

# Determination of the adequate vascular perfusion time of cross-leg free latissimus dorsi myocutaneous flaps in reconstruction of complex lower extremity defects

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## Summary

**Background:** Lower limb defects may be present due to various causes including infections, vascular diseases, tumor resections, and crush or avulsion injuries. Management of lower leg defects is a complex problem, especially when they are large with deep soft tissue loss. These wounds are difficult to be covered with local skin flaps, distant skin flaps or even conventional free flaps because of the compromised recipient vessels. In such cases, the vascular pedicle of the free flap could be anastomosed to the recipient vessels of the contralateral healthy leg temporarily and then divided after adequate neo-vascularization of the flap from the wound bed. The ideal time to divide such pedicles should be investigated and accurately assessed to have the maximum success rate possible for these challenging conditions and procedures. **Methods:** Sixteen patients who did not have a suitable adjacent recipient vessel for free flap reconstruction had been operated with cross leg free latissimus dorsi flap between February 2017 and June 2021. The mean soft tissue defect dimension was 12 × 11 cm (the smallest 6 × 7 cm; the largest 20 × 14 cm). Gustilo type 3B tibial fractures were present in 12 patients, while no fractures were present in the other 4 patients. Preoperatively, arterial angiography was performed on all patients. After the fourth week post-operatively, non-crushing clamp was applied around the pedicle for 15 minutes. The clamping time was increased by 15 minutes on each consequent day (average 14 days). On the last 2 days, the pedicle was clamped for 2 hours, and bleeding was assessed by a needle prick test. **Results:** Clamping time was assessed in each case to reach a scientific calculation of the adequate vascular perfusion time needed for full flap nourishment. All flaps survived completely except two cases of distal flaps necrosis. **Conclusion:** Cross-leg free latissimus dorsi can provide a solution for large soft-tissue defects in lower extremities especially with absence of any suitable recipient vessels or when the use of vein grafts would not be feasible. However, ideal time before dividing the cross vascular pedicle should be identified to have the maximum success rate possible.

## Key words

vascular – perfusion – cross-leg – free flap

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## Introduction

The management of defects of the lower leg is a complex problem especially when they are large with deep soft tissue loss. In such cases, it is difficult to cover the defect with a local skin flap, a distant skin flap or even a conventional free flap because of the compromised recipient vessels [1–5]. The widespread use of free flaps had made it possible to repair these complex defects. A successful repair is achieved not only by ap-

propriate convenient flap planning by an experienced microsurgery team, but also by identifying the suitable donor vessels which could not be frequently found when joints, tendons, nerves, or vessels are open or where fracture lines and bone defects accompany periosteal bone structures [6].

The use of long venous grafts or A-V loops as solutions for these challenging cases may not be easy or preferred to vascularize free flaps away

from the zone of injury as it requires another donor site and increases the number of vascular anastomoses which in turn increases the risk of thrombosis and failure of the free flap. An arterial jump graft from the ipsilateral popliteal artery is another option for reconstruction of the defect at the same leg but there is a possibility of kinking of the grafts and stenosis of the distal anastomosis [7].

In such cases, the vascular pedicle of the free flap could be anastomosed to

the recipient vessels in the contralateral healthy leg temporarily and then divided after adequate neo-vascularization of the flap from the wound bed, hence the name "cross leg free flap", first described by Taylor et al in 1979 using an osteocutaneous iliac flap [8].

However, since that time, no reports had tried to reach a scientific calculation and/or assessment of the needed time to have the full vascular perfusion of these flaps. The timing of the second surgical stage for division of such cross-pedicles is still to date a subjective evaluation.

Those patients usually have critical general conditions and challenging local wounds and should not have more risks for complete or partial necrosis of these unusual free flaps. The hypothesis of this work is to investigate the ideal time to divide such pedicles to



Fig. 1. A 21-year-old man sustained a work-related crush injury to his left leg with an open fracture of tibia and fibula accompanied with a large tissue defect over the distal third of the leg. Angiography was performed with no appropriate recipient vessel was identified. A cross-leg free flap was planned using the tibialis posterior artery and vein in the contralateral leg as recipient vessels. The muscle flap was covered with a partial-thickness skin graft. Both lower extremities were fixated together using an external fixator. The flap was divided in the fifth postoperative week. (A) Preoperative appearance of a soft tissue defect of the lower third of left leg with exposed sequestered bone. (B) Early postoperative appearance of the latissimus dorsi muscle cross-leg free flap. (C) Postoperative one-month appearance.

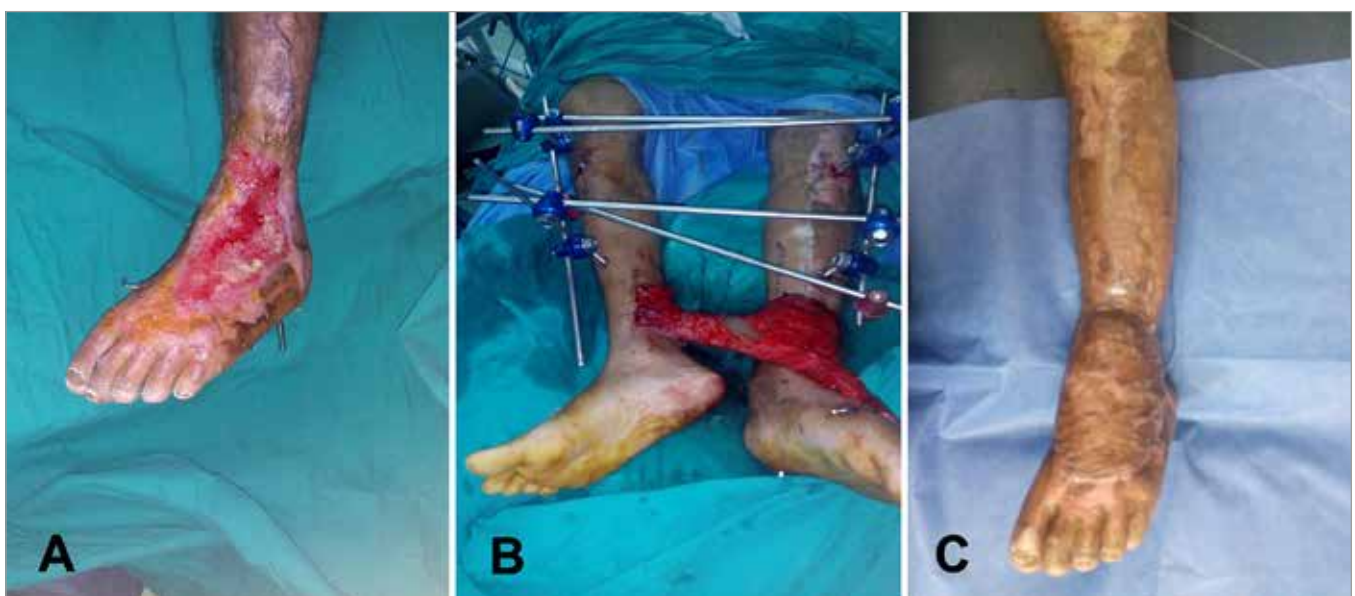


Fig. 2. A 27-year-old man sustained a crush injury to his left leg with an open fracture of tibia and fibula accompanied with a large tissue defect over left leg and dorsum of the foot with exposed bone in most of the defect. A cross leg latissimus dorsi free flap covered with split-thickness skin graft was applied for this defect. (A) Preoperative appearance of soft tissue defect dorsum left foot with bone exposed. (B) Early postoperative appearance of the latissimus dorsi muscle cross-leg free flap. (C) Postoperative one-month appearance.

Tab. 1. Defects – etiology, location, size, and the injured vessels.

Patient No.	Etiology	Location	Size (cm)	Injured vessels
1	traffic accident	left tibia anterior	11 × 7	ant. tibial + post. tibial
2	fire gun injuries	left tibia anterior	14 × 12	ant. tibial + peroneal
3	traffic accident	right foot dorsum	15 × 8	ant. tibial + post. tibial
4	electrical burns	left tibia medial	12 × 11	post.tibial + peroneal
5	fire gun injuries	left heel	16 × 9	ant. tibial + post. tibial
6	marjolin ulcer	left tibia anterior	12 × 11	ant. tibial + peroneal
7	traffic accident	left foot dorsum	16 × 12	ant. tibial + post. tibial
8	traffic accident	left tibia medial	6 × 7	post. tibial + peroneal
9	marjolin ulcer	right heel	18 × 6	ant. tibial + peroneal
10	electrical burns	right foot dorsum	17 × 13	ant. tibial + post. tibial
11	traffic accident	left tibia medial	8 × 6	post. tibial + peroneal
12	electrical burns	left heel	9 × 7	ant. tibial + peroneal
13	fire gun injuries	left tibia and ankle	20 × 14	ant. tibial + post. tibial
14	electrical burns	left foot dorsum	12 × 8	ant. tibial + peroneal
15	traffic accident	right tibia and ankle	16 × 12	ant. tibial + post. tibial
16	fire gun injuries	left foot dorsum	15 × 7	ant. tibial + post. tibial

have the maximum success rate possible for these challenging conditions and procedures.

### Patients and methods

This study was performed in the period from February 2017 to June 2021 for patients who had cross-leg free latissimus dorsi flaps for reconstruction of soft tissue defects of the lower limbs – as shown in Fig. 2 and 3 – at the Department of Plastic and Reconstructive Surgery, Assiut University, Egypt. The study included 16 patients (10 males and 6 females) with a mean age of 27.4 years (range 7–39) who did not have a suitable adjacent recipient vessel for conventional free flap reconstruction.

The etiology of the injuries consisted of traffic accidents in 6 patients, fire gun injuries in 4 patients, electrical burns in 4 patients, and Marjolin ulcer in 2 patients. The mean soft tissue defect dimension was 12 × 11 cm (the smallest: 6 × 7 cm; the largest: 20 × 14 cm). Gustilo type 3B tibial fractures present in 12 pa-

tients, while no fractures were present in the other 4 patients.

Tab. 1 shows the defects' etiology, location, size and the injured vessels.

Preoperatively, arterial angiography was performed for all patients. Intraoperatively, the posterior tibial vessels of the contralateral leg were exposed as recipient vessels via H-shaped skin incision on the medial side of the leg. The vascular pedicle of the myocutaneous latissimus dorsi flap, combining with the subscapular and circumflex scapular vessels, forms a T-shaped vascular pedicle.

Both lower extremities were fixed using external fixators to maintain immobilization for 4–6 weeks. End to end anastomosis was performed to the posterior tibial artery and vein of the contralateral leg. All patients were hospitalized during this period.

The patients were managed with a prophylactic low dose of heparin to guard against deep venous thrombosis due to the long recumbency time. After the fourth week post-operatively, fine

vascular tourniquet was applied around the pedicle for 15 minutes. The clamping time was increased by 15 minutes on each consequent day in cases with good flap vascularity but in cases of diminished vascularity we released the clamp and started again next day with the same clamping time and force till reaching fresh blood through a needle prick test. On the last 2 days before the separation, the pedicle was clamped for 2 hours continuously as shown in Fig. 3, and the flap vascularity was assessed by a needle prick test. The bright red blood bleeding in the distal part of the flap was noted as a sign of sufficient circulation and full neo-vascularization. Tab. 2 shows the clamping and separation time of each flap.

### Results

Sixteen cross-leg free latissimus dorsi flap transfers were performed. Fourteen flaps survived completely, and two flaps developed distal flap necrosis which was managed by split thickness skin graft later. We found that the two flaps with



**Fig. 3.** A 48-year-old man sustained a malignant ulcer on the top of a long-standing burn scar over his right leg. Angiography revealed no appropriate recipient vessel and a cross-leg free latissimus dorsi flap was planned to cover the defect. Clamping of the pedicle using non-crushing intestinal clamp was applied on the fourth week post-operatively then separation of the pedicle was performed on the next week. (A) Preoperative appearance of malignant ulcer on top of long-standing burn scar over left leg. (B) Intraoperative appearance of contralateral leg showing the posterior tibial vessels. (C) The pedicle was clamped for 2 hours before separation.

distal necrosis had been separated at earlier time three weeks ago, so we prefer not to start clamping before the 4th 4<sup>th</sup> and to continue clamping for about a two-week interval before separation;

the pedicle was divided in the 5–6<sup>th</sup> weeks.

Minor infection had been observed in the recipient site in two cases which were successfully managed with more frequent dressings and aggressive antibiotics. Seroma occurred in the donor area in two cases. No pathology associated with the bone union had been observed in the patients with bone fractures. Satisfactory cosmetic results in the reconstructed areas and equal limb lengths were achieved in all patients.

did not achieve statistical significance [9].

The “cross-leg free flap,” first described by Taylor et al in 1979 was used to repair skin and bone defects in the lower leg with a free osteocutaneous flap. Various successful results have been published later using the cross-leg method. Yu et al published a case series of 85 patients using the cross-bridge method and reported a success rate of 95.29% [10]. The advantages of reconstruction with cross-leg free flaps include the possibility of preparation with the required tissue components such as bone and muscle of the requisite sizes and allowing the anastomosis line to be completely outside the trauma zone. The most important advantage of the cross-leg free flap is the possibility of saving the limb by transferring well-vascularized tissue to the leg in injuries with serious defects, even when amputation is considered. This method is especially suitable for patients with sensation in the soles of the feet and with a stable bone skeleton [11].

In this work, we applied the cross leg free latissimus dorsi flaps and applied external fixators for leg stabilization. Separation time of the cross-leg free

**Tab. 2. Clamping time and separation time of each flap.**

Patient No.	Clamping time	Separation time
1	28 <sup>th</sup> day	14 days
2	16 <sup>th</sup> day	12 days
3	27 <sup>th</sup> day	14 days
4	28 <sup>th</sup> day	15 days
5	26 <sup>th</sup> day	18 days
6	25 <sup>th</sup> day	17 days
7	26 <sup>th</sup> day	14 days
8	28 <sup>th</sup> day	14 days
9	27 <sup>th</sup> day	15 days
10	26 <sup>th</sup> day	12 days
11	28 <sup>th</sup> day	10 days
12	26 <sup>th</sup> day	11 days
13	28 <sup>th</sup> day	16 days
14	26 <sup>th</sup> day	14 days
15	27 <sup>th</sup> day	13 days
16	28 <sup>th</sup> day	16 days

**Discussion**

Once free flap reconstruction is planned for a challenging soft tissue defect, there would be limited options for the flap inset and donor vessels in cases of unsuitable conventional vascular anastomoses. Lin et al reported a case series of 65 traumatic limb injuries reconstructed with free tissue transfers using vein grafts of significant length (> 20 cm for the arterial gap). They used vein grafts for arterial defects, and a temporary arteriovenous loop in the case of both artery and vein defect. They observed a higher re-exploration rate associated with greater graft length, although this

flap vascular pedicle depends on the tissues included in the flap (muscle or fasciocutaneous), the size, and the recipient bed condition. One experimental study with 25 dogs demonstrated that approximately a period of 3 weeks is sufficient to establish revascularization of a random pedicled flap.

In this series, we started clamping the flap pedicle 4 weeks after the first operation in all cases (except those with distal flap ischemia) and continue to increase clamping time by 15 minutes daily with monitoring the vascularity on each clamping trial regularly. During the surgery, clamps were placed on the pedicles to confirm flap circulation. No problems in flap circulation after clamp application were observed in any of the cases. We prefer not to start clamping before the fourth week and to continue clamping for about a two-week interval before separation.

## Conclusion

Microvascular free tissue reconstructions for lower leg, heel, and foot are invaluable methods for the common complex wounds in these areas [12,13]. In this retrospective cohort study, we reported our experience treating a wide range of lower limb defects with cross leg latissimus dorsi myocutaneous flaps and assessed the ideal time to divide the crossed vascular pedicles to have the maximum success rate possible for these challenging conditions and procedures.

Our message from this research is to ensure adequate vascularity to the

cross leg latissimus dorsi myocutaneous flaps by clamping the pedicle before separation and to determine the optimal time of this critical step which found to be ideal between 5–6<sup>th</sup> week after anastomoses of the pedicle with the recipient vessels.

Clamping trials on consequent days with increasing time intervals in each trial is a fundamental adjunctive procedure to determine the optimal timing at which we can safely separate such critical flaps which are different from ordinary free flaps.

## Roles of authors

Mohamed Elyounsi and Awny Askhany: collection the data and clinical search and performing the analysis;

Mugahed Ali: conception and design of the study;

Mohamed Makboul: collection the data and clinical search, performing the analysis, writing the article with final approval of the version to be published;

Mohamed El-Shazly: conception and design of the study, writing the article and performing the final approval of the version to be published.

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