ORIGINAL ARTICLE

Reconstruction option in complex lower extremity defects where microsurgical repair is not possible: Randomized bipedicled flaps

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ABSTRACT

BACKGROUND: Lower extremity defects may occur due to many etiological causes such as trauma, peripheral arterial disease, diabetic foot infections, tumor resection, gunshot injuries, and burns. Lower extremity defects show a wide clinical presentation according to the affected anatomical localization, amount of tissue, and tissue content. In this study, it is aimed to present the use of bipedicled flaps as a simple and reliable salvage method in cases where microsurgical repairs such as free flaps are not possible.

METHODS: Patients with soft-tissue defect in their lower extremities between March 2018 and September 2021 were scanned retrospectively over the file. Among these patients, patients who were repaired with a bipedicle flap were included in the study. The patients were followed up regularly for at least 12 months. During the follow-ups, the patients were photographed, a physical examination was performed in terms of flap viability, wound dehiscence, and soft-tissue infection, and the data were recorded.

RESULTS: In this study, 23 patients with a defect in the lower extremity who were repaired with randomized bipedicled flap were retrospectively analyzed. In four patients, the location of the defect was located in the middle 1/3 of the leg, while in 19 patients, it was located in the distal 1/3 of the leg. The flap design was done vertically in 22 patients, and the flap design was done transversely in one patient. One bipedicled flap was used for defect repair in 14 patients, and two bipedicled flaps were used for defect repair in nine patients. While skin grafts were used for donor site repairs in 16 patients, the donor site was primarily repaired in seven patients. In the post-operative period, local soft-tissue infection was detected in five patients and dehiscence at the wound site in three patients, and uneventful healing was achieved with antibiotic therapy, resuturation, and appropriate wound care. No major complications such as flap or graft loss were experienced in any of the patients.

CONCLUSION: Randomized bipediculated flaps are a very reliable option for the reconstruction of middle and distal lower extremity defects. We think that it is a reconstruction option that can be safely applied in small and medium-sized defects of the lower extremity, since it can be used even in patients with comorbidities such as diabetes mellitus and peripheral arterial disease that adversely affect wound healing.

Keywords: Bipedicled; flap; lower extremity; nonmicrosurgical.

INTRODUCTION

Lower extremity defects may occur due to many etiological causes such as trauma, peripheral arterial disease, diabetic foot infections, tumor resection, gunshot injuries, and burns. Lower extremity defects show a wide clinical presentation according to the affected anatomical localization, amount of tissue, and tissue content.[1,2]

Defects of the lower extremities are clinical problems that can easily cause mobilization problems, regardless of whether they are simple or complex. These mobilization problems sig-

Cite this article as: Uyar İ, Aksam E, Yit K. Reconstruction option in complex lower extremity defects where microsurgical repair is not possible: Randomized bipedicled flaps. Ulus Travma Acil Cerrahi Derg 2023;29:877-882.

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Ulus Travma Acil Cerrahi Derg 2023;29(8):877-882 DOI: 10.14744/tjtes.2023.96633 Submitted: 12.10.2022 Revised: 12.10.2022 Accepted: 07.04.2023

nificantly affect the psychosocial and medical well-being of the patients. It is not always easy for plastic surgeons to break this cascade that develops so rapidly and reduces the quality of life.[3]

Many choices have been defined in the reconstruction ladder, from secondary healing to free tissue transplantation in the repair of lower extremity defects.[4] Recent advances in microsurgical techniques and a better understanding of the microvascular anatomy of the lower extremity have allowed us to customize flaps on a patient basis and achieve lower donor site morbidity. Free flaps are very important especially in the repair of distal lower extremity defects. However, factors such as the etiology of the aforementioned defects and the patient's existing comorbidities can significantly reduce free flap survival rates.[5]

In this study, it is aimed to present the use of bipedicled flaps as a simple and reliable salvage method in cases where microsurgical repairs such as free flaps are not possible.

MATERIALS AND METHODS

The study was planned retrospectively. The approval of the ethics committee and also informed consent forms was obtained before surgery from the patients or their legal representative if necessary. (Ethics Committe Decision Date – Number: September 22, 2022 – 0401) Patients with soft-tissue defect in their lower extremities between March 2018 and September 2021 were scanned retrospectively over the file. Demographic data (age and gender), details of the injuries (etiology, affected anatomical area, and defect size), and preferred flaps were examined using the hospital's patient data system and archives. Among these patients, patients who were repaired with a bipedicle flap were included in the study. Patients who had defect repaired by microsurgical methods had osteomyelitis, did not comply with the post-operative recommendations, and did not attend the controls regularly were excluded from the study. The patients were followed up regularly for at least 12 months. During the follow-ups, the patients were photographed, a physical examination was performed in terms of flap viability, wound dehiscence, and soft-tissue infection, and the data were recorded.

Surgical Technique

Serial debridement and appropriate wound care were applied first to the patients who presented with a defect in the lower extremity, depending on the condition of the wound site. When the defective area became suitable for reconstruction, one or two bipediculated flaps were designed in the vertical or transverse plane parallel to the defect (Fig. 1).

The flap sizes were designed to be larger than the existing defects to close the defect more easily and to make advancement more effective. Incisions were made extending to the muscle fascia, flaps were separated from the muscle fascia using a combination of sharp and blunt dissection. Care was taken to protect the perforators feeding the skin at both ends. The prepared randomized bipedicled flaps were then advanced over the wound under minimal tension. Then, ap-

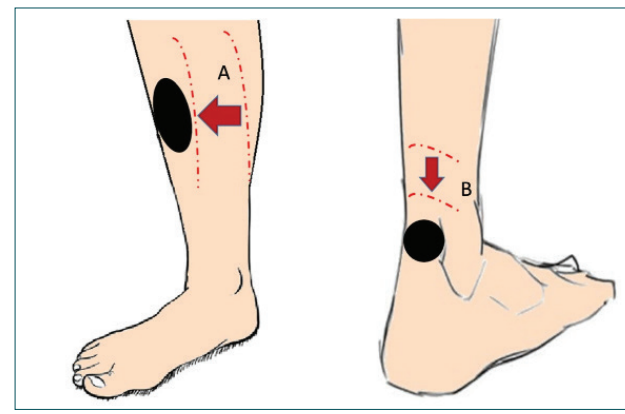

Figure 1. Schematization of defect design in patients. Flaps planned as vertical (a) and transverse (b) are advanced to the defects.

Figure 2. A wound on the distal 1/3 of the leg after another surgery. The defect was repaired with two bipediculated flaps prepared vertical plane, and the flap donor areas were repaired with split-thickness skin grafts. (a) Pre-operative view of the patient. (b) Early post-operative view of the patient. (c) Post-operative view of the patient at 12 months.

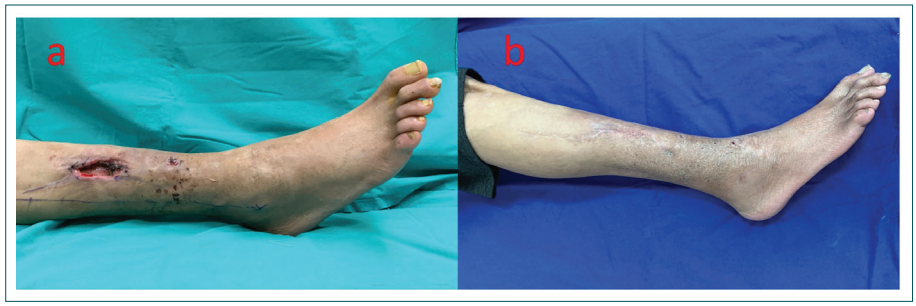

Figure 3. A wound on the middle 1/3 of the leg. The defect was repaired with a bipediculated flap prepared in the vertical plane. The donor area was primary repaired. (a) Pre-operative view of the patient. (b) Post-operative view of the patient at 14 months.

Figure 4. A wound on the distal 1/3 of the leg after trauma. The defect was repaired with a bipediculated flap prepared in the transverse plane. The donor area was primary repaired. (a) Pre-operative view of the patient. (b) Early post-operative view of the patient. (c) Post-operative view of the patient at 38 months.

propriate anatomical layer sutures were made. Care was taken not to overlap the sutures on the defect. Primary closure or skin grafts were applied to repair the donor areas. Appropriate wound care was performed in the post-operative period, and immobilization and elevation were applied until epithelialization was achieved in the skin flaps. When epithelialization was achieved, mobilization was recommended to the patients (Figures 2-4).

Statistical Analysis

IBM SPSS Statistics Version 20 (IBM, USA) was used for statistical analysis. The Shapiro–Wilk test was used for normality analysis. Chi-square test was used for binomial values, independent samples T-test was used for other values. Statistical significance was set as $P<0.05$.

RESULTS

Between March 2018 and September 2021, a total of 68 patients were followed up due to defects in the lower extremities. Twenty-three of these patients were included in the study. Sixteen of the patients were male and seven of them were female. The mean age of the patients was 50.9 years. The mean defect size was 7.6 cm^2. The mean operation time was 46.5 min. Seven patients were smoker. Diabetes mellitus (DM) was present in seven patients, peripheral vascular disease (PVD) in five patients, and DM+PVD in four patients. The etiology of the defect was trauma in six patients, iatrogenic in four patients (secondary to another surgery), diabetic infection in six patients, PVD in four patients, diabetic infection, and PVD in three patients. Defect localization was in the middle 1/3 of the leg in four patients, and in the distal 1/3 of the leg in 19 patients. The flap designed vertically in 22 patients, the flap designed transversely in one patient. One bipedicled flap was used for defect repair in 14 patients, and two bipedicled flaps were used for defect repair in nine patients. Skin grafts were used for donor site repairs in 16 patients; the donor site was primarily repaired in seven patients. The mean hospitalization time of the patients was 11.8 days. The mean follow-up period of the patients was 13.9 months. In the post-operative period, local soft-tissue infection was detected in five patients and dehiscence at the wound site in three patients, and uneventful healing was achieved with antibiotic therapy, resuturation, and appropriate wound care. There was no flap or graft loss in any of the patients (Table 1).

In the statistical analyzes performed, no statistically significant difference was found in patients in terms of gender, etiology, comorbidity, defect localization and defect size, and complication formation. No statistically significant difference was found in terms of complications in patients over 60 years of age and those under 60 years of age. The number of flaps used did not have a statistically significant effect on the development of complications. When smokers and non-smokers were examined, no statistically significant difference was found in terms of complications (Table 2).

Table 1. Demographic data of the patients

Patient	Gender/ Age	Etiology	Comorbidity	Location	Defect size (cm)	Smoking	Flap design	Complication	Number of the flap	Donor area repair	Surgery time	Follow-up (month)
1	M/45	Trauma	None	Middle 1/3	4*2	+	Vertical	None	1	Primary	40	13
2	M/59	Iatrogenic	DM+PVD	Distal 1/3	3*2	-	Vertical	Dehiscence	1	Greft	45	14
3	M/16	Trauma	None	Distal 1/3	4*2	+	Transvers	Infection	1	Primary	35	38
4	F/62	Iatrogenic	DM	Distal 1/3	4*4	-	Vertical	None	2	Greft	55	15
5	M/63	DM	DM	Middle 1/3	5*3	-	Vertical	None	2	Greft	65	13
6	M/63	DM+PVD	DM+PVD	Distal 1/3	2*2	-	Vertical	None	1	Primary	35	14
7	M/50	Iatrogenic	PVD	Distal 1/3	3*3	-	Vertical	Infection	2	Greft	60	12
8	M/49	PVD	PVD	Distal 1/3	3*1	-	Vertical	None	1	Primary	35	15
9	M/52	Trauma	None	Distal 1/3	4*3	+	Vertical	None	2	Greft	55	18
10	F/44	DM	DM	Distal 1/3	3*3	-	Vertical	Dehiscence	2	Greft	60	14
11	M/50	DM+PVD	DM+PVD	Middle 1/3	5*1	-	Vertical	None	1	Primary	35	12
12	M/55	DM	DM	Distal 1/3	3*2	-	Vertical	None	1	Greft	35	12
13	F/53	PVD	PVD	Distal 1/3	2*2	-	Vertical	None	1	Greft	40	16
14	M/48	DM	DM	Distal 1/3	4*3	-	Vertical	None	2	Greft	70	14
15	M/56	Trauma	None	Distal 1/3	4*3	+	Vertical	Infection	2	Greft	60	18
16	F/61	PVD	PVD	Distal 1/3	3*2	-	Vertical	None	1	Greft	40	12
17	F/49	DM	DM	Distal 1/3	2*2	+	Vertical	Infection	1	Greft	30	12
18	M/42	Trauma	None	Middle 1/3	4*3	-	Vertical	None	2	Greft	70	15
19	M/64	DM+PVD	DM+PVD	Distal 1/3	2*2	-	Vertical	Dehiscence	1	Greft	35	14
20	M/50	Trauma	None	Distal 1/3	3*1	-	Vertical	None	1	Primary	35	13
21	F/47	Iatrogenic	None	Distal 1/3	3*3	+	Vertical	None	2	Greft	60	15
22	M/40	PVD	PVD	Distal 1/3	2*2	-	Vertical	None	1	Primary	35	12
23	F/54	DM	DM	Distal 1/3	3*2	+	Vertical	Infection	1	Greft	40	15

F: Female; M: Male; DM: Diabetes mellitus; PVD: Peripheral vascular disease.

Table 2. Statistical analysis results in patients

	Age	Gender	Etiology	Comorbidity	Location	Defect size	Number of the flaps	Smoking
Complication	0.602	0.657	0.277	0.734	0.257	0.465	0.633	0.182

DISCUSSION

Reconstruction of lower extremity defects; it may vary according to the etiology of the defect, the existing comorbidity of the patient, the size of the defect, and the injured area. Different techniques such as primary repair, secondary healing, grafts, local flaps, regional flaps, and free tissue transplantation can be used in the reconstruction of these defects, and sometimes these techniques can be used in combination. While small-sized defects with minimal tissue loss can be reconstructed in a short time and easily; but reconstruction of defects that involving important structures such as bones, muscles, vessels, and nerves may not always be easily possible, even if the defect is small.[1,6]

Local flaps can be used depending on the localization of the defect. Gastrocnemius flap in proximal 1/3 defects, soleus flap in middle 1/3 defects, pedicle perforator flaps, and sural flap in distal 1/3 defects are the most preferred flaps. Although local flaps can be easily used in the repair of lower extremity defects, they may be insufficient in repairing middle and distal defects.[7,8]

Reconstruction of lower extremity defects with free flaps can produce excellent results that are quite satisfactory. Today, many free flaps such as latissimus dorsi flap, anterolateral thigh flap, superficial circumflex iliac artery perforator flap, and gracilis flap are used in the repair of lower extremity defects. These microsurgical free flap operations may be associated with different donor site morbidity depending on the type of tissue transferred. In addition, the need for appropriate recipient vessels, intensive pre-operative preparation, critical follow-up in the post-operative period, an experienced microsurgery team, appropriate equipment, and operating room resources are required. In addition, anastomosis problems that may occur in the post-operative period may require secondary operations.[9-13]

Bipedicled flaps were first described by Crawford in 1957.[14] Bipediculated flaps have a double circulation due to proximal-distal or medial-lateral pedicle entry.[15] This circulation pattern provides safe flap viability. It facilitates defect reconstruction in cases where there is no suitable recipient vessel for free tissue transplantation, in patients with comorbidities such as DM and peripheral arterial disease, and in patients where surgery needs to be completed quickly. Being easily applicable under spinal, regional, or local anesthesia due to its short mean operation time, it facilitates its use in patients with comorbidities and high ASA scores and reduces the risks of anesthesia-related complications.[13]

The learning curve is very short, intensive critical follow-up is not necessary. As in microsurgery operations, there is no need for a highly experienced team, it does not require the use of special tools, and its post-operative medication is not intensive. Although there are studies in the literature in which it is easily designed in the vertical plane in accordance with the lower extremity circulation pattern,[2,16] as we have shown in our study, adequate flap circulation and survival can be achieved with the transverse design. Another important advantage is that it can be easily used as a salvage method in unsuccessful lower extremity reconstructions.

Reconstructing the defect with similar tissue, easy flap design, easy surgical technique, not requiring special equipment, short operation time, not long hospitalization time, high flap viability, and low complication rate are the main advantages of bipedicled flaps. The only limiting factor in the use of bipedicled flaps is that there should be no widespread tissue loss around the defect.[2,6]

In this study, 23 patients with a defect in the lower extremity who were repaired with randomized bipedicled flap were retrospectively analyzed. In four patients, the location of the defect was located in the middle 1/3 of the leg, while in 19 patients it was located in the distal 1/3 of the leg. The flap design was done vertically in 22 patients, and the flap design was done transversely in one patient. One bipedicled flap was used for defect repair in 14 patients, and two bipedicled flaps were used for defect repair in nine patients. While skin grafts were used for donor site repairs in 16 patients, the donor site was primarily repaired in seven patients. In the post-operative period, local soft-tissue infection was detected in five patients and dehiscence at the wound site in three patients, and uneventful healing was achieved with antibiotic therapy, resuturation, and appropriate wound care. No major complications such as flap or graft loss were experienced in any of the patients.

CONCLUSION

Randomized bipediculated flaps are a very reliable option for the reconstruction of middle and distal lower extremity defects. We think that it is a reconstruction option that can be safely applied in small and medium-sized defects of the lower extremity since it can be used even in patients with comorbidities such as DM and peripheral arterial disease that adversely affect wound healing.

Ethics Committee Approval: This study was approved by the Izmir Katip Celebi University, Reconstructive and Aesthetic Surgery Ethics Committee (Date: 22.09.2022, Decision No: 0401).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: İ.U.; Design: İ.U.; Materials: İ.U.; Data collection and/or processing: İ.U.; Analysis and/or interpretation: E.A.; Literature search: K.Y.; Writing: K.Y.; Critical reviews: E.A.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Mikrocerrahi onarımın mümkün olmadığı kompleks alt ekstremite defektlerinde rekonstrüksiyon seçeneği: Randomize bipediküllü flepler

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AMAÇ: Alt ekstremite defektleri travma, periferik arter hastalığı, diyabetik ayak enfeksiyonları, tümör rezeksiyonu, ateşli silah yaralanmaları ve yanıklar gibi birçok etiyolojik nedene bağlı olarak ortaya çıkabilir. Alt ekstremite defektleri, etkilenen anatomik lokalizasyona, doku miktarına ve doku içeriğine göre geniş bir klinik görünüm gösterir. Bu çalışmada, serbest flep gibi mikrocerrahi onarımların mümkün olmadığı durumlarda basit ve güvenilir bir kurtarma yöntemi olarak bipediküllü fleplerin kullanımının sunulması amaçlandı.

GEREÇ VE YÖNTEM: Mart 2018-Eylül 2021 tarihleri arasında alt ekstremitelerinde yumuşak doku defekti olan hastalar dosya üzerinden geriye dönük olarak tarandı. Bu hastalardan bipediküllü flep ile rekonstrüksiyon yapılan hastalar çalışmaya alındı. Hastalar en az 12 ay düzenli olarak takip edildi. Takiplerde hastaların fotoğrafları çekildi, flep viabilitesi, dehisens, yumuşak doku enfeksiyonu açısından fizik muayene yapıldı ve veriler kayıt altına alındı.

BULGULAR: Alt ekstremitede defekt saptanan ve randomize bipediküllü flep ile onarım yapılan 23 hasta geriye dönük olarak incelendi. Defekt yeri 4 hastada bacağın orta 1/3'ünde, 19 hastada ise bacağın 1/3 distalindeydi. Flep tasarımı 22 hastada vertikal, 1 hastada transvers olarak yapıldı. Defekt onarımı için 14 hastada 1 adet, 9 hastada 2 adet bipediküllü flep kullanıldı. Hastaların 16'sında donör alan onarımı için cilt greftleri kullanılırken, 7'sinde donör alan primer olarak onarıldı. Postoperatif dönemde 5 hastada lokal yumuşak doku enfeksiyonu, 3 hastada yara yerinde ayrılma tespit edildi ve antibiyotik tedavisi, re-sütürasyon ve uygun yara bakımı ile sorunsuz iyileşme sağlandı. Hiçbir hastada flep veya greft kaybı gibi majör komplikasyon yaşanmadı.

SONUÇ: Sonuç olarak, orta ve distal alt ekstremite defektlerinin rekonstrüksiyonunda randomize bipediküllü flepler güvenilir bir seçenektir. Diyabetes mellitus ve periferik arter hastalığı gibi yara iyileşmesini olumsuz etkileyen komorbiditeleri olan hastalarda bile kullanılabilmesi nedeniyle alt ekstremitenin küçük ve orta büyüklükteki defektlerinde güvenle uygulanabilecek bir rekonstrüksiyon seçeneği olduğunu düşünüyoruz.

Anahtar sözcükler: Alt ekstremite; bipediküllü; flep; mikrocerrahi olmayan.

Ulus Travma Acil Cerrahi Derg 2023;29(8):877-882 DOI: 10.14744/tjtes.2023.96633