JOURNAL OF PLASTIC SURGERY AND HAND SURGERY
2020, VOL. 54, NO. 6, 377–381
https://doi.org/10.1080/2000656X.2020.1801456

ARTICLE

Profunda femoris artery perforator flaps: a detailed anatomical study

Said Algan[a] and Onder Tan[b]

[a]Said Algan Plastic and Reconstructive Surgery Clinic, İstanbul, Turkey; [b]Department of Plastic Reconstructive and Aesthetic Surgery, Medical Park Hospital, İstanbul, Turkey

ABSTRACT

The thigh region has many perforators when compared to the other areas in the body. Surgeons have disregarded the posterior thigh region as a potential donor site for perforator flap surgeries, presumably owing to the positioning difficulties of the patients during the intervention and inadequate anatomical information. The purpose of this study was to provide comprehensive data concerning the profunda femoris artery. Perforator flaps on an anatomical basis, and to describe anatomical landmarks, easing topographical flap dissection in various combinations. Eleven fresh cadaver thighs were obtained from different individuals using the Willed Body Program. The mean age was 43.5 years (29–63), and the male/female ratio was 7/4. We evaluated each cutaneous perforator for localization, diameter, source artery, numbers, length, and type (musculocutaneous or septocutaneous).We observed at least two perforators in all thighs in the study. Medial perforators consisted of 74.5% musculocutaneous and 25.5% septocutaneous perforators. Lateral perforators consisted of 68.3% septocutaneous perforators and 31.7% musculocutaneous perforators. Positioning difficulties of the patient during surgery and inadequate anatomical information cause surgeons to avoid this area. However, surgeons may easily perform these flaps in reconstructive surgery as a local or free flap with substantial success.

ARTICLE HISTORY
Received 31 July 2019
Revised 9 May 2020
Accepted 20 July 2020

KEYWORDS
Anatomical study; flap; perforators; posterior thigh; profunda femoris artery; PAP

Introduction

The thigh region has many perforators when compared to the other areas in the body. Anterior thigh flaps such as anterolateral thigh and anteromedial thigh are well known and widely preferred to the posterior profunda femoris artery perforator (PAP) flaps as local perforator flaps or free flaps in reconstructive surgery. The posterior thigh region (PTR) is usually bordered by the inferior gluteal fold superiorly, the iliotibial tract laterally, the thigh adductors medially, and the popliteal fossa inferiorly [1]. Surgeons have disregarded the PTR as a potential donor site for perforator flap surgeries, presumably owing to the positioning difficulties of the patients during the intervention and inadequate anatomical information [1,2].

Initially, Hurwitz described the posterior thigh flap in 1980, and then, Song et al. transferred it as a free flap in 1984 [3,4]. PAP flaps have been in the head and neck, breast reconstruction, ischiatic pressure sores, and lower extremity defects, either as free flaps or local perforator flaps. They offer a long paddle, a large skin island, and enough soft tissue volume with low donor site morbidity in a well-concealed area [5–12]. Anatomical studies, investigating localization, and classification of the perforators in the PTR as a whole unit are scarce. The purpose of this study was to provide comprehensive data concerning the profunda femoris artery (PFA) perforator flaps on an anatomical basis, and to describe anatomical landmarks, easing topographical flap dissection in various combinations.

Materials and methods

We performed an anatomical descriptive cadaver study at the Department of Anatomy and Embryology, Forensic Medicine Institution, Istanbul, Turkey. Eleven fresh cadaver thighs were obtained from different individuals using the Willed Body Program. The mean age was 43.5 years (29–63), and the male/female ratio was 7/4.

Cadaver preparation and dissection

As the topographical points, we identified the ischium, greater trochanter, coccyx, inferior gluteal fold, transverse line (between trochanter and coccyx), and the lateral and medial femoral condyles (Figure 1(A)). Primarily, PTR was divided into two parts as a proximal and distal. The proximal portion of the PTR was regarded for the PFA and its branches, which are the lateral circumflex femoral artery (LCFA) and the medial circumflex femoral artery (MCFA). Since the PFA and its branches end at this level, the distal part of the PTR was excluded in this study. Then, using a mid-vertical line, the PTR was divided into the medial and lateral regions (Figure 1(B)). A T-shaped incision of a 20-cm length was made to the skin along the infragluteal and mid-vertical lines. We followed all perforators retrogradely to the leading source artery. We used photographs for recording each stage of the dissection and recorded the perforators larger than 0.5 mm diameter in size.

Measurements

After dissection of the perforators, we evaluated each cutaneous perforator for localization, diameter, source artery, numbers, length, and type (musculocutaneous or septocutaneous). Perforators entering the muscle were called the musculocutaneous perforators, while perforators emerging between two muscles

CONTACT Said Algan saidalgan@gmail.com Plastic and Reconstructive Surgery Clinic, Istanbul 34330, Turkey

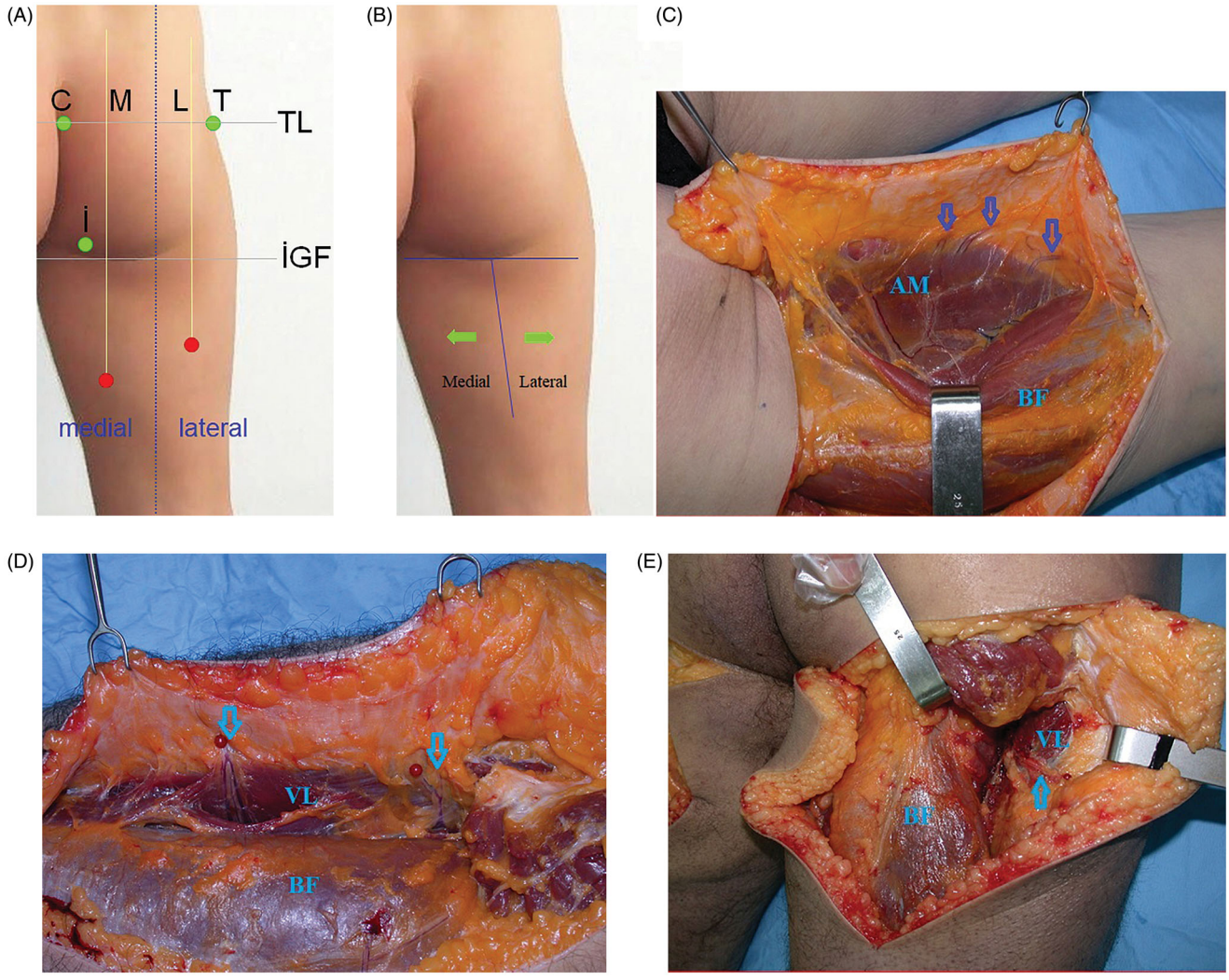

Figure 1. Cadaver preparation and dissection. (A) Marking topographical points; the ischium (I), the greater trochanter (T), coccyx (C), inferior gluteal fold (IGF), transverse line (TL), lateral (L) and medial (M) femoral condyles lines. (B) The appearance of infragluteal and midvertical line. (C) The dissection of musculocutaneous medial perforators. Arrows show perforators. AM: adductor magnus muscle; BF: biceps femoris muscle. (D) The dissection of musculocutaneous lateral perforators. Arrows show perforators. BF: biceps femoris muscle; VL: vastus lateralis muscle. (E) The dissection of septocutaneous lateral perforators. Arrows show perforators. BF: biceps femoris muscle; VL: vastus lateralis muscle.

were called the septocutaneous perforators (Figure 1(C–E)). The distance between each perforator and greater trochanter, ischium, coccyx, inferior gluteal fold, and the transverse line was measured. All medial and lateral distance measurements were recorded, and their means were calculated.

Statistical analysis

Each measurement was repeated for each perforator. The mean number and the standard deviation of the perforators as well as their lengths, diameters, sources, and types were recorded. The obtained data were analyzed by SPSS version 17.0 (SPSS for Windows, Chicago, IL, USA). Categorical variables were expressed as frequencies and percentages, and numerical variables as means and standard deviations (SD). We used Student's *t*-test or the Mann–Whitney *U* test depending on meeting the parametric assumptions. Statistical significance was determined as $p < 0.05$.

Clinical cases

We performed DFA perforator flaps in two clinical cases.

Case 1

A 35-year-old man had right ischial pressure ulcer due to paraplegia. After marking appropriate perforators on the PTR with a handheld Doppler, we planned to elevate an island flap based on the PTR. The ischial pressure ulcer scars and a part of necrotic ischial bone were debrided. We raised an island perforator flap resourcing in adductor magnus muscle without reaching to source vessels. After transporting the perforator island flap to the ischial defect, primary closure was done to the donor site (Figure 2(A–C)).

Case 2

A 46-year-old woman had left ischial pressure ulcers due to paraplegia. After marking appropriate perforators on the PTR with a handheld Doppler, we elevated a V–Y island advancement flap. The ischial ulcer and scars were debrided. We harvested an island perforator flap resourcing in the semitendinosus muscle without reaching to the source artery. After advancing the perforator island flap to the ischial defect area, the donor site was closed primarily.

Figure 2. A 35-year-old man had right ischial pressure ulcer due to paraplegia. (A) Preoperative, the ischial pressure sore and marking of the perforators of the V–Y island flap. (B) The V–Y Island flap raising. (C) Repairing of the ischial pressure and the donor site closure. (D) After 6 months postoperative appearance.

Results

Localizations, numbers, diameters, and length of the perforators

We observed at least two perforators in all thighs in the study. There were 51 and 63 medial and lateral perforators, respectively ($p < 0.05$). The mean diameter of the medial and lateral perforators was 1.2 and 1.5 mm, respectively ($p > 0.05$). On the other hand, the mean length of the medial and lateral perforators was 6.6 and 5.5 cm, respectively ($p < 0.05$). Detailed descriptive findings are given in Table 1.

The type of perforators

Medial perforators consisted of 74.5% musculocutaneous and 25.5% septocutaneous perforators (Table 2). The biceps femoris muscle was the most common origin of musculocutaneous perforators at the medial side (47.4%) (Table 3).

Lateral perforators consisted of 68.3% septocutaneous perforators and 31.7% musculocutaneous perforators (Table 2). The most observed origins of septocutaneous perforators were between the biceps femoris and vastus lateralis muscles (82.5%) (Table 4). Red points in Figure 3(A,B) show localizations of the musculocutaneous and septocutaneous perforators, respectively.

The source of perforators

The primary source of perforators was the PFA, which supplied 78.9% of the PTR perforators. Medial perforators were accessed by the PFA, MCFA, and LCFA in 82.3, 11.8, and 5.9% of the cases, respectively. On the other hand, lateral perforators were supplied by the PFA, MCFA, and LCFA in 76.2, 12.7, and 11.1% of the cases, respectively (Table 5).

The topographical distance

The mean medial topographical distances of the greater trochanter, ischium, coccyx, inferior gluteal fold, and transverse line were 24.7, 10.9, 20.1, 8.4, and 19.4, respectively. The same distances at the lateral side were 19.3, 13.8, 23.6, 9.8, and 17.9 cm, respectively (Table 6).

Table 1. Numbers, diameter, and length of perforators.

	Localization	
	Medial, $n = 51$	Lateral, $n = 63$
The number of perforators *p=0.035	Mean:2.3 mm Sd: 0.9 Min: 1 Max: 4	Mean:2.9 mm Sd: 0.8 Min: 1 Max: 4
The diameter of perforators **$p = 0.08$	Mean:1.22 mm Sd: 0.75	Mean:1.49 mm Sd: 0.84
The length of perforators **$p = 0.0001$	Mean:6.63 mm sd: 1.52	Mean:5.54 mm sd: 1.42

*Mann–Whitney U test, $p < 0.05$; **Student t test, $p < 0.05$.
Sd: Standard deviation; Min: minimum; Max: maximum.

Table 2. The type of perforators.

Localization	Musculocutaneous, *n* (%)	Septocutaneous, *n* (%)
Medial	38 (74.5)	13 (25.5)
Lateral	20 (31.7)	43 (68.3)

Table 3. The origin of musculocutaneous perforators.

Localization	GR	BF	STM	AD	VL	Total
Medial	1	18	15	4	–	38
Lateral	4	7	–	–	9	20

AD: adductor muscles; BF: biceps femoris muscle; GR: gracilis muscle; STM: semitendinosus and membranosus muscles; VL: vastus lateralis muscle.

Table 4. The origin of septocutaneous perforators.

Localization	BF-GR	BF-ST	BF-VL	SM-AD	Total
Medial	5	3	–	5	13
Lateral	10	–	33	–	43

BF-GR: biceps femoris–gracilis; BF-ST: biceps femoris–semitendinosus; BF-VL: biceps femoris-vastus lateralis; SM-AD: semimembranosus-adductors.

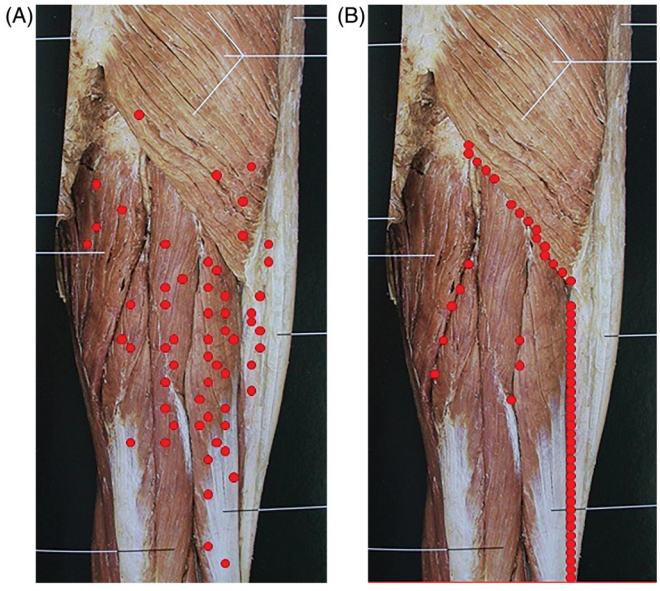

Figure 3. Localizations of all musculocutaneous and septocutaneous perforators. (A) Red points show localizations of all musculocutaneous perforators. (B) Red points show localizations of all septocutaneous perforators.

Table 5. The source of perforators.

Localization	PFA	MCFA	LCFA
Medial	42 (82.3%)	6 (11.8%)	3 (5.9%)
Lateral	48 (76.2%)	8 (12.7%)	7 (11.1%)

PFA: profunda femoris artery; MCFA: medial circumflex femoral artery; LCFA: lateral circumflex femoral artery.

Table 6. The mean distance to topographical points.

Localization	Trochanter	Ischium	Coccyx	Inferior gluteal fold	Transverse line
Medial (cm)	24.7	10.9	20.1	8.4	19.4
Lateral (cm)	19.3	13.8	23.6	9.8	17.9

Clinical study

Both flaps survived ultimately. We did not observe any complications such as hematoma, seroma, infection, wound dehiscence in early postoperative time, and the recurrence of the pressure ulcer during the follow up of about 2 years (Figure 2(D)).

Discussion

The purpose of this study was to demonstrate comprehensive data of the PFA flaps on the anatomical basis and to describe anatomical landmarks with which to ease topographically flap dissection in various combinations.

According to our findings, the lateral side of the PTR had both more perforators and septocutaneous perforators. These results may facilitate dissection and increase flap safety when planning and raising flaps. Besides, medial perforators were longer than lateral perforators. Therefore, medial perforators should be considered in repairing ischial ulcers and choosing free flaps. Because of the appropriate pedicle length and diameter, minimal donor site morbidity, hidden scar, and the wide arc of the flap rotation, we suggest using the PFA perforator flaps in reconstructive surgery.

The PTR is a convenient area for flap raising in the reconstructive surgery. However, there are few anatomical studies searching perforators of the PTR, and many of them focused on predetermined subunits of the PTR [6,7,9,13,14]. We made a detailed anatomical examination based on the PFA and its branches for flap raising from the PTR. We determined the aforementioned topographical points and found the mean distances between each perforator and the topographical locations. Furthermore, there are only a few studies about the details of the topographical points in the literature [1,2].

Manchot and Salmon investigated and defined the anatomy and blood supply of the PTR [15,16]. After describing axial flaps, Hurwitz et al. described the first clinical pedicled PTR flaps for repairing chronic wounds of the perineal and sacral regions by the gluteal thigh flap in 1983 [3]. Lamberty and Cormack, who are pioneers of the flap design, rediscovered, and detailed skin supply of the PTR through an anatomical study in 1985 [17].

Maruyama et al. performed a posterior thigh island flap based on the popliteal artery for the reconstruction of the knee defects. All seven flaps survived completely [18].

Paletta et al. elaborated clinical applications of the posterior thigh flap in 1993. They used 22 thigh flaps based on the inferior gluteal artery in 21 patients having chronic recurrent pressure sores and limited local donor sites [19].

Angrigiani et al. reported the adductor musculocutaneous flap from medial and posterior aspects of the thigh based on the first medial branch of the PFA in 20 cadaver dissections. According to their observation, skin flaps as large as 30×23 cm from the medial and posterior aspects of the thigh were performed successfully [20].

Ahmadzadeh et al. reported an anatomical study evaluating the course and source arteries of PAP flaps. They visualized the PTR arteries of six cadavers, by injecting intra-arterial radiopaque markers and mapped skin vascularization of the PTR. They stated that the PFA supplied the most significant part of the skin vascularization of the PTR. On average, 5 ± 2 cutaneous perforators arising from branches of the PFA were seen. Of these, 65% were septocutaneous, while 35% were musculocutaneous perforators. The musculocutaneous perforators consisted of 80% biceps femoris muscle and 20% semimembranosus muscle.

On the other hand, the septocutaneous perforators consisted of 69% posterior lateral septum and 31% posterior medial septum of the thigh. The mean diameter of the perforators was 0.8 ± 0.3 mm, while the mean pedicle length of PFA perforators was 68 ± 33 mm. The mean PFA cutaneous vascular territory was $229 \pm 72\ cm^2$, with a $46 \pm 13\ cm^2$ perforator zone. They defined that most perforators would be seen on a line extending from the ischium to the lateral femoral condyle [1].

Hupkens et al. investigated proximal, middle, and distal part of the posterior thigh region anatomically using 12 fresh cadavers. Of the perforators, 69.1 and 30.9% consisted of the musculocutaneous and septocutaneous varieties, respectively. The primary origin of perforators was PFA 61.7%. Of the perforators, 52% were located in the middle third of the PTR. The PFA perforators were the longest with an average length of 13.7 ± 4.69 cm. The largest diameter of perforators was seen in the PFA (2.9 ± 0.98 mm). Musculocutaneous perforators consisted of 38.4% adductor magnus muscle, 23.0% gracilis muscle, and 23.07% biceps femoris muscle. However, this study included only perforators with a minimum diameter of 1 mm [2].

Unal et al. operated 11 patients having ischial sores with limited donor sites by utilizing the inferior gluteal artery and posterior thigh perforators. They stated that a major disadvantage of the PAP flaps is their short pedicle [21].

In a recent anatomical study of the profunda femoris artery, they found more frequent (71.21%) posterolateral and lateral aspect origin than posterior and posteromedial aspect origin (24.24%). Their findings are in line with our results [22].

This study can guide the surgeon about operation planning, especially the length of the flap pedicle. However, further clinical studies needed to verify the practical applicability of our results.

Conclusion

The PTR has rich vascular connections and numerous perforators. Positioning difficulties of the patient during surgery and inadequate anatomical information cause surgeons to avoid this area. However, surgeons may easily perform these flaps in reconstructive surgery as a local or free flap with substantial success.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

[1] Ahmadzadeh R, Bergeron L, Tang M, et al. The posterior thigh perforator flap or profunda femoris artery perforator flap. Plast Reconstr Surg. 2007;119(1):194–200.

[2] Hupkens P, Ozturk E, Wittens S, et al. Posterior thigh perforator flaps: an anatomical study to localize and classify posterior thigh perforators. Microsurgery. 2013;33(5):376–382.

[3] Hurwitz DJ. Closure of a large defect of the pelvic cavity by an extended compound myocutaneous flap based on the inferior gluteal artery. Br J Plast Surg. 1980;33(2):256–261.

[4] Song YG, Chen GZ, Song YL. The free thigh flap: a new free flap concept based on the septocutaneous artery. Br J Plast Surg. 1984;37(2):149–159.

[5] Allen RJ Jr., Lee Z-H, Mayo JL, et al. The profunda artery perforator (PAP) flap experience for breast reconstruction. Plast Reconstr Surg. 2016;138(5):968–975.

[6] Satake T, Muto M, Ko S, et al. Breast reconstruction using free posterior medial thigh perforator flaps: intraoperative anatomical study and clinical results. Plast Reconstr Surg. 2014;134(5):880–891.

[7] Scaglioni MF, Enrique Carrillo Jimenez L, Kuo Y-R, et al. Pedicled posteromedial thigh (PMT) flap: a new alternative for groin defect reconstruction. Microsurgery. 2017;37(4):339–343.

[8] Scaglioni MF, Fakin RM, Giovanoli P, et al. The lower medial thigh perforator (LMTP) flap for lower extremity reconstruction: preliminary results. Microsurgery. 2016;36(6):474–479.

[9] Scaglioni MF, Hsieh C-H, Giovanoli P, et al. The posteromedial thigh (PMT) flap for lower extremity reconstruction. Microsurgery. 2017;37(8):865–872.

[10] Scalise A, Tartaglione C, Bolletta E, et al. Profunda Femoris artery perforator propeller flap: a valid method to cover complicated Ischiatic pressure sores. Plast Reconstr Surg Glob Open. 2015;3(8):e487.

[11] Ito R, Huang J-J, Wu JC-W, et al. The versatility of profunda femoral artery perforator flap for oncological reconstruction after cancer resection – clinical cases and review of literature. J Surg Oncol. 2016;114(2):193–201.

[12] Ciudad P, Huang TC-T, Manrique OJ, et al. Expanding the applications of the combined transverse upper gracilis and profunda artery perforator (TUGPAP) flap for extensive defects. Microsurgery. 2019;39(4):316–325.

[13] Sakai S, Shibata M. Free adductor perforator flap in lower leg reconstruction. J Plast Reconstr Aesthet Surg. 2006;59(9):990–993.

[14] Salvador-Sanz JF, Torres AN, Calpena FT, et al. Anatomical study of the cutaneous perforator arteries and vascularisation of the biceps femoris muscle. Br J Plast Surg. 2005;58(8):1079–1085.

[15] Manchot C. Die Hautarterien des menschlichen Körpers (1898) [The cutaneous arteries of the human body]. New York: Springer; 1983.

[16] Salmon M, Taylor GI, Tempest MN. Arteries of the skin. London: Churchill Livingstone; 1988.

[17] Cormack GC, Lamberty BG. The blood supply of thigh skin. Plast Reconstr Surg. 1985;75(3):342–354.

[18] Maruyama Y, Iwahira Y. Popliteo-posterior thigh fasciocutaneous island flap for closure around the knee. Br J Plast Surg. 1989;42(2):140–143.

[19] Paletta C, Bartell T, Shehadi S. Applications of the posterior thigh flap. Ann Plast Surg. 1993;30(1):41–47.

[20] Angrigiani C, Grilli D, Thorne CH. The adductor flap: a new method for transferring posterior and medial thigh skin. Plast Reconstr Surg. 2001;107(7):1725–1731.

[21] Unal C, Ozdemir J, Yirmibesoglu O, et al. Use of inferior gluteal artery and posterior thigh perforators in management of ischial pressure sores with limited donor sites for flap coverage. Ann Plast Surg. 2012;69(1):67–72.

[22] Rajani SJ. Cadaveric study of profunda femoris artery with some unique variations. JCDR. 2015;9(5):AC01.