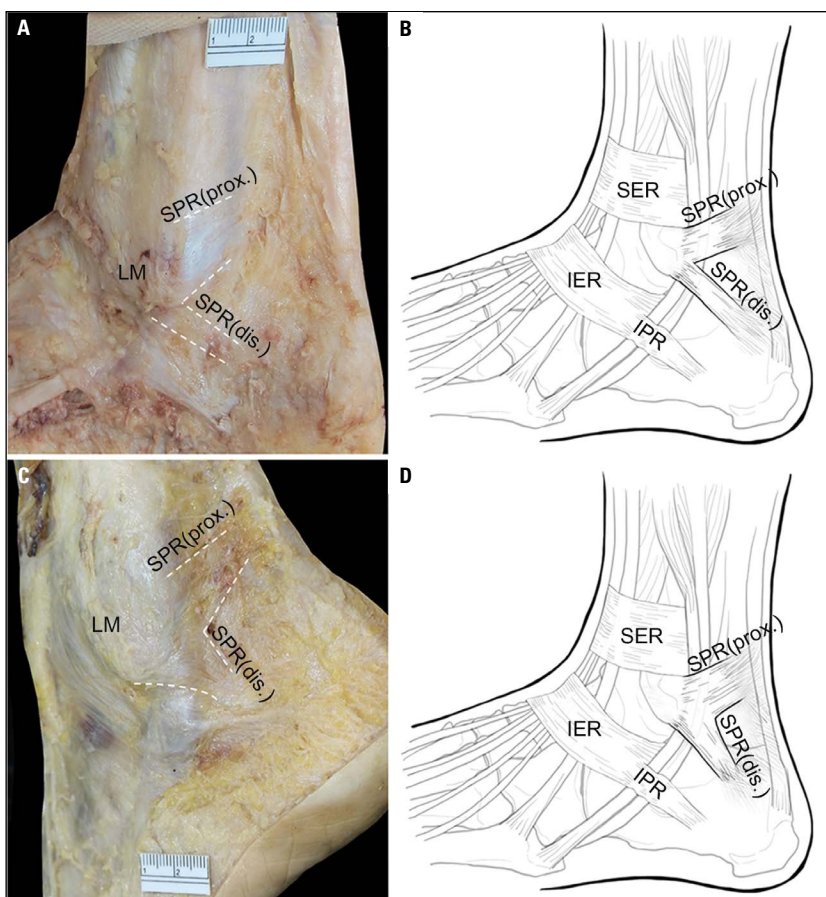


Figure 2. Photograph and illustration of type Ia (**A, B**) and Ib (**C, D**) of superior peroneal retinaculum (SPR). Superior peroneal retinaculum proximal band [SPR (prox)] and superior peroneal retinaculum distal band [SPR (dis)] inserted on the posterior intermuscular septum and lateral wall of calcaneus; IER — inferior extensor retinaculum; IPR — inferior peroneal retinaculum; LM — lateral malleolus; SER — superior extensor retinaculum.

PB tendon tear was recorded. Each parameter was measured 3 times and the average was calculated. To ensure consistency, the same digital Vernier calliper and standard goniometer were used. All measurements were done by the same investigator.

Statistical analysis

Statistical analysis was performed by using IBM SPSS software version 22.0. The intra-class correlation coefficient (ICC) was used to determine the intra-tester reliability. Mean and standard deviation for each parameter were obtained. Shapiro-Wilk test of normality was used to determine the distribution of sample population. Unpaired t-test in normally distributed data and Mann-Whitney U test in non-normally distributed data were used to compare parameters between genders and sides. One-way ANOVA (for parametric test) or Kruskal-Wallis (for nonparametric test) was used to compare the difference of the presence of PB tendon tear in each type.

Ethical consideration

This cadaveric study has been approved by the Institutional Review Board (IRB), Faculty of Medicine, Chulalongkorn University (IRB NO. 110/61).

RESULTS

Characteristics, origin and the attachment of the SPR

The SPR had a common origin which extended from the fibrocartilaginous ridge of the posterolateral surface of the lateral malleolus, but its insertion was varied. The SPR might be a single band or split into proximal and distal bands to insert on the posterior intermuscular septum and lateral wall of calcaneus. Direction of proximal band might be slightly upward or parallel to the horizontal axis. In this study, the SPR could be classified into three types according to their insertion patterns (Fig. 2–4). Type I consisted of double bands while type II and type III had single band. Details of the characteristic of each type are described

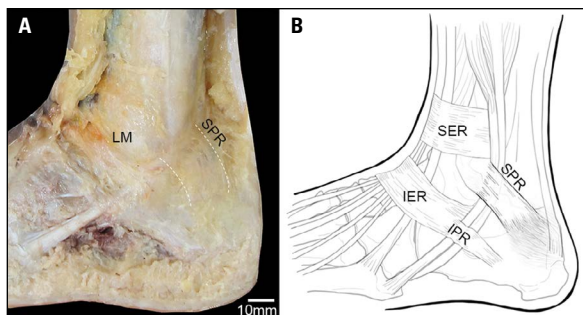


Figure 3. Photograph and illustration of type II (A, B) of superior peroneal retinaculum (SPR) with a single band inserted on lateral wall of the calcaneus; IER — inferior extensor retinaculum; IPR — inferior peroneal retinaculum; LM — lateral malleolus; SER — superior extensor retinaculum.

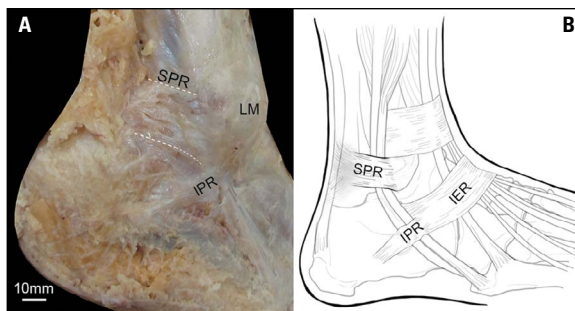


Figure 4. Photograph and illustration of type III (A, B) of superior peroneal retinaculum (SPR) with a single band inserted on posterior intermuscular septum; IER — inferior extensor retinaculum; IPR — inferior peroneal retinaculum; LM — lateral malleolus; SER — superior extensor retinaculum.

Table 1. Description of the types of superior peroneal retinaculum (SPR)

Type	Definition
Type I	
Type Ia	The SPR originated from fibrocartilaginous ridge of the posterolateral surface of lateral malleolus and split near its origin into two bands: the proximal band coursed slightly upward and distal bands coursed slightly downward to insert on the posterior intermuscular septum and lateral wall of calcaneus respectively
Type Ib	The SPR originated from fibrocartilaginous ridge of the posterolateral surface of lateral malleolus and divided at its middle part into two bands: the proximal coursed slightly upward or parallel to the horizontal plane and distal bands coursed slightly downward to insert on the posterior intermuscular septum and lateral wall of calcaneus respectively
Type II	The SPR originated from fibrocartilaginous ridge of the posterolateral surface of lateral malleolus and coursed slightly downward to insert on the lateral wall of the calcaneus
Type III	The SPR originated from fibrocartilaginous ridge of the posterolateral surface of lateral malleolus and coursed slightly upward or parallel to the horizontal plane to insert on the posterior intermuscular septum

Table 2. Prevalence of the superior peroneal retinaculum — N (%)

Type	Total	Left		Right	
		Male	Female	Male	Female
Type Ia	14 (12.84%)	1 (0.92%)	6 (5.50%)	3 (2.75%)	4 (3.67%)
Type Ib	48 (44.04%)	13 (11.93%)	12 (11.01%)	8 (7.34%)	15 (13.76%)
Type II	2 (1.83%)	—	2 (1.83%)	—	—
Type III	45 (41.28%)	14 (12.84%)	7 (6.42%)	16 (14.68%)	8 (7.34%)

in Table 1. However, type I could be divided into two subtypes: type Ia and type Ib based on the site of splitting into proximal and distal bands. The splitting site of type Ia was closed to its origin (Fig. 2A, B) while that of type Ib was at its middle part (Fig. 2C, D). The prevalence of each type is shown in Table 2. The most common was type Ib and the least common was type II. In addition, a symmetrical pattern was found in 29 (52.73%) cadavers with a prevalence of 15 (27.27%), 13 (23.64%) and 1 (1.82%) cadavers in type III, type Ib and type Ia, respectively. In cases of asymmetrical

pattern, characteristic features found in the cadavers were type Ib with type III, type Ia with type Ib, type Ia with type III, type Ia with type II and type Ib with type II with a prevalence of 12 (21.82%), 9 (16.36%), 2 (3.64%), 1 (1.82%) and 1 (1.82%), respectively. One cadaver with only one leg of type III was excluded from consideration of symmetrical pattern.

The width of SPR

Width of the SPR was obtained from its origin (Wo) and its insertion (Wi). The SPR had a common origin at the lateral malleolus with an average width of 18.37 ± 4.13 mm. The widest part of Wo was found in type Ib. In contrast, the widest part of Wi was found in type III. In addition, the average of Wi of SPR inserted on the lateral calcaneus was lesser than those inserted on the lateral intermuscular septum (Table 3). Comparisons of the width of SPR between genders and sides in each type revealed that only the proximal and distal band of Wi of type Ia had a statistically significant difference between sides ($p = 0.018$ and 0.040 , respectively).

Table 3. Width of the superior peroneal retinaculum (SPR) — mean \pm standard deviation (range) [mm]

Type		Width at origin	P	Width at insertion	P
Type Ia					
Proximal band	Left	16.57 \pm 4.03 (10.33–21.11)	0.278	10.93 \pm 3.84 (6.31–17.42)	0.018*
	Right	19.59 \pm 2.42 (14.98–21.74)		16.25 \pm 3.47 (11.38–21.70)	
	Total	17.58 \pm 3.36 (10.33–21.74)		13.59 \pm 4.47 (6.31–21.70)	
Distal band	Left	NA	NA	8.96 \pm 3.15 (4.59–14.17)	0.040*
	Right	NA		12.24 \pm 2.08 (8.76–14.49)	
	Total	NA		10.60 \pm 3.08 (4.59–14.49)	
Type Ib					
Proximal band	Left	18.91 \pm 3.19 (13.17–27.71)	0.081	14.51 \pm 3.74 (8.23–24.07)	0.926
	Right	20.23 \pm 3.45 (15.37–28.98)		14.53 \pm 4.05 (7.96–24.38)	
	Total	19.73 \pm 3.40 (13.17–28.98)		14.52 \pm 3.85 (7.96–24.38)	
Distal band	Left	NA	NA	10.22 \pm 4.25 (5.65–29.94)	0.556
	Right	NA		10.25 \pm 2.63 (6.14–18.46)	
	Total	NA		10.23 \pm 3.53 (5.65–26.94)	
Type II					
Single band	Left	14.53 \pm 5.54 (10.62–18.45)	NA	10.83 \pm 7.00 (5.88–15.78)	NA
Type III					
Single band	Left	16.98 \pm 4.37 (8.05–25.34)	0.656	14.86 \pm 2.76 (10.54–21.12)	0.573
	Right	17.61 \pm 4.97 (10.81–26.22)		14.26 \pm 3.97 (5.64–21.02)	
	Total	17.31 \pm 4.65 (8.05–26.22)		14.55 \pm 3.42 (5.64–21.12)	
All cases of SPR based on insertion site					
Posterior intermuscular septum				14.34 \pm 3.80 (5.64–24.38)	
Lateral wall of calcaneus				10.32 \pm 3.42 (4.59–26.94)	

*Statistical significance; NA — not available

The length of SPR

Results of the length of SPR revealed that the mean length of those inserted on the posterior intermuscular septum and on the lateral wall of the calcaneus were 22.05 \pm 3.99 and 28.41 \pm 5.49 mm, respectively. The distal band of type Ib was the longest, while type III was the shortest. Comparisons of the length of SPR between genders and sides revealed no statistically significant difference. Detail of morphometric data is tabulated in Table 4.

The angle of SPR

Results of the angle of the SPR revealed that most were acute angles, except those aligned parallel to the horizontal axis. The prevalence of parallel alignment of SPR was found in 1 and 4 cases of type Ib and type III, respectively. The mean upward angle of all type was 10.02 \pm 5.80 degrees. All distal bands coursed downward to their insertion on the lateral border of calcaneus. The mean downward angle of all type was 40.75 \pm 18.98 degrees. Details of the angle of SPR

in each type are described in Table 4. Comparisons of the angle of SPR between genders and sides revealed no statistically significant difference.

The thickness of the SPR

The thickness of the SPR was measured at its middle part. The average thickness of both proximal and distal bands in all types was 0.47 \pm 0.20 and 0.38 \pm 0.19 mm, respectively. The thickest SPR was found in the proximal band of type III while the thinnest was found in the distal band of type Ib. Comparisons of the thickness of SPR between genders and sides showed no statistically significant difference (Table. 4).

Horizontal and vertical distances from the midpoint of origin and insertion of the SPR to the inferior tip of fibula

In order to locate the precise attachment of the SPR, horizontal and vertical distances from the midpoint of the common origin and the insertion of the

Table 4. Morphometric data of the superior peroneal retinaculum (SPR) — mean \pm standard deviation (range) [mm]

Type		Length	P	Thickness	P	Angle	P
Type Ia							
Proximal band	Left	22.34 \pm 5.21 (16.51–32.83)	0.716	0.52 \pm 0.22 (0.19–0.75)	0.217	13.95 \pm 8.31 (4.67–26.00)	0.351
	Right	23.39 \pm 5.26 (16.70–32.35)		0.37 \pm 0.19 (0.15–0.68)		10.48 \pm 4.55 (3.33–14.67)	
	Total	22.86 \pm 5.06 (16.51–32.83)		0.45 \pm 0.21 (0.15–0.75)		12.21 \pm 6.69 (3.33–26.00)	
Distal band	Left	22.55 \pm 5.56 (16.27–32.72)	0.381	0.54 \pm 0.23 (0.27–0.82)	0.291	34.57 \pm 18.47 (6.67–59.33)	0.332
	Right	24.91 \pm 4.03 (17.16–29.94)		0.43 \pm 0.16 (0.24–0.64)		24.95 \pm 17.13 (2.33–48.33)	
	Total	23.73 \pm 4.82 (16.27–32.72)		0.49 \pm 0.20 (0.24–0.82)		29.76 \pm 17.83 (2.33–59.33)	
Type Ib							
Proximal band	Left	23.01 \pm 3.45 (18.45–31.15)	0.633	0.46 \pm 0.18 (0.17–0.86)	0.954	10.32 \pm 5.78 (0.00–19.00)	0.125
	Right	22.57 \pm 2.93 (16.24–27.76)		0.46 \pm 0.22 (0.20–0.98)		8.13 \pm 3.58 (3.67–19.33)	
	Total	22.80 \pm 3.18 (16.24–31.15)		0.46 \pm 0.20 (0.17–0.98)		9.27 \pm 4.92 (0.00–19.33)	
Distal band	Left	28.79 \pm 4.71 (22.38–40.71)	0.073	0.29 \pm 0.15 (0.08–0.63)	0.180	43.72 \pm 15.36 (10.67–73.33)	0.910
	Right	30.83 \pm 5.03 (22.50–39.44)		0.37 \pm 0.19 (0.11–0.78)		44.33 \pm 21.18 (3.67–83.33)	
	Total	29.77 \pm 4.92 (22.38–40.71)		0.33 \pm 0.17 (0.08–0.78)		44.02 \pm 18.23 (3.67–83.33)	
Type II							
Single band	Left	26.39 \pm 3.54 (23.89–28.89)	NA	0.73 \pm 0.25 (0.55–0.91)	NA	18.69 \pm 4.68 (15.38–22.00)	NA
Type III							
Single band	Left	20.30 \pm 3.09 (15.68–26.60)	0.438	0.49 \pm 0.22 (0.14–0.93)	0.707	10.27 \pm 5.40 (0.00–18.33)	0.609
	Right	21.27 \pm 4.92 (13.13–36.64)		0.46 \pm 0.17 (0.22–0.76)		9.32 \pm 6.76 (0.00–23.00)	
	Total	20.82 \pm 4.15 (13.13–36.64)		0.47 \pm 0.20 (0.14–0.93)		9.76 \pm 6.11 (0.00–23.00)	
All cases of SPR based on insertion site							
Posterior intermuscular septum		22.05 \pm 3.99 (13.13–36.64)		0.47 \pm 0.20 (0.14–0.98)		10.02 \pm 5.80 (0.00–26.00)	
Lateral wall of calcaneus		28.41 \pm 5.49 (16.27–40.71)		0.38 \pm 0.19 (0.08–0.82)		40.75 \pm 18.98 (2.33–83.33)	

NA — not available

SPR to the inferior tip of fibula were obtained. The midpoint of the origin was always above the fibular tip but the midpoint of insertion was varied with type. Since the proximal band of type I and the single band of type III inserted on the posterior intermuscular septum, the midpoint of insertion was always above the fibular tip. In contrast, the distal band of type Ia, Ib and II which inserted on the lateral wall of calcaneus was always below the fibular tip. The longest horizontal and vertical distances from midpoint of the origin were found in type Ia. The longest horizontal and vertical distance from midpoint of insertion was found in type Ia (Table 5). The X-coordinate represents the horizontal distance from the tip of fibula and the Y-coordinate represents the vertical distance from tip of fibula. The average coordinates (X, Y) of origin in all types were 7.26 ± 3.15 (0.87–15.15) and 10.45 ± 4.52 (1.69–26.23) mm. The coordinates (X, Y) of the insertion could be divided into two categories according to the insertion site. Average coordinates of SPR which inserted on the posterior intermuscular

septum were 24.06 ± 4.94 and 13.35 ± 5.18 , and those inserted on the lateral wall of calcaneus were 21.45 ± 7.88 and 13.59 ± 6.73 mm (Table 5, Fig. 5). Comparisons of the horizontal and vertical distances from mid-point of origin and insertion to inferior tip of fibula between genders and sides showed that only vertical distance of type Ib at its origin and vertical distance of type III at its insertion were significantly different between sides ($p = 0.003$ and 0.014 , respectively).

The PB tendon tears

After cutting the SPR at its origin, the superior peroneal tunnel (SP tunnel) was exposed. The contents of the SP tunnel are generally composed of the PB and PL tendons. The PL tendon lied superficial to the PB tendon. The PB tendon tear occurred in 14 from 109 (12.84%) cases. They were found in SPR type Ib (10 cases), type III (3 cases) and type 2a (1 case). Moreover, one male cadaver with symmetrical SPR type Ib had bilateral PB tendon tears. The prevalence

Table 5. Horizontal and vertical distances from mid-point of superior peroneal retinaculum (SPR) to the inferior tip of fibula — mean ± standard deviation (range) [mm]

Type		Origin				Insertion			
		X axis	P	Y axis	P	X axis	P	Y axis	P
Type Ia									
Proximal band	Left	8.63 ± 3.43 (5.41–13.69)	0.849	12.32 ± 5.36 (4.55–18.82)	0.058	26.09 ± 5.50 (20.18–32.64)	0.879	14.31 ± 2.87 (10.75–19.45)	0.152
	Right	9.02 ± 4.00 (2.62–15.15)		20.04 ± 8.13 (2.47–26.23)		25.62 ± 5.87 (15.02–32.52)		19.19 ± 7.94 (4.12–25.76)	
	Total	8.82 ± 3.59 (2.62–15.15)		16.18 ± 7.73 (2.47–26.23)		25.85 ± 5.47 (15.02–32.64)		16.75 ± 6.27 (4.12–25.76)	
Distal band	Left	NA		NA	NA	22.94 ± 8.00 (14.90–35.14)	0.909	14.48 ± 4.64 (7.20–22.38)	0.166
	Right	NA		NA		23.42 ± 7.64 (11.58–35.13)		10.11 ± 6.32 (1.53–20.03)	
	Total	NA		NA		23.18 ± 7.52 (11.58–35.14)		12.30 ± 5.79 (1.53–22.38)	
Type Ib									
Proximal band	Left	6.46 ± 3.16 (1.76–11.75)	0.749	8.27 ± 2.56 (3.85–14.33)	0.003*	23.27 ± 5.80 (10.46–35.67)	0.568	12.54 ± 4.39 (4.24–21.44)	0.125
	Right	6.74 ± 2.56 (2.36–11.64)		10.70 ± 2.77 (4.21–15.98)		24.10 ± 3.96 (16.57–32.37)		14.68 ± 5.07 (5.32–22.64)	
	Total	6.59 ± 2.86 (1.76–11.75)		9.43 ± 2.91 (3.85–15.98)		23.67 ± 4.97 (10.46–35.67)		13.56 ± 4.80(4.24–22.64)	
Distal band	Left	NA	NA	NA	NA	20.94 ± 8.39 (8.54–36.79)	0.439	14.19 ± 6.94 (0.00–27.69)	0.824
	Right	NA		NA		20.95 ± 7.70 (11.17–38.66)		13.73 ± 7.19 (0.00–31.79)	
	Total	NA		NA		20.94 ± 7.98 (8.54–38.66)		13.97 ± 6.99 (0.00–31.79)	
Type II									
Single band	Left	7.31 ± 1.48 (6.27–8.36)	NA	9.13 ± 5.13 (5.51–12.76)	NA	26.22 ± 7.53 (20.90–31.55)	NA	4.48 ± 2.48 (2.73–6.24)	NA
Type III									
Single band	Left	7.75 ± 3.09 (2.73–14.65)	0.587	9.78 ± 3.57 (1.69–17.33)	0.988	21.90 ± 3.83 (13.85–29.14)	0.014*	12.27 ± 5.37 (1.06–20.34)	0.790
	Right	7.22 ± 3.39 (0.87–13.74)		9.79 ± 3.02 (4.62–17.28)		25.51 ± 4.81 (17.43–36.49)		12.64 ± 4.00 (3.12–18.37)	
	Total	7.47 ± 3.22 (0.87–14.65)		9.79 ± 3.25 (1.69–17.33)		23.82 ± 4.70 (13.85–36.49)		12.47 ± 4.64 (1.06–20.34)	
All cases of SPR based on insertion site									
Posterior intermuscular septum		7.26 ± 3.15 (0.87–15.15)		10.45 ± 4.52 (1.69–26.23)		24.06 ± 4.94 (10.46–36.49)		13.35 ± 5.18 (1.06–25.76)	
Lateral wall of calcaneus		NA		NA		21.45 ± 7.87 (8.54–38.66)		13.59 ± 6.73 (0.00–31.79)	

*Statistical significance; X axis — the horizontal distance; Y axis — the vertical distance; NA — not available

of the PB tendon tear in type Ib was significantly higher than the others ($p = 0.001$). The extension of PB tendon tear was from above the lateral malleolus to the entrance of inferior peroneal tunnel in most cases. However, there were 2 cases of PB tendon

tears extended from the retromalleolar groove to the inferior peroneal tunnel.

The intra-tester reliability on data extraction indicated good to excellent reliability [ICC (3, 1) = 0.882 – 0.999].

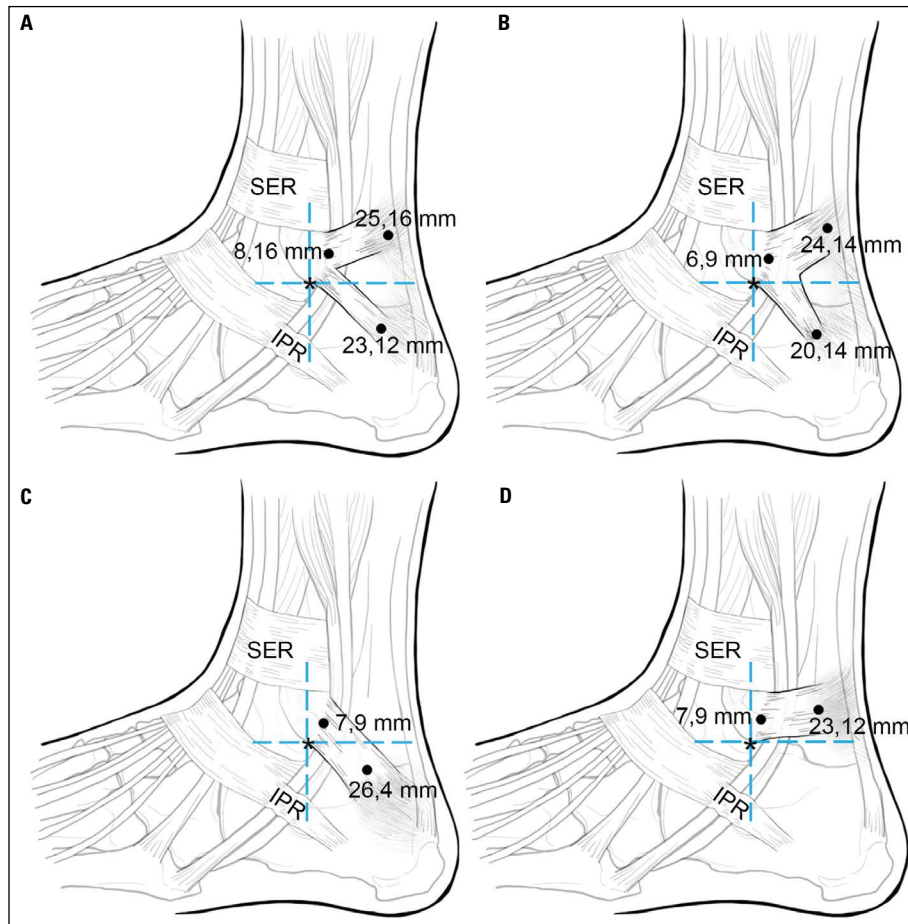


Figure 5. Illustrations of coordinates of mid-point of superior peroneal retinaculum (SPR) origin and insertion measured from the tip of fibula (*) in each type (X, Y axis); **A.** Type Ia; **B.** Type Ib; **C.** Type II; **D.** Type III; IPR — inferior peroneal retinaculum; SER — superior extensor retinaculum.

Table 6. Prevalence of peroneus brevis tendon tear and its association between types — N (%)

SPR	Peroneus brevis tendon tear		P
	Present	Absent	
Type Ia	1 (7.14%)	13 (92.86%)	0.001*
Type Ib	10 (20.83%)	38 (79.17%)	
Type III	3 (6.67%)	42 (93.33%)	

*Statistical significance; SPR — superior peroneal retinaculum

DISCUSSION

Morphology of the SPR has been described in standard textbook and previous reports [2, 6, 15, 21]. The origin of SPR observed in this study was from the fibrocartilaginous ridge of the lateral malleolus with an extension to the distal tip of the fibula which was in accordance with previous studies [2, 6, 15, 21]. The SPR had at least one insertion site either on the posterior intermuscular septum or lateral wall of the

calcaneus. Insertion on the posterior intermuscular septum was in accordance with that described previously [21]. Moreover, magnetic resonance imaging (MRI) study also revealed that the horizontal band of the SPR attached to the superficial and deep aponeuroses of the posterior compartment of the lower portion of the leg [3]. However, we did not find insertion on the lateral border of the calcaneal tendon as reported by Davis et al., 1994 [6]. Hence, we divided the SPR based on the insertion pattern into three types; the double band of type I with subtype Ia and Ib, and the single band of type II and III. The difference between subtype Ia and Ib was the site of splitting into proximal and distal band.

The average length of SPR inserted on the posterior intermuscular septum was approximately 23 mm. However, the length of type III was shorter than others. The length of distal band was similar in both type Ia and Ib. The average width of origin was in accordance with previous report [6]. Thickness of SPR

reported in this study was lesser than previous study in MRI [16]. This might result from the difference in method and site of measurement.

The SPR plays an important role as the primary stabilizer of peroneal tendons to prevent the subluxation/dislocation [5, 18]. Insufficiency of the SPR could cause symptomatic tendon instability and tendon injury afterwards [5, 7, 24]. The morphometric data showed that the site of splitting of type Ib was in its middle part which was thinner than the rest. This would cause a decreasing in the strength of this retinaculum and resulted in SPR insufficiency. Furthermore, bilateral PB tendon tear was found in one case of symmetrical SPR type Ib. Taken together; the presence of type Ib might have a potential to increase the risk of PB tendon tear.

There are several surgical procedures for treatment of peroneal tendon instability including the SPR repair or reconstruction, bone block procedures, and retromalleolar groove deepening [4, 5, 7, 13, 18]. Reconstruction of SPR using either autologous graft including gracilis tendon and plantaris tendon or allograft including tensor fascia latae has been reported [9, 14, 20]. Groove deepening is classically recommended in peroneal tendon instability with flat or convex retromalleolar groove contour. However, anatomical SPR reattachment without groove deepening is reported to be effective in any types of retromalleolar groove contour [4]. Morphometric data of SPR including its length, width and thickness provided in this study would be beneficial for surgical planning of graft type and harvesting in SPR reconstruction with autograft or allograft. The knowledge of coordinate of midpoint of SPR origin measured from the fibular tip would provide the precise area for attachment of repaired or reconstructed SPR on the lateral malleolus. Furthermore, the angle of the SPR and the coordinate of horizontal and vertical distance from midpoint of SPR insertion measured from fibular tip reported here can be used to design the direction and also specify the precise area for SPR reattachment on the lateral wall of calcaneus.

Superior peroneal retinaculum injury resulting in peroneal tendon instability can be associated with the calcaneal fracture, especially Sanders A type of calcaneus fracture [11, 12]. In this study, the SPR had at least one insertion site on the lateral wall of calcaneus, except type III. Type II of SPR inserted solely on the lateral wall of the calcaneus. Therefore, the SPR integrity and stability of peroneal tendon should

always be evaluated in the treatment of calcaneal fractures.

Limitations of the study

Limitations of this study were the use of the formalin fixed cadaver which might affect the positions of the foot and ankle. Although the adjustment of the foot and ankle to the neutral position by Achilles tendon releasing and a supporting frame was performed, embalmed cadaveric legs might yield different results from fresh or soft-embalmed cadaveric legs.

CONCLUSIONS

Characteristics and morphometric data of the SPR were described. SPR could be divided by the insertion pattern into type Ia, type Ib, type II and type III. SPR had at least one insertion band on the posterior intermuscular septum or lateral wall of calcaneus. Morphometric data provided in this study are beneficial for SPR surgical procedures including reattachment and reconstruction. Moreover, type Ib had a trend to be associated with PB tendon tear.

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