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Clinical aspects of reconstruction of the lower third of the leg with fasciocutaneous flap based on peroneal artery perforators

Klinički aspekti rekonstrukcije distalne trećine potkolenice fasciokutanim režnjem baziranim na perforatorima peronealne arterije

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Abstract

Background/Aim. Fasciocutaneous flaps are tissue flaps that include the skin, subcutaneous tissue and underlying fascia, and are based on the septocutaneous system of blood vessels. They have a number of characteristics that give them an advantage in many cases, especially in treatment of lower extremity defects. The aim of this study was to clinically analyse the outcomes of patients surgically treated with *a. peroneae* perforator-based reverse flaps of the lower leg. **Methods.** This prospective study was conducted on a group of 22 patients with tissue defects in the lower third of the lower leg and foot. All the 22 patients underwent standard diagnostic procedures and the preoperative preparation for spinal anesthesia. During the surgery, the location of the recipient site with a future flap and an accompanying vascular stem was marked. Having prepared the recipient site in accordance with the surgical principles, the lobe was prepared, rotated and positioned in the defect region. **Results.** The proportion of male to female patients in our study group was 19 (86%) to 3 (14%), respectively. The maximal defect frequency (14 or 63%) was found in the age group of 30–50 years, i.e. working-age people. Trauma in 16 (72%) of patients was the most common reason for surgical treatment. The most common defects our patients had were found in the distal third of the leg (5, 22%), medial malleolus (4, 18%), the dorsum of the foot (3, 13%) and the foot (4, 18%). The number of lobes (18, 81%) applied in the course of our clinical study was statistically more significant ($p < 0.05$) than the number of lobes applied along with the skin autografts (4, 19%). During the final follow-up of the applied lobes, 6 (27.2%) of early and 2 (9%) of late complications were observed, making a total of 36.2% of complications occurring in the applied lobes, of which only 1 was lost. **Conclusion.** Clinical application of *a.suralis superficialis mediani*-based reverse flap is justified by a high percentage (95.5%) of preserved lobes. Functional recovery of Achilles tendon injuries treated with the fasciocutaneous flap appeared to be effective. The results obtained during the clinical investigation can be very helpful in using this flap more optimally and more often in a wide range of different reconstructive surgical procedures in the field of plastic surgery.

Key words:
reconstructive surgical procedures; lower extremity; surgical flaps; recovery of function.

Apstrakt

Uvod/Cilj. Fasciokuatni režnjevi su režnjevi koji u svom sastavu imaju kožu, potkožni sloj i fasciju, a bazirani su na septokutanom sistemu krvnih sudova. Imaju niz karakteristika koje im daju prednost kod velikog broja povređenih, a posebno u zbrinjavanju defekata na ekstremitetima. Cilj ove studije bila je klinička analiza rezultata operativnog hirurškog lečenja bolesnika kod kojih su korišćeni reverzni režnjevi potkolenice bazirani na perforatorima *a. peroneae*. **Metode.** Ova prospektivna studija sprovedena je na 22 bolesnika sa defektom tkiva na zadnjoj strani donje trećine potkolenice i stopala kod kojih su urađene preoperativno standardne dijagnostičke analize i priprema bolesnika za spinalnu anesteziju. U operativnom postupku markirano je mesto davajuće regije sa budućim režnjem i pripadajućom vaskularnom peteljkom. Režanj je ispreparisan, rotiran i postavljen na mesto defekta uz predhodnu pripremu primajuće regije shodno hiruškim principima. **Rezultati.** U ovom kliničkom ispitivanju dominirali su bolesnici muškog pola, 19 (86%), dok je žena bilo 3 (14%). Najveća učestalost defekata, 14 (63%), bila je u starosnoj grupi od 30–50 godina, tj. kod radno sposobnih ljudi. Trauma, 16 (72%), bila je najčešći razlog za operativno liječenje. Defekt se najčešće nalazio na distalnoj trećini potkolenice, 5 (22%), medijalnom maleolusu, 4 (18%), dorzumu stopala 3 (13%) i peti 4 (18%).

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Broj primijenjenih režnjeva, 18 (81%), u toku kliničkog rada bio je statistički značajniji ($p < 0,05$) nego broj primijenjenih režnjava zajedno sa autotransplantatom kože, 4 (19%). U toku praćenja primenjenih režnjeva bilo je 6 (27,2%) ranih komplikacija i 2 (9%) kasne što iznosi ukupno 36,2% komplikacija na primenjenim režnjevima, od kojih je samo jedan bio izgubljen. **Zaključak.** Primena reverzibilnog režnja baziranog na *a. suralis superficialis medianae* je opravdana zbog velikog procenta (95,5%) očuvanih režnjeva. Funkcionalni oporavak kod povreda u predelu Ahilove tetive pri primeni fasciokutanog režnja bio je efikasan. Dobijeni rezultati mogu biti višestruko korisni u plastičnoj hirurgiji radi optimalnije i češće upotrebe ovoga režnja u različitim rekonstruktivnim hirurškim zahvatima.

Ključne reči:
hirurgija, rekonstruktivna, procedure; potkolenica; režnjevi, hirurški; funkcija, povratak.

Introduction

Fasciocutaneous flaps are tissue flaps that include the skin, subcutaneous tissue and underlying fascia, and are based on the septocutaneous system of blood vessels. They have a number of characteristics that give them advantages over other types of flaps, especially in the management of the lower extremity defects. A fasciocutaneous flap is vascularized by fasciocutaneous (septocutaneous) blood vessels originating from the regional blood vessels, that pass through an intermuscular and intercompartmental fascial septa to the surface of the fascia, where they branch off to form the plexuses which deliver the blood to the subcutaneous fatty tissue and the skin of the region above the perforator. The most important feature of a fasciocutaneous flap is the vascularization system which distinguishes it from the other flaps [1, 2]. The distally-based superficial sural artery flap was been first described in the experimental study of Masquelet et al [3]. It is a skin island flap supplied by the vascular axis of the sural nerve. Arterial blood supply to the flap is provided by the superfacial sural artery which anastomoses with septocutaneous perforators *a. peroneae*. The pivot point of the pedicle must be at least 5 cm proximal to the lateral malleolus [4, 5]. Hasegawa et al. [6] presented the successful use of that flap in 21 patients on the basis of the results published in the 90s of the last century [3]. During the postoperative period, the largest number of patients had venous stasis flaps, of which the largest ones (10 × 13 cm) were maintained for two months. A more favorable clinical course was observed in patients with smaller flaps. There were two great advantages of that flap. The first referred to the easy and fast surgical preparation and flap design without doppler diagnosis, while the second referred to the fact that there was no need to sacrifice the main arteries of the lower leg [7, 8]. The flap size, location, width as well as esthetic requirements of the recipient rergion should be taken into consideration during planning and designing [8, 9]. The flap was then outlined and the vascular pedicle marked 5 cm proximally to the lateral malleolus, where the point called the "pivot point" of the flap was marked. Further, the flap was designed along the medial line of the lower leg which represented the path of the neurovascular pedicle.

The aim of the study was to analyze clinical outcomes of surgical treatment with reverse lower leg flaps based on *a. peroneae* perforators.

Methods

This prospective study on a group of 22 patients with tissue defects in the lower third of the lower leg and foot was conducted in the Military Medical Academy, Belgrade, Serbia the Clinic for Plastic Surgery, the Clinical Center of Montenegro, Podgorica, Montenegro and the Surgical Ward, Foča General Hospital, Foča, Bosnia and Herzegovina.

All the 22 patients with the defect in the lower third of the lower leg and proximal part of the foot underwent standard diagnostic procedures and the preoperative preparation for spinal anesthesia.

During the surgery itself, we marked the location of the recipient site with a future flap and accompanying vascular stem.

After the recipient area has been prepared, accordind to surgical principles of this procedure, the lobe was prepared, rotated and positioned in the defect region.

The functional and esthetic outcomes of the reconstruction method applied in all the 22 patients who underwent the lower leg reconstruction with reversible fasciocutaneous flap based on *a. suralis superficialis mediani* were postoperatively analyzed. Functional investigations referred to the evaluation of the mobility of the distal third of the lower leg and hinge joint, where the planned flap could ensure, through further rehabilitation, the functional recovery at the highest level possible.

All the obtained data were statistically processed upon their collection. The $p < 0.05$ was considered to be of statistical significance.

Results

During our clinical investigation period, a total of 22 patients of different ages and gender underwent surgery, i.e. reconstruction of the lower leg with the flap based on *a. suralis superficials mediani*.

During this clinical investigation there were more male than female patients in the study group, the ratio being 19 (86%) to 3 (14%), respectively.

The maximal sickness frequency (14 patients, 63%) was found in the age group of 30–50 years, i.e. working-age people, $p < 0.05$ (Figure 1).

Trauma was found to be the most common reason for surgical treatment in the course of this clinical investigation (16 patients, 72%), $p < 0.05$ (Table 1, Figure 2).

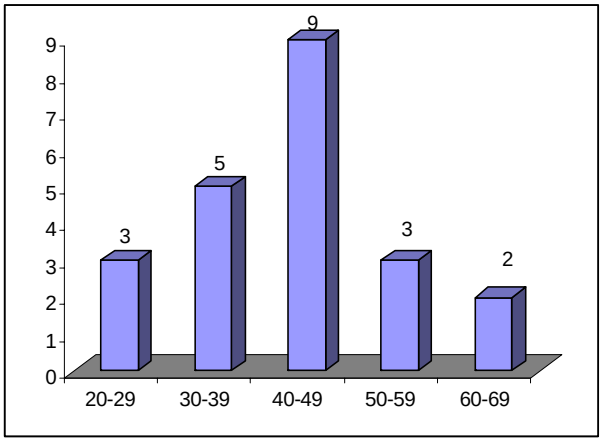

Fig. 1 – Age structure of the patients.

The most common defects were observed in the distal third of the leg (5 patients, 22%), medial malleolus (4 patients, 18%), the dorsum of the foot (3 patients, 13%) and the foot (4 patients, 18%) (Table 1).

A total of 18 (81%) lobes applied in the course of this clinical study was statistically more significant ($p < 0.05$) than the number of lobes applied along with the skin autografts, 4 (19%).

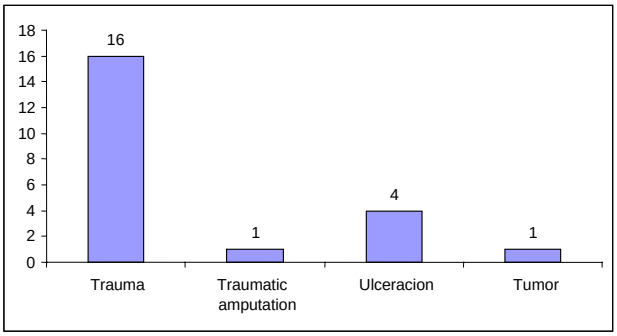

Fig. 2 – The types of injuries.

During the postoperative flap monitoring period, we observed 6 (27.2%) early and 2 (9%) late complications, making a total of 36.2% complications in relation to the applied flaps, of which only one was lost (Table 2).

Table 1

The size of fasciocutaneous arterial flap and defect dimensions and the application and transfer of flap through the subcutaneous tunnel or not through it

Patient's number	Cause of the defect	Size of the defect (cm)	Size of the lobe (cm)	Localization of the defect	Path
1	Trauma	9 × 6	11 × 8	Distal third of the leg	Not through the tunel
2	Trauma	10 × 6	12 × 8	Hell, *malleolus*	Not through the tunel
3	Ulceration	5 × 4	6 × 5	Med. *malleolus*	Through the tunel
4	Ulceration	5 × 4	6 × 5	Med. *malleolus*	Through the tunel
5	Trauma	5 × 5	7 × 6	Med *malleolus*	Not through the tunel
6	Trauma	9 × 8	11 × 7	Hell	Through the tunel
7	Trauma	7 × 6	9 × 7	*Malleolus*	Not through the tunel
8	Trauma	9 ×8	12 × 8	Distal third of the leg	Not through the tunel
9	Tumor	6 × 5	7 × 6	Hell	Through the tunel
10	Trauma	8 × 8	9 × 8	Distal third of leg	Not through the tunel
11	Ulceration	7 × 6	8 × 8	Med. *malleolus*	Through the tunel
12	Trauma	7 × 4	8 × 5	Distal third of the leg	Not through the tunel
13	Ulceration	5 × 4	6 × 4	Med. *maleolus*	Passage through the tunel
14	Trauma	10 × 6	11 × 7	Distal third of leg	Not through the tunel
15	Trauma	4 × 3	5 × 4	Hell	Through the tunel
16	Trauma	5 × 3	6 × 4	The defect in a part of the Achilles' tendon	Not through the tunel
17	Trauma	9 × 7	10 × 9	Dorsum of the foot	Not through the tunel
18	Traumatic amputation	12 × 8	15 × 10	Dorsal side of the foot with amputating stump of it	Not through the tunel
19	Trauma	7 × 6	10 × 7	Front side, distal third of the leg	Not through the tunel
20	Trauma	5 × 5	7 × 6	Hell	Through the tunel
21	Trauma	10 × 7	12 × 8	Dorsum of the foot	Not through the tunel
22	Trauma	9 × 7	10 × 8	Lateral *malleolus* and the hell	Through the tunel

Table 2

The presentation of immediate and late complications

Early complications	Patients n (%)	Late complications	Patients n (%)
Hematoma	2 (9)	Hypertrophic scar	1 (4.5)
Infection	1 (4.5)	Hyperkeratosis	1 (4.5)
Superficial flap necrosis	1 (4.5)		
Marginal necrosis	1 (4.5)		
Lost lobe (infection and necrosis)	1 (4.5)		

All the patients underwent a complete physical therapy. Functional recovery from Achilles' tendon injuries managed with the fasciocutaneous flap that was observed in our patients was much better.

Results of flap incorporation to the recipient defect site are presented in Figure 3.

Discussion

The methods of clinical investigation were classified into 3 groups: preoperative preparation, surgical technique

Fig. 3 – The flap postoperative follow-up to its final incorporation into the recipient defect site.
a, c, e – Recipient defect site preoperativelly; b, d, f – Flap final incorporation into the recipient defect site.

for the fasciocutaneous flap, postoperative monitoring of the flap until its definite placement into the recipient defect site. Through surgical treatment, we showed the possibilities of and justification for the use of this flap in reconstruction of distal lower leg and foot defects. This surgical procedure was performed in the patients with the following indications: posttraumatic defects in the areas of the distal third of the lower leg on its medial and posterior side, the Achilles' tendon and the foot, the medial and lateral malleolus, and the dorsal side of the foot including the posttraumatic distal foot amputation; chronic ulcus in the area of calcaneus, and postoperative defects after tumor excisions.

The surgical procedure was performed after the standard preoperative preparations, biochemical tests, necessary cardiological examinations, color doppler imaging of the lower-extremity blood vessels and other required exams.

The surgical procedure was performed under spinal anesthesia with the patient in the pronate position, and intraoperative changing of the patient's position in relation to the defect localization.

The surgery started with devitalized injury tissue and skin edges debridement, and granulation tissue removal in cases of posttraumatic defects, or with vulnerable scarf, i.e. tumor excision, and the definite soft-tissue defect formation. After that, a footprint of the formed soft-tissue defect was taken over the sterile rubber material, and, after precise planning of the pedicle, used for covering the recipient site on the posterior side of the proximal lower leg, and for raising the planned flap slightly larger than the primary defect. Finally, the flap was elevated by using our own technique along with careful hemostasis and bipolar coagulation.

Particular care and attention was paid to the width of the neurovascular pedicle containing 1 cm deep fascia taken on either side of the pedicle to allow for better vascularioza-tion of the flap.

The flap was transferred to the prepared soft-tissue defect site through a subcutaneous tunnel or without passing it through the tunnel, taking care not to twist the pedicle. The edges of the flap were sutured together in one layer. The base of the flap, dependent on its width, was closed by direct undermining the skin flaps on the sides or using autotransplants. Direct closure of donor defect sites up to 6 cm in diameter was possible with the flaps equal in width, but if the skin island flap was wider, the donor site closure was possible with the Thiersch skin autotransplant. The skin graft was harvested from the opposite leg with the electric dermatome, placed in the donor site, and fixed with separate unresorbable sutures. It was covered with vaseline gauze, wet gauze and dry gauze in 4 layers. The graft was also dressed with vaseline gauze and dry gauze in 3 layers, and a circular hole cut out in the middle of it to monitor the graft vitality. After the surgery, a patient could lie on the left and the right side, but was not allowed to lean on the dorsal side of the operated lower leg.

During this investigation, there were more male than female patients, the ratio being 19 (86%) to 3 (14%), respectively. The maximal sickness frequency (n = 14, 63%) was found in the age group of 30–50 years, i.e. working-age people.

In the course of this clinical investigation, trauma 16 (72%) appeared to be the most common reason for the surgical treatment. The most frequent defects were found in the distal third of the leg (n = 5, 22 %), medial malleolus (n = 4, 18%), the dorsum of the foot (n = 3, 13%) and the foot (n = 4, 18%).

The flaps and defects we investigated were of various dimensions, ranging from 5 × 3 cm (injuries) to 12 × 8 cm (traumatic amputations). During surgical application of the flap, the length of the vascular pedicle ranged from 14 cm maximally to 9 cm minimally, with the average values of 11.5 cm and standard deviation of 6.5 cm. The flap mobility was extraordinary, with the possibility to rotate up to 180 degrees. Having in mind that the flap could be rotated in any direction, it was possible to cover any point of the full circle within the diameter of the maximum flap length, taking care not to twist the pedicle. The number of patients surgically managed using the flap passed via the subcutaneous tunnel was 9 (41%), while the number of those with the flap not passed through the tunnel to the site of application was 13 (59%).

The number of flaps used in the patients was 18 (81%), and the number of flaps applied together with the skin autografts was 4 (19%).

The donor sites in 9 (41%) of patients were closed directly, while the closure of the donor site in 13 (59%) of patients was done using autotransplants ($p < 0.05$).

Bleeding edges of the flap during the surgical procedure were the first sign of its vitality. During the immediate postoperative period, the vitality of the flap was monitored using the "refillig" test (a change in the flap color to redness upon releasing finger pressure or closed forceps) and bleeding upon the insertion of the insulin needle. Temporary venous congestion of the flap was seen in distally based flaps [10, 11]. It occurred due to the retrograde flow of venous blood, and the retrograde position of the valves in the venous blood vessels [12, 13]. Venous drainage of the transferred flap was monitored by evaluating the two parameters, that is, the flap color and capilary refilling. The color of the flap was assessed by comparing it with the color of the adjacent skin. If the color was the same as that of the adjacent skin, it was regarded as normal (blanchable red). If it was darker when compared with the color of the adjacent skin, it was assessed as livid. The lividity of the flap, and the adenoma developed in the later stage were caused by venous congestion. Adenoma sometimes exists for up to two months. Similar results were reported by the other authors [14–17]. The reason for venous congestion of the distally based flap lies in the fact that venous drainage is carried out through small veins running parallel with the small saphenous vein.

Venous congestion is considered to be an accompanying postoperative phenomenon by many authors [18–20]. On one side, they bypass the adjacent valves of the large superficial veins, and on the other side, they anastamose with the perforator concomitant veins through which the definite drainage is carried out. The function of the fascious plexus in the venous drainage is emphasised here [19, 20]. The flap refill test

performed by applying thumb pressure was assessed normal when the color returned within 3 seconds, indicating, thus, that the capillary blood flow in the flap was normal. If color change took more than 3 seconds, capillary refill was considered to be slow.

In the postoperative period, the status of the recipient site was inspected regularly through dressing changes. However, care was given to the donor sites of both the flap and free skin graft. Aspiration drainage of directly closed donor sites was performed after 48 hours, while running sutures used to close the wound were removed on the day 14 postoperatively. Some authors report earlier removal of sutures, and later removal of a drainage tube depending on its activity [19, 20]. Following complete epitalization, the donor sites closed with the free Thiersch's skin grafts were controlled, and the dressings removed from the donor sites between the day 15 and the 20 postoperatively.

The grafts applied on the donor sites were dressed on the day 2 after the surgery to ensure they were properly attached to the site, that no blood accumulated beneath the grafts and that there was so partial nor complete graft lisis. The adherence to the donor site was achieved within 10 days, when the sutures used to hold the graft in place were also removed. Dressing changes were performed not later than 28 days to ensure complete healing of both the donor site and the autotransplant. In the patients with bone fractures, callus formation at fracture site and fracture healing were submitted to radiography and regular orthopedic controls. Callus formation at sites of fractures has been described by other authors as well [20–22]. On the basis of the radiography and clinical findings, the inserted osteosynthetic material was removed. Depending on the histopathological findings, regular postoperatove follow-ups were indicated to prevent reccurence of recedives.

During the postoperative monitoring of the flap, 6 (27.2%) early and 2 (9%) late complications were observed, making together a total of 36.2% complications in relation to the applied flaps, of which only 1 was lost. The postoperative follow-up of the applied flaps was also described by other authors who reported the total number of complications similar to determined in this investigation [21, 22]. The number of flap failures reported by other authors was larger due to the various numbers of applied flaps [23, 24].

The foot bones knited together can move to the left and to the right, and these movements play a very crucial role in the foot stability and balance. As a whole, the foot and its connection with the lower leg bones, in combination with some knee actions are considered a functional entity. Therefore, after a short resting period, the complete physiotherapy including electrotherapy, ultrasound therapy, magnetotherapy with the emphasis on the lymphatic drainage, massage and mobility exercises was initiated to reduce swelling as fast as possible. Depending on the extent of surgical procedure and concrete possibilities, the aim was to reestablish the normal range of the joint motion, and load it with the full-body weight.

All the patients underwent a complete physical therapy. The functional recovery from Achilles' tendon injury managed with the fasciocutaneous flap was shown to be considerably better than. Namely, long after all the symptoms removal, foot instability to a smaller or larger extend was demonstrated. It is the reason for indicating the functional treatment as to regain the lost abilities. It mostly includes strength, extension and balance exercises. Once the functional therapy has been completed, we could say that everything possible has been done to prevent new damage to the joint itself, to its functional components or surrounding physical structures.

Conclusion

The use of the reverse flap based on *a. suralis superficialis mediani* is justified by a high percentage (95.5%) of preserved lobes.

Functional recovery of Achilles tendon injuries treated with the fasciocutaneous flap was shown to be effective.

The results obtained during the investigation can be very helpful for using this flap more optimally and more often in a variety of reconstructive surgical procedures in the field of plastic surgery.

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