ORIGINAL ARTICLE

An idea for bringing the recipient pedicle of cross leg free flap closer: Fasciocutaneous flap above pedicle

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ABSTRACT

BACKGROUND: Cross leg free flaps are one of the salvage methods used for free tissue transfer in large tissue defects in the absence of recipient vessels. The fasciocutaneous flap above the posterior tibial artery can be harvested to protect the pedicle and to advance a distance to wound, which is equal to the length of fasciocutaneous flap.

METHODS: Patients who were operated with cross leg free flap with the supporting fasciocutaneous flap on unwounded side were included in the study between years 2010 and 2020. Age, sex, location and size of the defects, arterial patencies, flap choices, fasciocutaneous flap size, duration of operation, cross flap separation timing, complications, and time to return to work were evaluated.

RESULTS: There were six patients with the etiology of high-energy electrical burns and trauma. There was only one arterial refilling for three patients and no refilling for others. Latissimus dorsi skin muscle flap was used in all but one patient. The mean defect size was 6.6×14.8 cm. The mean size of fasciocutaneous flaps was 4.08×5 cm. The mean operation time was 360 min. There was no complication except one dehiscence and one marginal necrosis and infection which were healed with wound care. Average time to return to work was 9 months.

CONCLUSION: In similar cases, as wounded lower extremities with one or no artery refill, harvesting a fasciocutaneous flap with recipient vessels will be useful before considering the option of using a bridge free flap in medium to moderate sized defects.

Keywords: Cross-leg; free flap; limb salvage; reconstruction.

INTRODUCTION

Lower extremity amputations are a serious morbidity that adversely affects the entire life of the patient. Trauma, diabetic wounds of the lower extremity, atherosclerosis, and tumors are the most common causes of limb amputations.[1] Due to the complexity of progressive limb salvage methods, the negative impact of the patient's psychology over time, and the prolonged time before being able to stand up and walk, there are opinions supporting the option of amputation, especially in severely devascularized and denervated extremities.[2–4] However, the necessity to try limb salvage treatments is accepted by the current reconstructive microsurgery literature, especially in neurosensitively intact extremities that are fed with a single artery or have no nutrient vessels but provide viability with collateral circulation.[5] In such patients, if defect sizes are irreparably large for use of local flaps, the free flap option should be considered. For the free flap recipient vessel problem, carrying a vascular structure to the defect by a loop method or with a vein graft separately from the proximal of the extremity or selecting recipient vessels from the opposite intact extremity are the most commonly used solutions.

It is difficult for crossed leg flaps to cover particularly wide flaps and defects extending to the 1/3 proximal lateral cruris. Another problem with these flaps is the risk of the exposition of the pedicle, which would cause drying, eventual infection, and other problems caused by infection. The aim of this article is to present the method of application and results of a technique which we believe minimizes these two problems with a single process (See surgical plan in Fig. 1).

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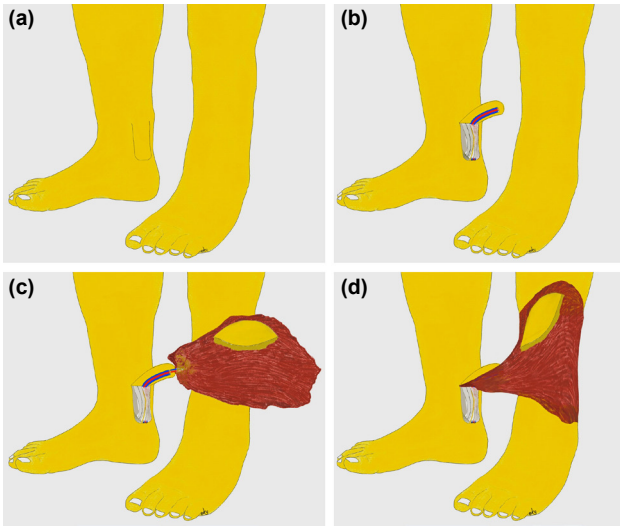

Figure 1. The posterior tibial artery (PTA) vascular bundle is found using hand Doppler, and a fascicutaneous (FC) flap containing the PTA vascular bundle is designed on the uninjured extremity. Since the fasciocutaneous flap contains the vascular bundle, it is thought that it would be more appropriate to elevate the flap at the rate of 1.5×1 or 2×1 instead of the random pattern flap in standardized 1×1 ratios **(a)**. While elevating the fasciocutaneous flap, care should be taken to keep the skin contact of the vascular bundle at the maximum level **(b)**. The free latissimus dorsi musculocutaneous flap (LD) is adapted to the defect in the contralateral limb with temporary sutures. Microvascular anastomoses are performed between PTA vascular bundle and thoracodorsal vascular bundle under microscopic magnification **(c)**. At the end of the microvascular anastomoses, the flaps are adapted each other with absorbable sutures. Thus, the vascular pedicle is covered by the FC flap at the top and LD flap at the bottom. The LD flap is adapted to the defect by placing permanent absorbable sutures **(d)**.

MATERIALS AND METHODS

Patients with moderate tibial region defects who did not have arterial nutrition or were fed with a single artery on traumatic lower extremity side and in whom posterior tibial artery (PTA) and concomitant veins were used with the fasciocutaneous flap above it for recipient vessels on the contralateral side were included in the study from 2010 to 2020 years. The study was approved by Kocaeli University Local Ethics Committee with project number 2022/111. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study. Age, sex, location and size of the defects, arterial patencies, flap choices, fasciocutaneous flap size, duration of operation, cross flap separation timing, complications, and time to return to work were evaluated.

Case Examples and Surgical Technique

Case 3

A 21-year-old male patient, who had no additional disease or history of drug use, was operated on for fractures of the right tibia and fibula after a motorcycle accident. A week later, when skin necrosis occurred in the cruris area, he was evaluated by our team. On physical examination, it was observed that there was necrosis extending from the proximal third to the distal third, anterior to the right cruris, and plate-screw exposure in the middle of the necrosis. PTA and anterior tibial artery (ATA) were weakly palpated in his vascular examination. Ankle movements were painful and motor strength assessment was ¼ points. Radiograms showed a single oblique fracture in the middle third of the tibia and a plate and its screws were observed. Radical debridement was planned and applied. Subsequently, the assessment was that there were no viable tissues of any compartment, except the posterior compartment. The area around the plate was intensively debrided. Hyperbaric oxygen therapy (HBOT) was started after being followed up with conventional dressing. Diagnostic computerized tomography (CT) angiography was performed and total occlusion in a segment of the popliteal artery and recanalization in the distal part was observed, and the ATA was not patent distally. Teicoplanin 1×400 mg, ciprofloxacin 2×400 mg, and ceftazidime 3×2 g as antibiotics and enoxeparin sodium 2×0.4 ml and iloprost 0.5 mcg/kg/min treatment were started as medication.

Reconstruction was planned as promptly as possible due to the risk of deterioration of bone viability. Free latissimus dorsi (LD) muscle skin flap was harvested, choosing recipient vessels of the PTA and concomitant vein in the opposite leg, due to the absence of vessels in the injured extremity. Harvesting with the adjacent skin over the PTA and concomitant vein was performed with flap dimensions of 3×5 cm. After the thoracodorsal artery and vein were anastomosed to the PTA and concomitant vein, one side of the pedicle was covered by the left cruris fasciocutaneous flap and the other side was covered by the LD flap. An external fixator (EF) was used to fix and approach the bilateral tibias, and the LD flap was adapted to the defect (Fig. 2). The donor area for the fasciocutaneous flap, removed from the left cruris, and the top of the flap were repaired with split thickness skin graft (STSG).

Three weeks later, the flap was separated after staged pedicle clamping was performed and flap viability was tested. The EF was removed and the PTA was sacrificed. The fasciocutaneous flap was turned in to its original position after removing the graft of its donor site. Rehabilitation was followed with a short leg splint to prevent foot drop deformity. The patient, who had completely lost his anterior and lateral compartment muscles and had findings of foot drop, could walk without support at the 30th month after the operation (Fig. 3). Although the orthopedic surgery department recommended arthrodesis for foot drop, the patient has not yet accepted this.

Case 6

A 39-year-old patient was evaluated with extensive necroses on his left cruris caused by a high voltage electrical burn. There was no history of comorbidity or drug use. The

Figure 2. After tibia fracture, the presence of a necrotic area and an exposed plate on the anterior aspect of the tibial bone due to thrombus of the popliteal artery is seen. **(a)** The defective area is exposed after complete debridement of the anterior and lateral compartment group muscles. **(b)** Application of latissimus dorsi myocutaneous free flap as a cross leg flap, after harvesting a 3×5 cm fasciocutaneous flap above the posterior tibial artery **(c, d)**.

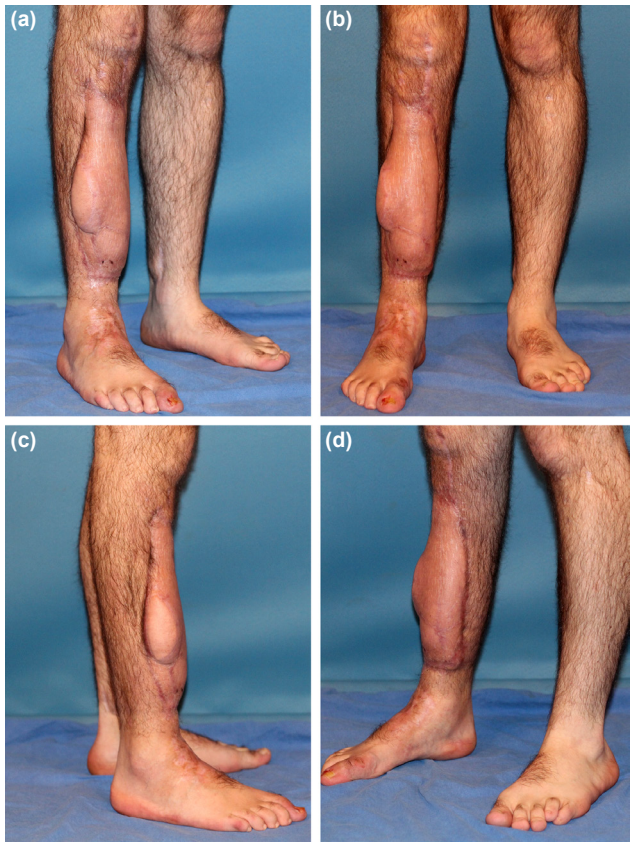

Figure 3. (a-d) Views of the patient from different angles 30 months postoperatively.

necrosed area extended from the middle third of the anterolateral aspect of the tibia to the dorsum of the foot. Although it was reported that there was a weak flow in the ATA and PTA on CT angiography preoperatively, no flow was observed in the ATA during the surgical procedure perioperatively. Due to the absence of healthy recipient vessels for anastomoses on the burned side of the lower extremity, it was decided to perform a cross leg free flap, selecting the PTA and concomitant veins for recipient vessels.

Similar to the first case, radical debridement was completed and vacuum assisted closure (VAC) therapy and HBOT was applied during a few sessions and in one of these sessions, the areas which were suitable for skin grafting were covered by STSG. It was thought that the risk of tension of the LD muscle skin flap was not greater than in Case 3, due to both distal and anterolateral replacement of the defective area. The anastomoses were completed by harvesting a fasciocutaneous flap on the PTA with a width of 3.5 cm and length of 4 cm. Postoperatively, the patient was followed up in a similar way to Case 3 after EF application. During the follow-up, marginal necrosis occurred in the distal and posterior parts of the flap and this was followed up until radical debridement was performed on the 10th day after the free flap procedure. There was no osseous exposure after debridement and wound management was performed with VAC therapy and skin grafts. The pedicle was separated during the postoperative 4th week and the defects were repaired with STSG.

Antibiotic therapy was applied because wound culture results showed that *Enterococus fecalis* was present. Finally, debridement and local flap repair was performed. The patient, who had completely lost anterior and lateral compartment muscles of the wounded lower extremity and had findings of foot drop, could walk without support at 1 year after the operation. The situation 1 year after the first operation and 1 month after the last operation is shown in Figures 4–5.

Case 3 was followed up for 3 years and Case 6 was followed up for 18 months. In the early period, they were followed up with classical 90-degree angle splints and ankle foot orthosis. Then, rehabilitation and movement exercise procedures were performed. No finding suggestive of osteomyleitis was found in either patient. In Case 6, antibiotic treatment was given due to soft tissue infection. Arthrodesis was recommended for both patients with the diagnosis of foot drop. Scar tissue on the intact recipient vascular structures was acceptable (Fig. 6) The patients had foot drop and irregularities on the wounded lower extremity. Neither patient had complaints about the contralateral lower extremity.

Figure 4. After a high-energy electrical burn, the presence of a large necrotic area extending from the distal third anterolateral aspect of the tibia to the dorsal foot and exposed osteotendinous structures are seen. **(a)** After debridement, it was evident that the lateral compartment group muscles were totally necrosed and anterior group muscles were partially necrosed. **(b)** After debridement, VAC, and HBOT, the granulated areas on foot were skin grafted. **(c)** After harvesting a fasciocutaneous flap of 3.5×4 cm above the PTA, the latissimus dorsi myocutaneous flap was applied as a cross leg free flap **(d)**.

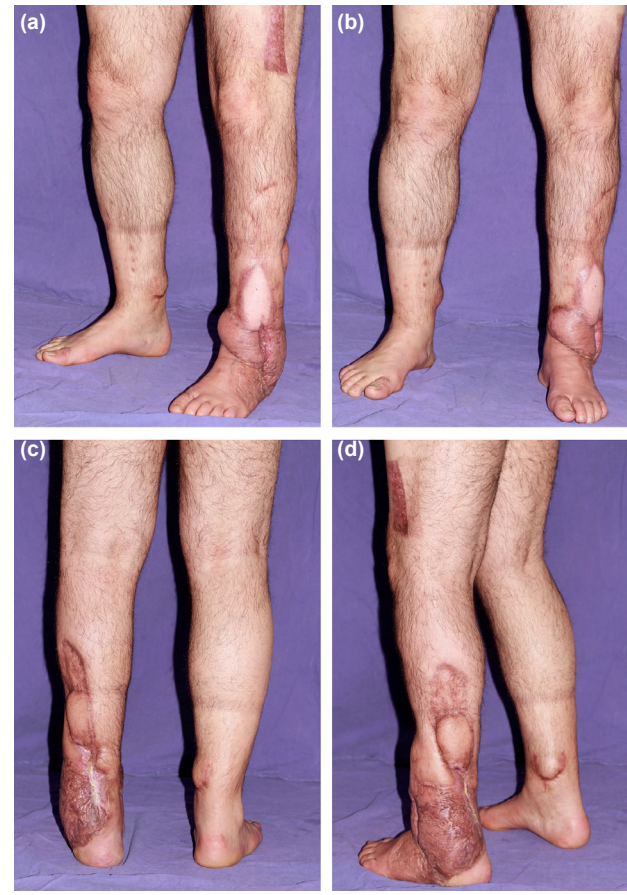

Figure 5. (a-d) Views of the patient from different angles 12-month postoperatively.

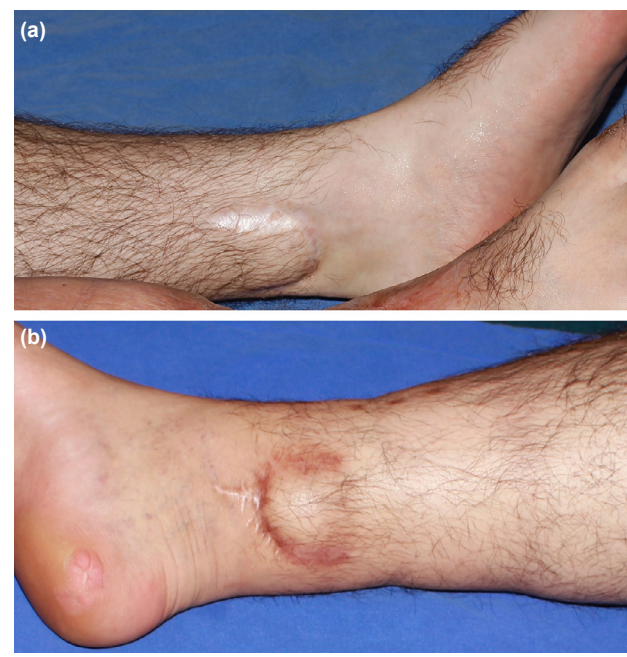

Figure 6. Late period images of the two cases are shown following replacement of fasciocutaneous flaps in the lower extremity of the uninjured side (Case 3 **(a)** and Case 6 **(b)**).

RESULTS

The mean age of the patients was 27.5 years. Four patients were injured by high-energy electrical burns and two patients had crush injuries. There was no arterial circulation in three of the traumatized extremities of the patients, ATA was patent in one and PTA was patent in two of them. One of these two patients with PTA patency had monophasic flow and insufficient blood pressure (Table 1).

The mean size of the defective areas was 6.6×14.8 cm. LD flap was used in five patients, Anterolateral thigh flap-vastus lateralis (ALT-VL) flap was used in one patient. The mean operation time was 360 min. The mean time for flap separation was 23.8 days. In one of the patients, there was a slight discharge and dehiscence. The local wound care was controlled this situation. In another patient, marginal tissue loss and infection developed. It was controlled with debridement surgeries, local wound care, and systemic antibiotic therapy. Dropped foot and ankle motion problems were observed in patients with muscle damage in the anterior and lateral compartment muscles. The arthrodesis treatment for ankle was applied to two patients by orthopedic surgeons. The mean time to return to work of the patients was 9 months. None of the patients complained of fasciocutaneous flap scar in the donor area. No other complaints such as cold intolerance and pain were observed in the foot due to sacrificing PTA in the donor area.

Table 1. The characteristics of the patients who have been treated with cross- leg free flap

Number	Age/Sex	Aetiology	Defect area	Defect size (cm)	Patency of ATA/PTA	Flap choise	FC flap size (cm)	Operation Duration (minutes)	Flap seperation timing (weeks)	Complication	Return to work (months)
1	16/M	Crush	2/3 distal tibia, anteromedial	5x17	+/–	LD	3x5	350	22	Dehiscence	9
2	30/M	High voltage electric burn	1/3 distal tibia, anteromedial	7x12	–/–	ALT + VL	3.5x5	320	24	–	8
3	21/M	Crush	3/4 distal tibia, anterior	6x21	–/–	LD	3x5	410	21	–	10
4	34/M	High voltage electric burn	1/3 distal tibia anterolateral	5x14	–/–	LD	3.5x6	340	24	–	9
5	25/M	High voltage electric burn	2/3 distal tibia anterior	6x12	–/+	LD	3x5	360	25	–	9
6	39/M	High voltage electric burn	1/3 distal tibia, lateral semisircular	11x13	–/–+	LM	3.5x4	380	27	Marginal necrosis infection	9

LD: Latissimus dorsi muscle; ALT+ VM: Anterolateral tigh flap + Vastus lateralis muscle flap; ATA: Anterior tibial artery; PTA: Posterior tibial artery; M: Male.

DISCUSSION

In traumatic lower extremity injuries, if there is extensive devitalized tissue and vascular damage, patients are candidates for amputation, but scoring systems designed for amputation indication fail to make the right decisions.[6–8] It is reported that there is no difference in the results of amputation and reconstruction in severely damaged lower extremities.[2] The reconstruction option has advantages due to avoidance of phantom pain, loss of workforce, psychiatric problems, and decreased care costs after amputation.[4,9] Large defects that cannot be repaired with local flaps can be repaired with free flaps. However, it is a clinical challenge to identify recipient vascular structures in the lower extremities, which are fed by only one artery. For this reason, vein grafts, arteriovenous loops, cross leg flaps, cross leg free flaps, and cross leg bridge flaps are used.[5] It is also possible to use a reverse-flow, pedicled, and ALT flap in proximal defects in selected cases.[10]

Healthier vascular structures can be advanced with vein grafts closer to the defect from intact vascular structures in the proximal part of the ipsilateral lower limb. However, as the length of this structure increases, the probability of risk of failure also increases.[11] Arteriovenous loops are a method that reduces this failure rate and can give successful results in such extremities with high-flow vascular network transfer adjacent to the defect.[11–13]

Fasciocutaneous flaps supplied by posterior tibial artery perforators and gastrocnemius muscle flaps can be used in proximal defects for cross leg flaps and the reverse-flow sural flap can also be used in distal defects.[5,14,15] However, these flaps are generally insufficient in large defects and defects extending from the proximal to the lateral. The cross-leg free flap may be preferred for reconstruction in large defects. The most commonly used flaps are the LD with or without serratus anterior muscle flap, the vertical rectus abdominis flap (VRAM), and the ALT±VL flap.[5,16] During the transfer of these flaps, the extremities are brought closer to each other with the help of an EF, leaving a sufficient gap to prevent irritation from constant skin contact. Due to the anatomical proximity at the medial malleolar region, the PTA and concomitant veins are superior choices for use as recipient vascular structures.

To prevent the risk of failure when the flap size is not sufficient for defect closure larger than 500 cm^2, it is recommended to use a free flap that can be a bridge flap.[5,17] While the bridge flap allows the main flap to reach the defect margin more easily, it both protects the pedicle and is used to close the rest of the defective areas that the main flap cannot cover, after separating the cross leg flaps at about 4 weeks. One disadvantage of the bridge flap is that it causes an extra free flap session. Its advantage is that it allows not only the PTA but also other arteries to be used as recipient vessels when necessary.

If the pedicle of the flap is not covered with soft tissue, it may cause drying or infection. To avoid this, chimeric flaps such as LD±SA and ALT±VL can be used. An advantage of the length of fasciocutaneous flaps based on the perforators of the PTA is that the application of the fasciocutaneous flap can proceed to greater distances without tension. It is thought that this PTA perforator-based fasciocutaneous flap wraps the pedicle superiorly and the upper part of the LD muscle flap wraps the pedicle from the inferior, so that the pedicle is fully protected. A one to one ratio is chosen for random flap elevation in the lower extremity, but the dimensions may increase according to the perforator concept.[18] Due to the profusion of PTA perforators in this area, flap removal with two to one dimensions does not pose any risk. In addition, after cross-free flap separation, this fasciocutaneous flap is also returned to its original place, providing a good donor area aesthetic appearance. It is also thought that this fasciocutaneous flap can be moved to the defective side while the cross leg free flap is being separated, especially when needed in large defects of up to 500 cm^2 in size and when the vitality of this flap is confirmed.

Sacrificing the PTA at the flap separation stage is a disadvantage for the contralateral extremity. To overcome this disadvantage, if the length of the pedicle is suitable for clamping, the pedicle can be divided at the most distal branching point inside the flap. Thus, the original artery can be reanastomized to its original distal part and the morbidity of the contralateral extremity can be reduced. Although not preferred, interpositional vein grafting is another method that can reduce morbidity.

The limitation of this study is the number of cases and that they are presented retrospectively. The success rates of this technique would be better investigated with a greater number of cases.

Conclusion

The PTA is the optimal and most commonly used recipient vascular structure for cross-leg free flaps due to its anatomical position. Before performing the free flap transfer, the fasciocutaneous flap, which is harvested based on PTA perforator arteries, can protect the superior side of the pedicle from risks such as infection and drying. Simultaneously, the lengthening of the pedicle makes it easier to reach and cover more distant defects contralaterally. The use of this flap may reduce the difficulty of reconstruction, especially in defects of medium width that may require consideration of the bridge free flap option.

Ethics Committee Approval: This study was approved by the Kocaeli University Non-interventional Clinical Research Ethics Committee (Date: 21.04.2022, Decision No: KÜ GOKAEK-2022/08.04).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: E.K.Y.; Design: E.K.Y.; Supervision: M.Ş.A.; Materials: İ.T.; Data: E.K.Y., İ.T.; Analysis: M.Ş.A., C.İ.D.; Literature search: C.İ.D.; Writing: E.K.Y., İ.T.; Critical revision: M.Ş.A., C.İ.D.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Çapraz bacak serbest flebin alıcı pedikülünün yaklaştırılmasına yönelik bir fikir: Pedikül üstü fasyokütan flep

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AMAÇ: Çapraz bacak serbest flepleri, büyük doku defektlerinde alıcı damar yokluğunda, serbest doku transferi için kullanılan ekstremite kurtarma yöntemlerinden birisidir. Posterior tibial arterin üzerindeki fasyokütan flep, pedikülü korumak ve fasiyokütan flep uzunluğuna eşit bir mesafede yaraya yaklaşabilmek için kullanılabilir.

GEREÇ VE YÖNTEM: Çalışmaya 2010–2020 yılları arasında çapraz bacak serbest flebi ile yaralanmamış taraftan fasiyokütan flep kullanılarak ameliyat edilen hastalar alındı. Yaş, cinsiyet, defektlerin yeri ve boyutu, arteriyel açıklıklar, flep seçenekleri, fasyokütan flep boyutu, ameliyat süresi, flep ayırma zamanlaması, komplikasyonlar ve işe dönüş süresi değerlendirildi.

BULGULAR: Yüksek enerjili elektrik yanığı ve travma etiyolojisi olan altı hasta vardı. Üç hastada sadece bir arterde dolum varken, diğerlerine hiç dolum yoktu. Latissimus dorsi cilt kas flebi, bir hasta dışında tüm hastalarda kullanıldı. Ortalama defekt boyutu 6.6x14.8 cm idi. Fasiyokütan fleplerin ortalama boyutu 4.08x5 cm idi. Ortalama operasyon süresi 360 dakikaydı. Yara bakımı ile iyileşen bir açılma ve bir marjinal nekroz ve enfeksiyon dışında komplikasyon görülmedi. Ortalama işe dönüş süresi dokuz aydı.

TARTIŞMA: Bir arter dolumu olan veya dolumu hiç olmayan alt ekstremiteli benzer olgularda orta büyüklükteki defektler varsa, köprü flep seçeneği adımından hemen öncesinde, alıcı damarlar üzerindeki fasyokütan flebin kullanılması iyi bir seçenektir.

Anahtar sözcükler: Çapraz bacak; ekstremite kurtarma; rekonstrüksiyon; serbest flep.

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