ORIGINAL ARTICLE

UDC: 611.13/.16::611.98]:617-089.844
DOI: 10.2298/VSP1107575G

Skin vascularisation field by the ascending branch of the peroneal artery *ramus perforans*

Zona vaskularizacije kože ascedentnom granom *ramus*-a *perforans*-a peronealne arterije

Milomir Gačević*, Milan Milisavljević†, Marijan Novaković*, Danilo Vojvodić#, Ivica Milosavljević‡ , Milena Jović‡, Boban Đorđević*, Žarko Borović§, Nikola Ostojić*, Mikica Lalković*, Saša Milićević*

Military Medical Academy, *Clinic for Plastic Surgery and Burns, #Medical Research Institute, ‡Institute of Pathology and Forensic Medicine, **Belgrade, Serbia; †University of Belgrade, School of Medicine, Anatomy Institute, Belgrade, Serbia; §Clinical Center, Podgorica, Montenegro**

Abstract

Background/Aim. Soft tissue defects in the distal third of the lower leg are persistent and constitute a major problem in the reconstructive surgery. This study presents an analysis of the anatomical vascularization filed of ascending branch of the peroneal artery *ramus perforans* (PARS). The aim of this study was to assess reliability of the distal flap on the antero-lateral aspect of a lower leg distal third. **Methods.** Direct gentiana violet injection into the interosseal perforator of ten fresh cadaveric lower legs with subsequent corrosion acrylic preparation was performed to reveal vascularization filed of the ascending branch of the PARP. Height, length, diameter and communication of perforating branch and its subsequent smaller ascending and descending branches were determined. The CAMIA software was used. **Results.** Our results show that the PARP is always present. Its origin from the peroneal artery is at the medial height of 66 mm when measured from the inferior border of the lateral malleolus. Medium length of *ramus perforans* is 51.7mm. After transition through the interosseous membrane, *ramus perforans* divides into ascending and descending branches. The diameter proximal to the level of bifurcation is 1.37 mm (variation 1.0–1.8 mm), and the diameter of the ascending branch distal to the level of bifurcation is 1 mm. Using CAMIA software, the medium length, width and area of the vascularization filed labeled with gentian violet were calculated to be 164 mm (variation 125–210 mm), 66 mm (57–77 mm), and 10,305 mm² (6,385 mm²–14,341 mm²), respectively. C**onclusion.** Our results support the use of fasciocutaneous distal flap, vascularized by the ascending branch of the PARP for reconstruction of soft tissue defects in the distal third of the lower limb, malleolar regions and *dorsum*.

Key words:
leg; soft tissue injuries; therapeutics; reconstructive surgical procedures; surgical flaps; anatomy, regional.

Apstrakt

Uvod/Cilj. Mekotkivni defekti distalne trećine potkolenice i dalje predstavljaju veliki problem u rekonstruktivnoj hirurgiji. Cilj ove studije bio je da se ispita anatomsko polje vaskularizacije ascedentne grane *ramus*-a *perforans*-a peronealne arterije (RPPA) radi provere mogućnosti kreiranja distalno baziranog režnja na anterolateralnoj strani donje trećine potkolenice. **Metode.** Na deset svežih kadaveričnih potkolenica koristili smo metod ubrizgavanja boje gencijana violet direktno u interosalni perforator. Na ovaj način dobili smo polje vaskularizacije ascedentne grane RPPA. Metodom izrade korozivnih akrilatnih preparata kod deset kadaveričnih potkolenica odredili smo visinu, dužinu, promer i komunikacije RPPA i njegove ascedentne grane. **Rezultati.** RPPA je konstantan krvni sud (prosečna dužina 51,7 mm). Odvaja se od peronealne arterije kroz interosealnu membranu na prosečnoj visini od 66 mm, mereno od donje ivice lateralnog maleolusa. Po prolasku kroz interosealnu membranu deli se na ascedentnu i descedentnu granu. Promer *ramus*-a pre bufurkacije iznosi prosečno 1,37 mm (1–1,8 mm), a ascedentne grane na početku 1 mm (0,8–1,3 mm). Prosečna vrednost dužine dobijene prebojenosti na ascedentnoj grani i zone vaskularizacije potencijalnog režnja je 164 mm (125–210 mm), širine 66 m (57–77), a površine 10 305 mm² (6 385–14 341 mm²), određeno pomoću softvera za automatsku obradu slike CAMIA. **Zaključak.** Svi dobijeni parametri ukazuju na dobru i konstantnu vaskularizaciju opisanog segmenta kože od ascedentne grane RPPA i na mogućnost podizanja adekvatnog fasciokutanog, distalno baziranog režnja, čime se omogućava rekonstrukcija mekotkivnih defekata distalne trećine potkolenice, maleolarnih regija i dorzuma stopala.

Ključne reči:
noga; meka tkiva, povrede; lečenje; hirurgija, rekonstruktivna, procedure; režnjevi, hirurški; anatomija, topografska.

Correspondence to: Milomir Gačević, Military Medical Academy, Clinic for Plastic Surgery and Burns, Crnotravska 17, 11 040 Belgrade, Serbia. Phone: +381 11 3608 750, 381 63 342 660. E-mail: adonisscg@excite.com

Introduction

Blast injuries to the lower extremities and the feet inflicted with a large number of landmines and explosive ordnance used in modern warfare, as well as injuries resulting from industrial, traffic or similar accidents are frequently seen today.

The complexity of the management of lower leg and foot injuries accompanied by soft tissue defects arises from the anatomical specificity of the region, localization area, the size and structure of tissue defect.

The latest knowledge of anatomy, concerning particularly the structure of vascularization of some compartments, makes this area, in terms of reconstruction, very specific.

The anterior surface of the tibia is covered with a thin layer of the skin and subcutaneous tissue, so, defects to this part are ussually accopmanied by the exposed bone without periosteum, due to what an autotransplant is excluded as a method of surgical treatment [1]. Poor elasticity of the lower leg outer layer and foot skin limits its ability for transfer.

Tendons, neurovascular structures and bones are seated immediately under the skin in the distal third of the lower leg. However, reconstructive surgery requires application of full- thickness skin grafts which could hardly be harvested from that region [2–5].

The most distal part of the lower leg, the malleolar region as well as the Achilles tendon area still present a serious reconstructive problem [4].

So far, some attempts have been made to bridge the defects in the malleolar and Achilles tendon area with grafts obtained from the foot *dorsum* [2, 6–9], and the middle third of the lower leg [4, 5, 10, 11]. All reverse fasciocutaneous flaps raised in the projection of magistral blood vessels (*arteria peroneae*, *a. tibialis posterior*, *a. tibialis anterior*, *a. dorsalis pedis*) have been used, but due to rotation of almost 180° they do not give satisfactory results, and the lack is that a large blood vessel is sacrified.

Numerous anatomical studies reporting great variations among the obtained results have been conducted to localize peroneal artery perforators more precisely [10, 12, 13]. Application of computed tomography (CT) angiography has been described in some recently published papers as well [14].

The aim of this study was to define vascularization fields of the skin and fascia vascularized by the ascending branch of the peroneal artery *ramus perforans* (PARP) in order to assess the level of reliability of the distal flap on the anterolateral aspect of the distal third lower leg.

Methods

This study involved 20 lower extemities from cadavers of both sex and various age. Age, sexual maturity, fully completed growing process, undiagnosed diabetes or some other vasculopathy in the lower extremity prior to death were the criteria we followed in selecting cadavers.

We applied two investigation methods, presuming that they would be sufficient to ensure reliable findings required for the assessment of the quality, design and size of a potential distally placed graft. The first method was injection of gentian violet dye with subsequent dissection of dyed tissue as potential graft material. The second method was corrosion preparation.

Prior to the application of either method, we recorded all sex- and age-related data, measured body height in centimeters (cm), and height (length) of the fibula bone in millimeters (mm).

Injection of gentian violet dye with subsequent dissection of dyed tissue as potential graft material

The selected cadavers (group 1) were positioned laterally on the opposite side to dissection. Proceeding from the principals of the topographic anatomy, we dissected 10 lower legs. Using lateral approach, we separated the peroneal artery 15 cm in length measured from the distal point of the lateral malleolus proximally, clearly localized the point of bifurcation of the perforating branch, and tied off the peroneal artery 2 cm below the bifurcation. A transverse arteriotomy was then made on the peroneal artery 5–10 cm above the bifurcation of *ramus perforans*, and a braunila (Romed 20G) was placed (Figure 1a). Firstly, we injected 10 cm^3 of lukewarm water (45ºC), and then 20 cm^3 of solution containing 95% gentian violet and 5% gelatine at temperature of 40ºC (Figure 1, b and c). An antilaterally marked surface of the skin on the distal third of the lower leg was, thus, obtained, and was clearly inked (red or black ink).

We then laid a transparent foil directly on the limited area of the skin and took an actual-size photo of it (Figure 1d). Upon reviewing the skin areas marked by gentian violet on the same legs, we started with separation and raising of the skin and fascia as ascendent branch of the PARP–based fasciocutaneous flap. Separation was done under magnification with Keller eyeglasses.

The marked surface area on the anterolateral side of the foot was not measured, it was the vascularization field of the distal branch of the PARP.

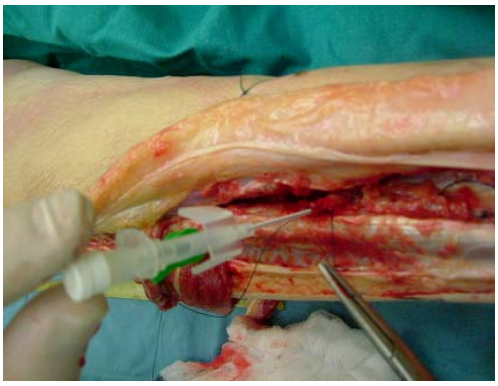
We measured the medial height of the origin of perforating branch from the inferior border of the lateral malleolus, the medium length of the marked area, the medium width and medium area of the stained segment (Figure 1, e–g).

The area of the skin labeled by gentian violet dye was measured in mm^2 using CAMIA software (Figure 2).

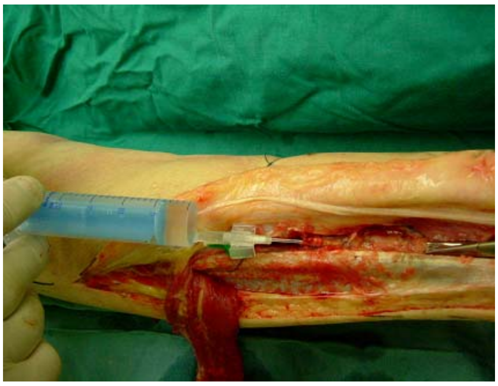
Corrosion preparation

We made corrosion preparations in the 10 lower legs of cadavers from the group 2 at the Anatomic Institute, School of Medicine Belgrade in the following way:

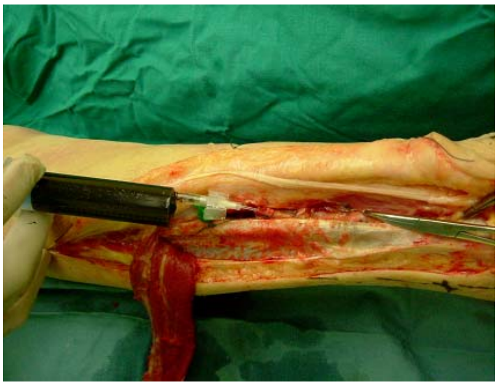
We separated popliteal artery at the level of popliteal fossa before it bifurcates into its terminal branches and firstly injected 50 cm^3 of lukewarm water to rinse even the tiniest blood vessels, and then 50–70 cm^3 of methyl metacrylate. When it became consolidated, after three weeks, we obtained a corrosive preparation by maceration, i.e. the prints of blood vessels of the lower leg and foot (Figure 3).



a – placement of braunila into the peroneal artery



b – insertion of lukewarm water into the peroneal artery



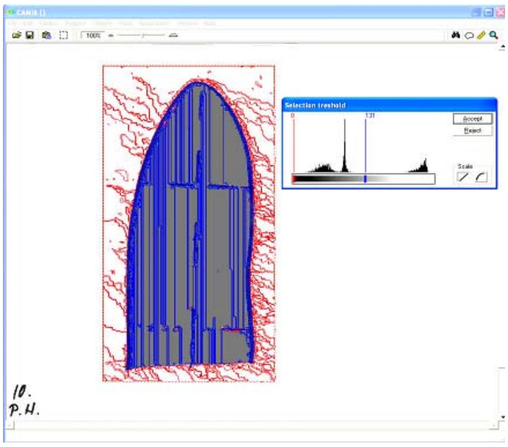
c – insertion of a gentian violet dye into the peroneal artery

d – marked surface area of a potential flap upon insertion of a gentian violet dye on the anterolateral side of the lower leg

e – measurement of the flap length bifurcation

f – the height of the perforating branch measured from the lateral malleolus

Fig. 1 – Injection of gentian violet dye with subsequent dissection of the stained tissue as potential graft material



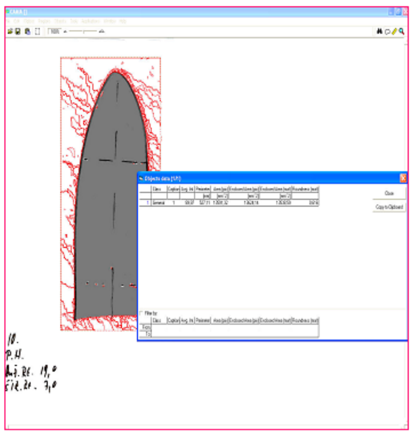


Fig. 2 – Computer-based calculations of the flap surface area

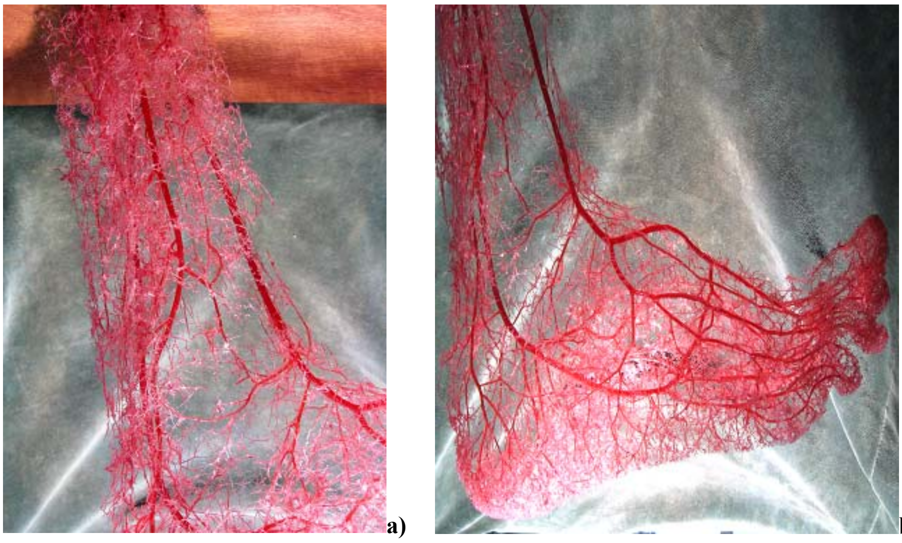


Fig. 3 – Corrosion preparation for the lower leg (a) and for the foot (b)

This technique enabled us to obtain even more precise anastomoses of vessels and the adjacent vascular territories as well as the internal diameters of the viewed blood vessels.

Results

The method of injection of gentian violet was applied on 10 lower legs harvested from 10 cadavers (9 males and 1 female). We always used one lower leg of one cadaver; the left leg in 6 cases and the right one in the other 4 cases.

Cadavers in the group 1 aged 22–69 years (the mean age 54 years), their body height ranged from 170–192 cm (the medium height 184.5 cm), and the length of the fibular bone averaged 467 mm (range, 410–500 mm) as presented in Table 1.

The measured parameters included the height of the origin of perforating branch from the inferior border of the lateral malleolus, and the length, width and area of the marked skin.

The length of the marked area of the skin from the origin of perforator, distally to the top proximally, was measured to range 125–210 mm, with an average of 164 mm, while its width averaged 66 mm (range 57–77 mm). At the same time, using a special computer technique, the marked skin area was calculated to range 6 385 mm^2–14 341 mm^2, with an average of 10 305 mm^2. The mean height of the *ramus perforans* measured origin from the inferior border of the lateral malleolus was 66 mm (range 39–82 mm) (Table 1).

Age, sex, body height and length of fibula of the studied cadavers from the group 2 are presented in Table 2.

Table 1

Characteristic parameters of cadavers in the group 1 (the method with gentian violet dye)

Parameter	n	$\bar{x}$ ± SD (range)
Sex		
male/ female	9/ 1	
Age (years)		54 ± 13 (22–69)
Body height (cm)		185 ± 7 (170–192)
Fibula length (mm)		468 ± 27 (410–500)
The perforator origin height from malleolus (mm)		66 ± 13 (39–82)
Flap length (mm)		164 ± 26 (125–210)
Flap width (mm)		66 ± 6 (57–77)
Flap surface area (mm^2)		10,305 ± 2,763 (6,385–14,341)

Table 2

Characteristic parameters of cadavers in the group 2 (the corrosion preparation)

Parameter	n	$\bar{x}$ ± SD (range)
Sex		
male/ female	7/ 3	
Age (years)		50 ± 13 (27–68)
Body height (cm)		180 ± 8 (174–192)
Fibula length (mm)		417 ± 27 (335–445)
Diameter of the PARP* before bufurcation (mm)		1.37 ± 0.21 (1–1.8)
Diameter of the ascending branch after bifurcation (mm)		1 ± 0.17 (0.8–1.2)
Diameter of the descending branch after bifurcation (mm)		0.99 ± 0.19 (50.7–1.3)
Length of the ascending branch after bifurcation (mm)		139 ± 24 (100–180)
Communication with the *arteria tibialis anterior* (mm)		102 ± 16 (75–128)

PARP – peroneal artery *ramus perforans

By applying this technique, we obtained very precise results and presented them in Table 2 as follows: length of the perforating branch to the point where it bifurcates into the ascending and descending branches; the diameter of the perforating branch before its bifurcation; height of the communication between the ascending branch and *a. tibialis anterior*; diameter of the ascending branch after its bifurcation; diameter of the descending branch after its bifurcation; communication between the ascending and descending branch and the adjacent blood vessels.

The parameters obtained by this method were as follows: the diameter of the perforating branch before its bifurcation was calculated to be 1.37 mm (1.0–1.8 mm); the diameter of the ascending branch after its bifurcation averaged 1.0 mm (0.8–1.2 mm) and the diameter of the descending branch was 0.99 mm (0.7–1.3 mm). The mean length of the ascending branch was 139 mm (range 120–180 mm) and the height of its communication with the ATA ranged from 75 to128 mm, with an average of 102 mm (Table 2).

Figure 4 shows the view of distally-based flap on the ascending branch of the PARP.

Discussion

The lower leg reconstruction presents a great challenge to the surgeons due to the simple reason that the amount of soft tissue available for reconstruction is insufficient.

The insufficiency in tissue is not reflected in the lack of the available skin cover only but in poorly developed subcutaneous tissue and a small number of muscles for reconstruction of some defect [15].

It is important to emphasize that during the war waged on the territory of the former Yugoslavia the wounds to the lower legs and foot (mostly in Bosnia and Herzegovina) were the most common due to the specific characteristics of the warfare and the use of a large number of explosive ordnances and contact mines. These wounds are most often seen in industry, and situations such as car accidents.

The Pontén's [16] research (1981) and his findings that the subcutaneous, deep fascia is very rich in blood vessels of the perforators of the anterior and posterior tibial artery, and that *a. peronea* provides raising of reliable fasciocutaneous flaps with the length to width of the base ratio of 2.5–3:1 [16].

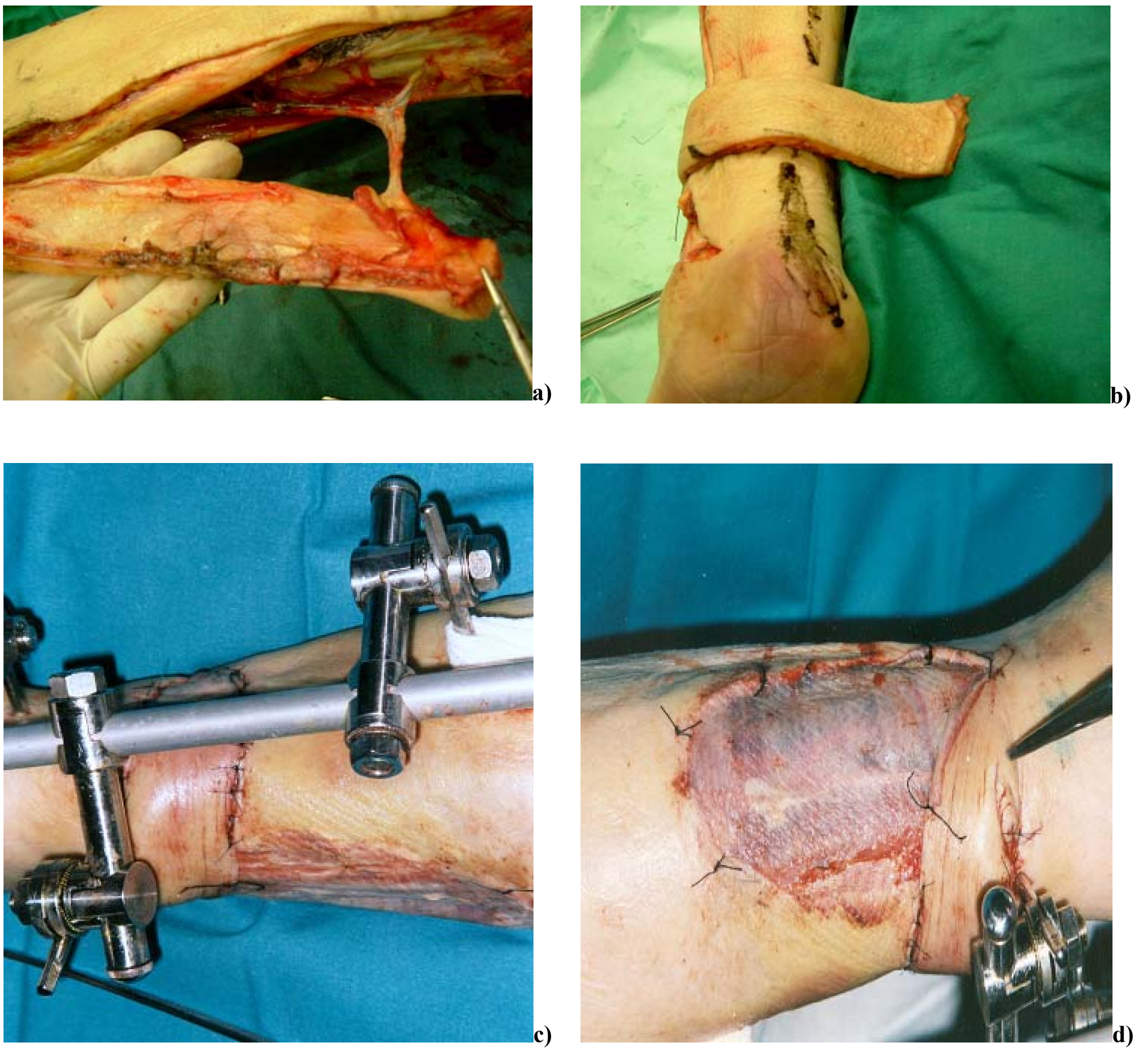


Fig. 4 – The view of a distally-based flap on the ascending branch of the peroneal artery *ramus perforans* (PARP): a – the bifurcation point of the ascending and discending branch of the PARP; b – flap reconstruction possibility; c and d – clinical appliction of the flap (the secondary defect reconstructed with the autotransplant)

At the end of the 1980s, the first papers describing distally-based, reverse and recurrent flaps appeared in the literature, that to a great extent facilitated a high-quality management of soft-tissue defects of the lower arm and foot [17–20].

These distally-based flaps are fasciocutaneous, that makes them reliable, with the base to length ratio of even 1 : 3–4. Contrary to the reverse-flow flaps, recurrent flaps have the physiological entry into the circulation, that secures distal position and makes them highly reliable.

One of those distally-based flaps is a flap based upon the ascending branch of the PARP. Circulation in this flap is recurrent, meaning that it has a physiological flow and a base on the anterolateral aspect of the lower arm, that it is vascularized *via* the recurrent, ascending branch of the PARP [12]. That recurrent circulation was in fact the topic of our investigation.

Published and available papers clearly show the presence of the ascending branch, but not its basic parameters such as diameter, length and probable communication with the adjacent blood vessels. The first paper to mention diameters of this distally-placed flap was published by Chang et al. [12] in 2004. In the series of 7 patients, they elevated the flaps of 17 × 6 cm in size on average and called them the new fasciocutaneous distally-placed flaps. They introduced them into the clinical practice.

Well aware that reconstruction procedures involving the region of the distal third of the lower leg are very limited [13, 21, 22], our aim was to clearly define a potential flap and its application.

The cadaver age-related data proved to be very remarkable, since the vascularization of a potential flap is directly proprtional to the age. In other words, the older a cadaver, the smaller the length, width, and the surface of the marked skin. It is also known that the elasticity of blood vessels decreases, and their diameter is smaller in proportion to age.

The height of a cadaver was found to be another significant data indicating size of a potential flap. During the investigation, our results revealed a direct proportion between the height and size of a flap. It is also important to emphasize that the point from which the *ramus perforans* branches off the peroneal artery, measured from the lower edge of the lateral malleolus was also proprotional to the height of a patient. The important data concerning the cadaver's height is the point at which the ascending branch communicates with *a. tibialis anterior*. The measured values showed that the height of communication was directly proportional to the height of a cadaver.

Observing these parameters (age, height, tibular bone length) we found them to be very crucial for potential use of a flap in the clinical practice. It is clear that we should consider the patient's age, but in designing a flap, it is important to know at what level *ramus perforans* bifurcates, because those parameters indicate the size of a flap we could harvest, and the diameter of a defect and its localization that we can reconstruct.

Blood vessels in the group A, instilled with the mixture of gentian and gelatine, enabled us to adequatelly measure length and diameter of the perforator and its two branches. At the same time, marking of the skin on the lateroanterial aspect of the lower leg showed the maximum dimensions, including both length and width, of a potential flap.

It should also be pointed out that, during instillation of gentian violete, we observed the changes in color in the distal two-thirds of a potential flap after instillation of the first 20 cm^3. The color change in the upper third occured after instillation of the second 20 cm^3 under a higher pressure. We assumed that it was that height or length of the ascending blood vessel where it communicated with *a. tibialis anterior*, and that the proximal third was a part lying over that communication. In this case as well, the height of bifurcation of the perforating branch was proportional to the cadaver's height and the length of fibula.

The average length of a potential flap in those 10 lower legs, measured from the height of the bifurcation of the perforating branch proximally, was 164 mm (125–210 mm). Our expectation to obtain longer marked skin areas from higher cadavers and those with a longer fibula was fully confirmed.

If we compare the obtained data, it is clear that this flap by its length, width and design could be completely used for reconstruction of lateral malleolus defects, since the rotation point (pivot) was only 6.6 mm, proximal to the lower edge, and the average length of the marked surface was considerably larger. The distance of a potential flap rotation point from the medial malleolus was less than 7 cm, that makes it more convinient for reconstruction of medial malleolus defects as well.

The average width of potential flaps in the same 10 lower legs was 66 mm (57–77 mm). However, it should be emphasized that the length was clearly limited, whilst the width was asymmetrical. The widest part of a potential flap was 7–10 cm from the lower distal measurement point. In other words, the largest flap width was found at the level of communication between the ascending artery and *a. tibialis anterior*.

Upon completion of outer measurements of those 10 lower legs, we started dissection and elevation of the marked skin and fascia as fasciocutaneous flaps. During dissection, we closely followed the course and the length of the ascending branch of the perforator as the basic vascular branch of the flap, as well as the diameter of the ascending and discending branches at their origin immediately after their point of bifurcation.

The ascending branch is situated on the inner side of the deep fascia; on its recurrent course, it gives off a large number of small blood vessels which partly penetrate the fascia and pass into the subcutaneous region pushing their terminal branches towards the skin surface. Running from distal to proximal, this blood vessel is lost in the network of tiny blood vessels and capillaries. That visual effect completely matches the area of the marked skin.

By its characteristics, the obtained fasciocutaneous flap covered a great part of the distal third of the lower leg, including a part of the area of the Achilles tendon insertion as we have shown in this study.

The obtained parameters were compared with the available data in the literature.

The height of the perforator bifurcation point measured, as well, from the distal plane of the lateral malleous in cadavers (20 cadaveric lower legs) by Beveridge et al. [10] was 44–90 mm in diameter (the average of 67 mm). In the group of 10 cadavers, we measured the same height which averaged 66 mm.

Based on the data obtained by the same authors, the length of the perforator from its origin down through the interosseous membrane and up to the bifurcation point was 65 mm. We obtained the average length of 51.7 mm during our investigation.

The mentioned authors measured the diameter of ascending and discending branches shortly after bifurcation from the same tree in the same group of cadavers. The average diameter of ascending and descending branches were 10 mm and 11 mm, respectively. They came to the conclusion that the descending branch appeared to be stronger, and that it communicated with the terminal branches of the peroneal artery (*aa. maleolares*) and lateral branches (*a. dorsalis pedis*) forming, thus, a strong lateral malleolar *plexus*. At the same time, they pointed out that it is possible to design a distally-based flap that can be very reliable. It might be concluded from the presented that the obtained results are very compatible, with an insignificant discrepancy in measurements of the diameter of those two branches.

Our investigation proved that it might be possible to elevate a reliable, distally-based flap from the base in the direction of lateral malleolus. Our investigation confirmed that in the early 2010, Li et al. [23] used this flap for reconstruction of knee defects with microvascular anastomosis.

The method of making preparations is a very precise and reliable procedure which provided us with all the data significant for assessing the possibility of raising a distally-based reverse-flow flap vascularized by the ascending branch of the PARP and its use in the clinical practice.

This method was thoroughly applied in 10 lower legs at the Anatomic Institute of the School of Medicine. The main point of the method is to obtain the smallest blood vessel print of the lower leg and foot which relate to the actual anatomy, position and diameter.

The obtained preparation enabled us to precisely measure all the required parameters for assessing the quality of the analyzed blood vessel and its position and relationship to the adjacent blood vessels.

The diameter of the perforating branch before its bifurcations into ascending and descending branches averaged 1.37 mm (1.0–1.8 mm) in those 10 lower legs.

The diameter of the ascending branch at the level of its bifurcation from the main tree was 1.00 mm, whilst the diameter of the descending branch at its origin measured 0.99 mm. By this measurement, we found the diameter of the ascending branch to be minimally increased for 0.01 mm only.

Latest investigations conducted by Ribuffo et al. [14] using CT and a very sensitive Doppler sonography showed that the average diameter of *ramus perforans* was 1.91 mm, and the diameter of the first part of the ascending branch was 0.8 mm, that almost corresponded to the measurement results we obtained during the investigation.

The height at which the ascending branch communicates with the anterior tibial artery was 75–128 mm (the average of 102 mm).

In the precise study of the corrosive preparation, we observed that the terminal branches including both ascending and descending ones, give off a large number of tiny blood vessels to supply deep fascia and the overlying skin. The next issue observed was that they both communicate with *a. tibialis anterior*. The descending branch participates in the formation of the lateral malleolar plexus and communicates as well with the terminal branches of peroneal artery through *rami lateralis*.

Beveridge et al. [10] also very accurately described the communication of the descending branch of *ramus perforans* and its participation in the formation of the *rete maleolaris lateralis* as well as the possibilities of reverse-flow vascularization.

Based on those investigations, statistical data processing and the comparison of some methods, we determined that *ramus perforans* of the peroneal artery is a constant branch which branched off the peroneal artery at the average height of 57 mm, measured from the lower edge of the lateral malleous, pierced the interosseous membrane, and after transition of the average 47 mm and the diameter of 1.37 mm on transition, *ramus perforans* divided into an ascending and a descending branch, and that the ascending branch communicated with the anterior tibial artery in 90% of cases. By precise measuring and comparing the ratio between the length from the lateral malleolus to the rotation point (pivot point) of that flap, and from the rotation point to its tip, we could conclude that a flap is convenient for covering a defect exactly at the lateral malleolus level. By simultaneous measuring the length from the medial malleolus and Achilles tendon at the same level, we obtained the same results which indicated the possibility of using this flap for covering defects in those regions.

With respect to the clinical application of this flap, Xia et al. [24] in their study in 2009, reported the edge necrosis as a complication that occured in 2 of 22 patients. Statistical processing of the measured data revealed that the height at which *ramus perforans* branches off the peroneal artery, measured from the distal plane of the lateral malleolus, was 1/8 of the total length of the fibula. This data was found to be very essential for clinical planning and design of a potential flap based on *ramus perforans*, what was clinically confirmed by our study results (Figures 4, c and d).

We also confirmed that the length of the ascending branch from the bifurcation point to the point of communication with the tibial artery was 1/5 of the total length of the fibula, that confirms the possibility of raising a reliable distally-based flap.

Conclusion

Based on the obtained findings analyses, the following could be concluded:

The peroneal artery is a constant blood vessel which supplies blood *via* its *ramus perforans* to a certain part of the lateral and antero-lateral surface of the lower leg. R*amus perforans* branches off at the average height of 66 mm from the lower edge of the lateral malleolus, penetrates immediately the interosseous membrane, and bifurcates into two terminal branches: *ramus ascendens i ramus descendens*. Ascending branch provides nutrition and blood supply to a flap of an average length of 164 mm, and width of 66 mm.

By analyzing all the obtained data and parameters, we could conclude that the length of a potential flap is directly proportional to the height of a pateint, and what might be even more important, the height of *ramus perforans* bifurcation point is also proportional to the patient's height.

This proportionality was also found to the length of tibia as a local comparative parameter what can help us in the evaluation of the height of the perforator bifurcation, and the base of the distally based flap in its clinical application. The investigation of the vascularization of the ascending branch of the PARP led us to a conclusion that it is possible to raise a flap on the anterolateral side of the lower leg, distally based on this perforating branch of the peroneal artery, and that it can be used in clinical practice to treat soft tissue defects of the distal third of the lower leg, both maleolar regions, and the region of the insertion of the Achilles tendon and at the dorsal region of the foot.

Clinical application of this flap cannot endager any magistral blood vessel. It is easy to raise the flap with a good knowledge of its anatomy. The flap is easy to design, it is very mobile and reliable for skin reconstruction.

R E F E R E N C E S

1. *Panajtovic Lj, Kozarski J, Krtinic-Rapaic S, Stanojevic B.* Management of war burns of the lower leg using free flaps. Vojnosanit Pregl 2003; 60(6): 741–5.
2. *Valenti P, Masquelet AC, Romana C, Nordin JY.* Technical refinement of the lateral supramalleolar flap. Br J Plast Surg 1991; 44(6): 459–62.
3. *Koshima I, Itoh S, Nanba Y, Tsutsui T, Takahashi Y.* Medial and lateral malleolar perforator flaps for repair of defects around the ankle. Ann Plast Surg 2003; 51(6): 579–83.
4. *Koshima I, Nanba Y, Tsutsui T, Takahashi Y, Itoh S.* Perforator flaps in lower extremity reconstruction. Handchir Mikrochir Plast Chir 2002; 34(4): 251–6.
5. *Lee S, Estela CM, Burd A.* The lateral distally based adipofascial flap of the lower limb. Br J Plast Surg 2001; 54(4): 303–9.
6. *Ali MW, Mohajir AM.* Dorsalis pedis artery: variations and clinical significance. J Indian Med Assoc 1996; 94(11): 417–8.
7. *Converse JM.* Reconstructive plastic surgery. 2nd ed. Philadelphia: W.B. Sounders Company; 1977.
8. *Lawrence SJ, Botte MJ.* The deep peroneal nerve in the foot and ankle: an anatomic study. Foot Ankle Int 1995; 16(11): 724–8.
9. *Cormack GC, Lamberty BG.* A classification of fascio-cutaneous flaps according to their patterns of vascularisation. Br J Plast Surg 1984; 37(1): 80–7.
10. *Beveridge J, Masquelet AC, Romana MC, Vinh TS.* Anatomic basis of a fascio-cutaneous flap supplied by the perforating branch of the peroneal artery. Surg Radiol Anat 1988; 10(3): 195–9.
11. *Le Nen D, Beal D, Person H, Lefevre C, Sénécail B.* Anatomical basis of a fascio-cutaneous pedicle flap based on the inferolateral collateral artery of the leg. Surg Radiol Anat 1994; 16(1): 3–8.
12. *Chang SM, Zhang F, Yu GR, Hou CL, Gu YD.* Modified distally based peroneal artery perforator flap for reconstruction of foot and ankle. Microsurgery 2004; 24(6): 430–6.
13. *Kawamura K, Yajima H, Kobata Y, Shigematsu K, Takakura Y.* Clinical applications of free soleus and peroneal perforator flaps. Plast Reconstr Surg 2005; 115(1): 114–9.
14. *Ribuffo D, Atzeni M, Saba L, Guerra M, Mallarini G, Proto EB*, et al. Clinical study of peroneal artery perforators with computed tomographic angiography: implications for fibular flap harvest. Surg Radiol Anat 2010; 32(4): 329–34.
15. *Novaković M.* Vaskularized fibular graft. Belgrade: Zadužbina Andrejević; 2000. (Serbian)
16. *Pontén B.* The fasciocutaneous flap: its use in soft tissue defects of the lower leg. Br J Plast Surg 1981; 34(2): 215–20.
17. *Lamberty BGH.* Use of fasciocutaneous flaps in lower extreity reconstruction. Perspec Plast Surg 1990: 4: 146–51.
18. *Tolhurst DE.* Surgical indications for fasciocutaneous flaps. Ann Plast Surg 1984; 13(6): 495–503.
19. *Tolhurst DE, Haeseker B, Zeeman RJ.* The development of the fasciocutaneous flap and its clinical applications. Plast Reconstr Surg 1983; 71(5): 597–606.
20. *Amarante J, Costa H, Reis J, Soares R.* A new distally based fasciocutaneous flap of the leg. Br J Plast Surg 1986; 39(3): 338–40.
21. *Demirtas Y, Ayhan S, Sariguney Y, Findikcioglu F, Cukurluoglu O, Latifoglu O,* et al. Distally based lateral and medial leg adipofascial flaps: need for caution with old, diabetic patients. Plast Reconstr Surg 2006; 117(1): 272–6.
22. *Ahmed SK, Hashmi PM.* Delayed supramalleolar flap-an innovative technique for enhanced viability. J Ayub Med Coll Abbottabad 2005; 17(3): 76–9.
23. *Li F, Zeng B, Fan C, Chai Y, Ruan H, Cai P.* Distally based extended peroneal artery septocutaneous perforator cross-bridge flap without microvascular anastomoses for reconstruction of contralateral leg and foot soft tissue defects. J Reconstr Microsurg 2010; 26(4): 243–9.
24. *Xia ZB, Wang D, Yuan YJ, Min JK, Yang WL, Li HC,* et al. Repair of soft tissue defects on the lower limbs with the facial pedicled flap with vascular perforating branch of leg. Zhongguo Gu Shang 2009; 22(11): 853–5. (Chinese)

Received on June 16, 2010.
Revised on February 2, 2011.
Accepted on February 7, 2011.