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ORIGINAL ARTICLE

Cross-leg flaps: A nonmicrosurgical alternative treatment method in complex lower extremity trauma reconstruction

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ABSTRACT

Objectives: This study aimed to present our experiences with cross-leg flap surgery, which demonstrates successful outcomes in lower limb soft tissue defects without the necessity of microsurgical intervention.

Patients and methods: The retrospective study included 26 patients (18 males, 8 females; mean age: 35.6±12.2 years; range, 18 to 65 years) between January 2015 and September 2019. A fasciocutaneous cross-leg flap was applied to the recipient extremity, and the extremities were immobilized by a tubular external fixator. Flap divisions were performed on the 21st postoperative day. At least two years of clinical outcomes were presented.

Results: Twenty-five flaps survived and recovered completely without any complication at the donor site, flaps, or the recipient area. In one diabetic patient, partial flap loss was encountered, which granulated with secondary healing. All patients demonstrated stable wound coverage, with none demanding additional soft tissue surgeries. All patients resumed normal ambulation and physical activity without any residual joint stiffness.

Conclusion: Cross-leg flap method is an effective and respectable option for extremity salvage as a good alternative to free flaps for the management of traumatic complex lower limb defects. This method is simple, provides abundant blood supply to the wound, and does not require microsurgical experience or a good working recipient artery.

Keywords: Cross-leg flap, lower extremity defects, microsurgery, soft tissue defect, soft tissue reconstruction.

Traumatic injuries, burns, and circulatory disorders after previous surgery are frequently encountered in orthopedic practice and still constitute a challenging treatment area for many surgeons. Infection is still a severe problem, particularly for the healing of fractures and limb salvage. To avoid infection and regain motion in the early period, the traumatic absence of soft tissues should be treated appropriately (Figure 1). Currently, flap procedures used for the closure of skin and subcutaneous soft tissues in the lower extremities include regional flaps, local flaps, and free flaps applied via microsurgery.

The cross-leg flap was first depicted by Hamilton in 1854.[1] Since this date, cross-leg flaps have been utilized safely for years in the closure of lower extremity defects. Since the 1980s, with the advancement of microsurgical methods, free flap operations have begun to be performed more frequently in the closure of lower extremity defects.[2] However, free flap surgery requires not only a microscope and related surgical equipment but also microvascular technical experience, and moreover, it may not be applicable to every patient for various reasons. For these operations to be performed, the patient must not have comorbid diseases that pose a disadvantage to recovery, must be in good general health, and must not have circulatory failure. In this respect, cross-leg flap applications are a reliable option for patients who cannot undergo free flap surgery.

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Although recent advances in microsurgery have brought free tissue flap transfer procedures to the fore for large and complex wounds, the cross-leg flap continues to be effective in specific clinical scenarios, as it does not require microsurgical skills and can be selected on a patient-by-patient basis.

In our study, we aimed to present the clinical results of the patients we successfully treated with cross-leg flaps, which provide an effective solution in cases where free tissue transfer is not possible. This study also aimed to guide surgeons without microsurgery experience and training in effectively treating such soft tissue defects.

PATIENTS AND METHODS

Forty-six patients with lower extremity tissue defects surgically treated in the Muğla Training and Research Hospital Department of Orthopedics and Traumatology between January 2015 and September 2019 were retrospectively evaluated. The patients' age, sex, injury mechanism, injury regions, size of the defects, complications, and follow-up period (months) were compiled from our clinic's database. Patients who were surgically treated for lower extremity tissue defects using the cross-leg flaps and who had at least two years of follow-up were selected. Fracture fixations were performed at different times and did not display uniformity. A cross-leg flap was applied in the same session to patients whose soft tissues could not be closed during fracture fixation and in the next session to patients whose soft tissues could be closed but developed skin necrosis days later. The exclusion criteria were as follows: pediatric patients (n=2), bilateral soft tissue defects (n=1), age over 70 years (n=4), absent medical data and external facility follow-ups (n=9), and cases operated using other flap types (n=4), such as free flaps or localized flaps. After the excluded cases, 26 patients (18 males, 8 females; mean age: 35.6±12.2 years; range, 18 to 65 years) were qualified for the study, which also included 10 patients who received previous unsuccessful free flap surgery.

Surgical technique

General anesthesia was administered to all patients. The defect was delineated (Figure 1) and measured after wound debridement (Figure 2). The region of the donor extremity primarily counted on the appropriate positioning of the extremities and the range of the flap tissue. Since the defects in our patients were in the distal one-third of the tibia, ankle, or foot dorsum,



FIGURE 1. Primary nonclosable soft tissue defect in the medial ankle joint.

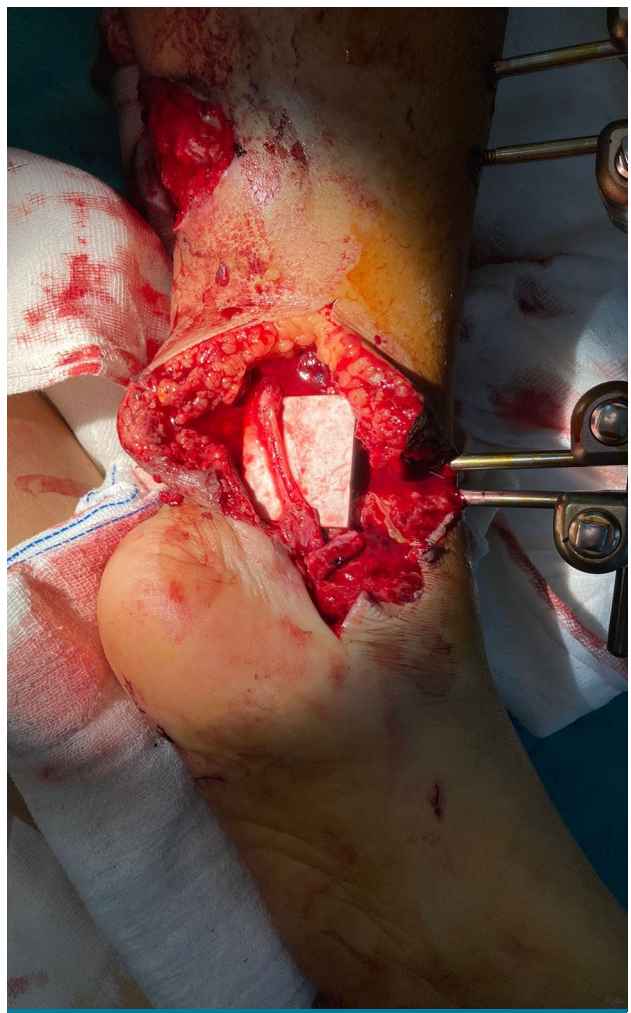


FIGURE 2. Wound debridement and external fixator application in the affected extremity.

we chose to use a distally based, posterior tibial artery perforator cross-leg flap. Near the base of the flap, perforators of the posterior tibial artery were found and retained. The base of the flap was generated broader than its length (Figure 3). Therefore, if the possible coverage of the defect could not be achieved completely, it was essential to cover tendons using the flap, while the remnant area could be conveniently covered up with a skin graft. The flap was raised in the subfascial plan.[3] The donor region was split skin grafted, and the flap inset was positioned after refreshing the margins of the defective area. The legs were stabilized with an external fixator or plaster in the appropriate position (Figure 4). External fixation was our preferred method to achieve a more stable construction and postoperative ease of care. The flap partition is attached to the connection with the other extremity, which was secured for three weeks to obtain revascularization. Flap division and donor site skin grafting were performed in all cases on the 21st postoperative day (Figure 5). For the donor site, a split-thickness skin graft was utilized, harvested from the anterior region of the thigh. The patients were assessed for appropriate wound coverage and functional outcomes.

Statistical analysis

Data were analyzed using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive and numerical data were displayed as mean ± standard deviation (SD), median (min-max), or frequency and percentage.

RESULTS

The causes of trauma were as follows: motor vehicle accidents (n=8), falls from height (n=12), and crush injuries (n=6). The right lower extremity of 18 patients and the left lower extremity of eight patients were affected. The defective regions were the foot dorsal region in six patients, foot plantar and dorsal region in two patients, ankle lateral region in five patients, ankle medial region in four patients, ankle anterior region in two patients, tibia distal one-third region in five patients, tibia one-third middle region in two patients. The mean follow-up duration was 28.7±3.2 months (range, 24 to 36 months). The mean hospital stay was 26±2.8 days (range, 23 to 34 days).

Among the 26 patients, eight underwent cross-leg flaps due to deficient pulsation of the recipient artery



FIGURE 3. The application of the cross-flap to the soft tissue defect of the affected extremity.



FIGURE 4. External fixator applied to fix both legs.



FIGURE 5. Flap division of the defective extremity on the 21st postoperative day.

observed on the affected extremity. Ten patients had unsuccessful attempts of free flap surgery. Seven were heavy smokers who refused to quit smoking in the preoperative term. One of the patients had uncontrolled diabetes.

All flaps except one diabetic patient fully survived without any complication at the donor site, flaps, or the recipient area (Figure 5). All cases demonstrated stable wound coverage, with none demanding additional soft tissue surgeries. Partial flap loss was detected in one patient who had diabetes, although this secondary defect was healed with granulation tissue by secondary healing.

TABLE I

Detailed information of the demographic data, injury regions, follow-up duration, and surgical outcomes of all patients

Patient no	Age/Sex	Region	Flap size (cm)	Hospital stay (Days)	Flap outcome	Follow-up period (months)
1	18/M	Foot dorsal	11×6	24	Complete survival	25
2	53/M	Tibia 1/3 middle	17×5	24	Partial flap necrosis healed with granulation tissue	33
3	34/M	Ankle lateral	12×6	25	Complete survival	30
4	30/M	Foot dorsal	10×5	34	Complete survival	27
5	19/M	Tibia 1/3 distal	18×14	27	Complete survival	27
6	32/F	Ankle medial	7×5	25	Complete survival	26
7	24/M	Ankle lateral	7×5	23	Complete survival	30
8	40/F	Ankle medial	8×5	25	Complete survival	34
9	35/M	Foot dorsal	6×4	25	Complete survival	25
10	45/F	Tibia 1/3 middle	18×6	30	Complete survival	29
11	30/F	Ankle medial	9×6	24	Complete survival	28
12	21/M	Foot dorsal	6×4	25	Complete survival	32
13	65/M	Tibia 1/3 distal	18×5	30	Complete survival	24
14	20/M	Tibia 1/3 distal	16×6	26	Complete survival	27
15	36/M	Ankle anterior	10×5	23	Complete survival	26
16	30/M	Ankle lateral	9×6	30	Complete survival	30
17	38/F	Ankle lateral	8×6	23	Complete survival	29
18	31/M	Ankle medial	9x4	26	Complete survival	30
19	59/M	Foot dorsal and plantar	20×12	28	Complete survival	28
20	33/F	Ankle anterior	8×6	28	Complete survival	27
21	36/M	Foot dorsal and plantar	22×16	28	Complete survival	25
22	52/M	Foot dorsal	11×5	23	Complete survival	36
23	25/M	Tibia 1/3 distal	21×11	27	Complete survival	28
24	45/M	Tibia 1/3 distal	19×15	25	Complete survival	28
25	30/M	Foot dorsal	8×6	25	Complete survival	28
26	44/M	Ankle lateral	8×6	23	Complete survival	35

Twenty-five patients began ambulating and weight-bearing six weeks after the surgery. Due to delayed secondary healing, one patient began weight-bearing three months after the surgery. Detailed information about all patients is presented in Table I.

DISCUSSION

The administration of complex traumatic soft tissue defects of the lower extremities still constitutes a challenge for orthopedic professionals. High-velocity traumas often involve fragmented tibial fractures, exposed tendons, and various vascular damage. The fundamentals of wound care include early and comprehensive debridement, fixation of the fractures, and effective soft tissue closing. The aesthetic condition of the extremity must also be acceptable to the patient. A total recovery without infection must be achieved to be able to effectively ambulate again. Therefore, the surgical treatment of soft tissue defects is critical, particularly to prevent infection, which may lead to fracture nonunion.

Microsurgical free tissue transfer is nowadays considered the gold standard in the administration of lower limb soft tissue defects in most trauma facilities.[2,4] With the increasing experience in microsurgery, free flap transfer is being more easily executed with an increased success rate.[5] However, free flap transfers have some limitations. First, this method requires significant microsurgery experience. The damage of two major vascular structures, intense peripheral vascular diseases, history of free flap surgeries, and unavailability of appropriate recipient vessels are the other limitations of free flap application. Smoking, electricity injuries, and the requirement for radiation also elevate the possibility of free flap failure.[3] In such cases, cross-leg flaps, which provide abundant blood supply to the defective area, are preferred over free flaps. The major reasons why we chose this method were that it did not require microsurgical experience, there was no adequately functioning vessel in the recipient area, diabetes, and peripheral vascular diseases. A sufficient recipient artery has a continuously leveled intima and red, pulsatile, and shiny flow.[6] The present study included four patients with intraoperative findings of insufficient blood flow through the recipient artery. Cross-leg flap is the appropriate alternative, which provides adequate blood supply as it does not confide in the recipient's vascular status. Another highlighted area of the cross-leg flaps is the closure of the failed free flaps. Secondary free flap application to previously failed free flap region involves many complications.[6-8] Considering all these, we preferred cross-leg flap in 10 patients who had unsuccessful free flap surgery. Furthermore, one patient with uncontrolled diabetes mellitus received a cross-leg flap since uncontrolled diabetes creates a predisposition to peripheral vascular diseases, although there are no strict contraindications.[8] Cross-leg flap surgery has also some disadvantages. The major disadvantages are the uncomfortable patient position and immobilization. Since there is a probability that patients do not want to remain immobile for three weeks, the procedure must be explained to the patient before surgery, and it is necessary to make sure that the patient understands the requirements of this procedure and gives their consent. Moreover, since the duration of the external fixation is up to three weeks, deep vein thrombosis and pulmonary embolism may be encountered, although these complications are mostly avoided by pharmacological thrombosis prophylaxis. The donor site is also in danger in terms of pin tract infection caused by external fixation, but again, it is generally avoided by antibiotic prophylaxis, and the infections encountered in the pin tracts are mostly superficial infections. In a study on the results of the treatment of 18 patients with lower limb defects with cross-leg flap surgery, Agarwal and Raza[9] reported complete recovery in 15 patients, marginal necrosis in two patients, and superficial necrosis in one patient. The authors concluded that when supported with an external fixator, cross-leg flap surgery was highly successful in saving the extremity and ensuring full recovery.[9] In the current study, we achieved successful recovery in 25 patients to whom cross-leg flap surgery was performed. Local flap tissue loss was observed in one patient, but the local defect in this patient healed with secondary granulation tissue. The clinical results presented by our study are compatible with the literature. In a review reported by Van Boerum et al.,[10] the most prevalent reason was trauma, with 93.2%, and anatomical restraints, such as insufficient vasculature, were the major argument for not applying free tissue transfer. In this large review, the authors found that flap survival was successful in 349 of the 350 patients, indicating a near 100% success rate, and concluded that these results make cross-leg flaps a solid and trustworthy reconstructive option. The aspect of the recipient vascular structures is the most important determinant for the success of the free flap.[8] In our current study, we achieved successful recovery in all patients treated with cross-leg flaps. Smoking is also a determinant in

flap collapse.[8] Patients should stop smoking two weeks before and after surgery.[11] A cross-leg flap was performed in seven patients in this study for this reason.

After the introduction of cross-leg flaps by Hamilton in 1854,[1,12] the fixation methods have advanced, and the reliability and safety of these flaps have long been improved. Long et al.[13] reported the cross-leg flap procedure as being an easy and persuasive choice in reconstruction. Sharma and Kola[14] advocated cross-leg flaps as being a trustworthy and easier alternative to microsurgery. Currently, cross-leg flap treatment is considered a salvage preference when all other options have been attempted.[15] For the reasons mentioned above, free flap application is a very selective type of surgery and carries a high probability of complications. In such circumstances, the cross-leg flap is an alternative limb salvage method that promises high success since it requires less selective conditions, provides good wound coverage, and does not require microsurgical experience.[15]

There are a few limitations to this study. The relatively small number of cases might have altered the credibility of the method, although it offered a success rate of nearly 100%. Second, no comparison between free flaps and cross-leg flaps was implemented in our study. Therefore, the superiority of these two methods over each other could not be investigated. However, the favorable treatment results of the traumatic lower extremities with cross-leg flaps lead us to strongly advocate for the widespread adoption of this technique in medical facilities.

In conclusion, cross-leg flap surgery is an exceptional alternative to free flaps for the care of complex traumatic lower extremity injuries. This method is simple, provides abundant blood supply to the wound, and does not require microsurgical experience or an intact recipient artery in the defective recipient area. Therefore, it appears to be an effective and reliable option for limb salvage, particularly in resource-limited conditions or in patients who are inappropriate for microvascular free tissue transfer.

Ethics Committee Approval: The study protocol was approved by the Izmir Bakırçay University Non-invasive Clinical Research Ethics Committee (date: 17.01.2024, no: 1426). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Design, data collection and processing, analysis and interpretation, writing the article, references and fundings: F.İ.C.; Idea/concept, control/supervision, literature review, critical review, materials: B.Ş.

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