



Coverage for the vascular pedicle of a free fasciocutaneous flap using split thickness skin graft with auxiliary procedure to achieve a safe method with no impairment of vessels: a case series and literature review

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Abstract

Background The vascular pedicle of a free flap is the most critical structure that determines its viability. Most of the times it is covered with local skin flaps raised from the recipient site or with part of the free flap itself. However, there are conditions in which the vascular pedicle can be covered with skin graft. The purpose of the present study is to describe our experience in the use of split-thickness skin grafts (STSG) as an auxiliary procedure for pedicle coverage.

Methods All patients who underwent microvascular fasciocutaneous free flap reconstruction at the Department of Plastic Surgery of China Medical University Hospital in Taichung from 1986 to 2021 were retrospectively evaluated. Patients who met all of the following criteria were eligible for the study: microvascular free flap reconstruction of any region of the body with a fasciocutaneous flap and cases where tension was detected during skin closure over the pedicle of the flap and STSG was applied as a cover.

Results There were 14 cases in this series treated from 1986 to 2021. Among them, 11 cases had no additional skin at the proximal end of the free flap, nor local flap at disposal in the recipient site to cover the vessels. In 3 other cases a vascular bridge flap was used for cross-leg flap transfer without possibility of tension free tubulization to protect the vessels. All reconstruction were successful.

Conclusions During microvascular transfer of free flaps, if no skin flap is available to cover the vascular pedicle, skin graft can be used to protect the vessels without compromising the circulation of the flap. Our results, in accordance with the literature, supports the safety of this technique when direct closure of the skin above and near the pedicle is not possible.

Level of evidence Level IV, Therapeutic.

Keywords Free flap pedicle · Split-thickness skin graft · Pedicle exposure · Free flap reconstruction · Free flap survival · Salvage procedure

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Introduction

The vascular pedicle is a crucial part of any free flap, as it conveys blood supply to the flap, thus maintaining its vitality [1], at the same time, it represents the most delicate portion. As with other critical structures such as nerves, it is widely accepted that a vessel should be covered by a tissue of good quality and vitality such as a flap. Nevertheless, to ensure laminar flow, it is important that the vessel is not deformed by any external pressure or kinked. For this reason, a tension-free covering is essential to avoid increased pressure on the pedicle. Indeed, strain and constriction over the pedicle can lead to vessel collapse and occlusion. In addition, it must be considered that in the post-operative period, the development of tissue edema and the possible formation of a hematoma may be responsible for the increase in extravascular pressure [2, 3].

In 1979, Ohtsuka et al. described several successful techniques that can be used to cover the vascular pedicle, including the use of split-thickness skin grafts (STSG) [2]. Since then, few reports have been published [2, 4–6], and literature lacks cases in which a pedicle has been directly covered with a STSG. Among these, a retrospective study showed that direct skin grafting over the pedicle was not associated with a higher risk of flap failure and other complications,

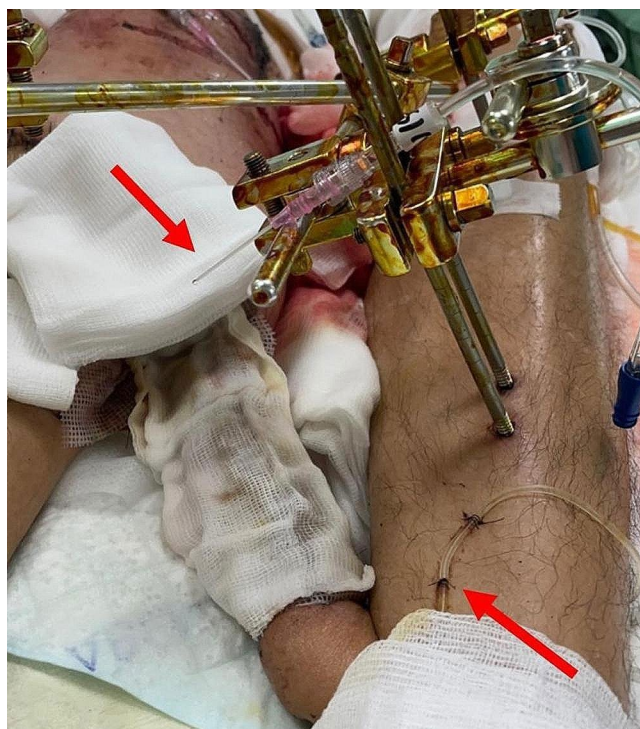


Fig. 1 A line for regular dripping of heparin solution is placed over the grafted area (arrow on the top). In the picture can be noted also the catheter obtained from a butterfly needle placed near the buried side of the pedicle for external irrigation of the vessels with lidocaine (arrow on the bottom)

revealing the safety of the procedure [4]. However, surgeons tend to avoid this procedure as pedicle coverage with flap's tissues or local skin flaps is considered the gold standard for major safety. The purpose of the present study is to describe our experience in the use of STSG as an auxiliary procedure for pedicle coverage.

Materials and methods

All patients who underwent microvascular fasciocutaneous free flap reconstruction at the Department of Plastic Surgery of China Medical University Hospital in Taichung from 1986 to 2021 were retrospectively evaluated. Patients who met all of the following criteria were eligible for the study:

- microvascular free flap reconstruction of any region of the body with a fasciocutaneous flap.
- cases where tension was detected during skin closure over the pedicle of the flap and STSG was applied as a cover.

Skin tension in closure of a free flap was defined as follow: the suture was considered to be in tension when the skin on both sides of the stitches showed stretching and whitening of the skin, indicating that the flaps were having difficulty joining together. In patients where a tension-free closure could not be achieved causing exposure of the pedicle, a thin STSG was placed over the pedicle to allow coverage. A 0.3 mm STSG was harvested from the thigh and meshed with a 1:3 or 1:1.5 ratio. The STSG was then placed gently over the pedicle avoiding any tension, without spread out the meshing. The graft was then covered with a grease gauze and 2% lidocaine gel to maintain the moisture. No compression garment was placed to avoid external pedicle compression. A catheter obtained from a butterfly needle was placed near the buried side of the pedicle for external irrigation of the vessels with 10 cc/h of 2% lidocaine. The catheter was then removed on 5 post-operative day (POD) (Fig. 1). For the next 7–10 days post-operatively, the dressing was daily renewed or dripping continued to prevent drying of the STSG and pedicle.

Results

Fourteen patients were retrospectively identified and enrolled in this study. Clinical, operative and post-operative data were recorded retrospectively and are summarized in Table 1.

Of all the 14 patients, 11 (79%) underwent a free flap fasciocutaneous reconstruction in which a tension-free

Table 1 Patient's clinical, operative and post-operative data

Patients <i>n</i> = 14	
Age, y.o., median (IQR)	31 (23–58)
Sex, n° (%)	1 (7)
Female	13 (93)
Male	
Comorbidities, n° (%)	1 (7)
Hypertension	1 (7)
Diabetes	0 (0)
Peripheral vascular disease	0 (0)
Chronic kidney disease	0 (0)
Cause of defect, n° (%)	2 (14)
Tumor excision	12 (86)
Post-traumatic wound	
Defect location, n° (%)	1 (7)
Head and neck	9 (64)
Upper limb	4 (29)
Lower limb	
Skin graft size, median (IQR)	27 cm ² (9–55)
Flap type, n° (%)	13 (93)
ALT, cross leg flap	1 (7)
RFFF	
Complications, n° (%)	0 (0)
Total flap necrosis	1 (7)
Partial flap necrosis	1 (7)
Venous congestion	0 (0)
Pedicule thrombosis	0 (0)
Pedicule Infection	0 (0)
Pedicule Hematoma	
Hospital stay, mean days	44
Cross leg flaps	20
Conventional flaps	
Follow up time, mean months	38

ALT: anterolateral thigh flap, RFFF: radial free forearm flap

closure of the skin over the pedicle could not be achieved, and therefore a STSG was placed to protect the vessels. A total of 14 fasciocutaneous free flaps (13 anterolateral thigh [ALT] flaps and 1 radial forearm free flap [RFFF]) were

performed to reconstruct a soft tissue defect. In addition to these, a further three RFFFs were raised as bridging flap. In those three cases (21%), a cross leg flap was performed. In these patients, a primary ALT flap was harvested to allow reconstruction of the defect and it was sequentially connected to a RFFF used as vascular bridge flap [7] which was anastomosed to the recipient vessels on the contralateral leg (these three RFFF are excluded from the count in Table 1). A thin meshed STSG was then applied over the raw part of the RFFF directly over the radial artery and veins to protect the vessels, as tubulization of the RFFF was considered at risk of pedicle compression (Fig. 2). The STSG was successful in all patient with a 100% uptake rate. No pedicle infection, hematoma or desiccation occurred in the analyzed population. In one case of cross-leg flap, we found venous congestion in the immediate post-operative period, which required revision of the pedicle by performing an additional venous anastomosis. This was the same patient in whom occurred a partial necrosis of a little edge of the ALT flap used for reconstruction of a Gustillo 3b fracture. In all other cases at least 1 artery and 2 veins were anastomosed. No complete flap necrosis has been reported and all reconstruction have been successful. Mean hospital stay was 44 day for cross leg flap cases, and 20 days for conventional flaps. The mean follow up was 38 months (Fig. 3).

Discussion

It has always been advocated from most authors that critical structures, such as nerve and vessels, should be safely covered with a flap. This principle is extended to free flap reconstruction, where the vessels forming the pedicle of the flap are crucial for its viability. Therefore, it is essential to

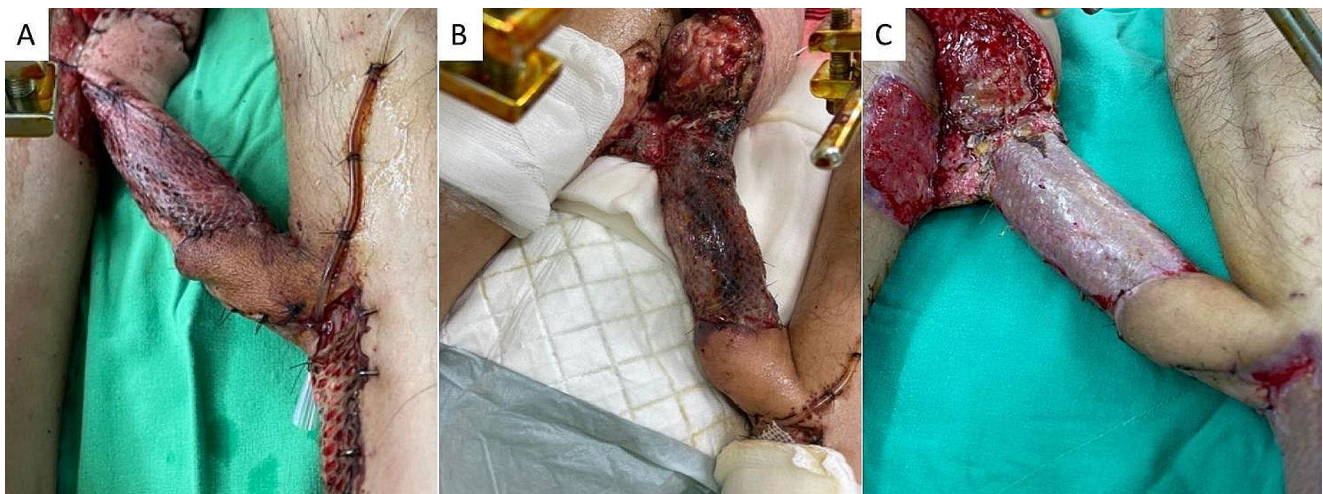


Fig. 2 STSG placed directly over the vessels of the bridge flap at the end of the procedure (A), on 5 POD (B) and 28 POD (C). At 28 POD the pulsation of the artery can be felt under the skin graft and Doppler assessment shows patency of both veins and artery

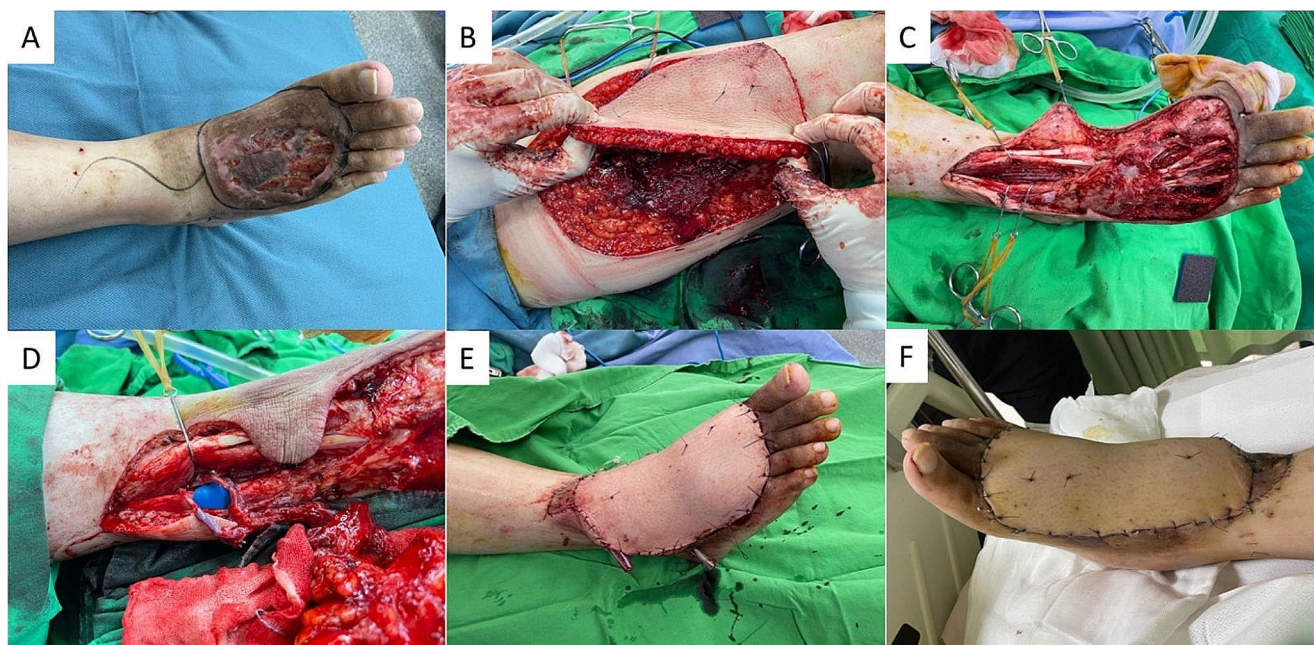


Fig. 3 Clinical case of a 30 y.o. man, with no relevant comorbidities, who developed a chronic post-traumatic ulcer of the dorsum of the right foot. The trauma was dated 8 years earlier. The patient underwent to a complete wide excision of the ulcer (A and B) and reconstruction with an adipocutaneous ALT flap (C) anastomosed to the anterior

tibial vessels (D). To ensure no tension over the pedicle, the site has been skin grafted (E). The specimen was analyzed by the pathologist excluding malignant evolution of the ulcer. At 8 POD the flap was completely viable (F)

cover these pedicle vessels with good quality tissue to avoid desiccation, which could lead to intravascular thrombosis.

The surgeon has to consider various variables when managing the flap's pedicle, including the type of flap used, whether the flap will be independent of the pedicle after it matures and, if so, how long will it take to mature. Each of these considerations is fundamental and can modify the approach to the reconstruction and the post-operative management. In this scenario, the flap inset and its post-operative management depends on the timing. Several options are implemented in the sequence to ensure the survival of the flap during its maturation. A flap is considered "mature" when it reaches a state of hemodynamic stability, which is achieved when it revascularizes with the surrounding tissue. In specific cases, the flap maturation leads to its vascular independency from the pedicle. This means that pedicle patency, which is fundamental in the early post-operative period, may become secondary and will no longer be necessary once the flap has matured.

The initial consideration is whether a flap can mature and become independent of the pedicle and how long this process would take. Fasciocutaneous, muscular, osseous, and intestinal flaps exhibit distinct characteristics and varying capacities for integrating their vascular supply with the recipient site. Each kind of flap has a different modality of revascularization and possibility to switch from their own vascular supply based on the pedicle to a vascular supply

that comes from the surrounding tissues. Compared to muscle and bone flaps, fasciocutaneous flaps have a maturation period that is shorter. Bone flaps get mature by neovascularization from the surrounding bone, similar to "direct fracture healing", in a process that can last from weeks to years [8]. In fasciocutaneous flaps the dermal peripheral neovascularization allows to achieve a secure and complete independency from the pedicle after 2–3 weeks from the inset [1], and in some cases has been reported even earlier [9]. This is not the case for other types of flaps such as the muscle [10] and intestinal flaps [11], where, while independence from the pedicle has been demonstrated in experimental studies [12, 13], the opposite has been seen in the clinical setting [9, 10, 14].

Another factor that seems to be important for flap's autonomy is the connection between the flap and the skin. In experimental studies [12–14] all flaps were composite musculocutaneous flaps or directly in contact with the surrounding skin [13]. In clinical setting we have also cases in which a muscle flap has been autotomized successfully [15]. In the study published by Bradshaw et al. [16], where muscle flaps have been used, it has been suggested that a determinant for muscle flap autonomy from the pedicle is the type of inset at the cutaneous level, meaning that the neovascularization from the dermal edge is a determinant factor. Based on previous clinical reports [10], the authors assume that buried flaps could not reach the vascular autonomy from

the pedicle due to the inability of the flap to establish contact with the dermis. This observation may extend to other types of “buried flaps” such as intestinal flaps, in which complete autonomy from the vascular pedicle seems never to be achieved, with the need to maintain at least arterial inflow for tissue survival [11, 17]. All these findings suggest that flap independence from the pedicle is closely linked to direct or indirect dermal neovascularization of the flap.

Ohtsuka et al. described various methods of pedicle coverage, introducing the possibility of using STSG. The authors presented the case of a patient who underwent a cross-leg flap, in which the completely skeletonized vascular pedicle was covered with STSG, without compromising the survival of the flap [2]. Through this case it was demonstrated that a flap pedicle could be skin grafted safely without compromising flap’s viability.

Since then, only few studies have been published on this topic [3–5]. Moreover, skin grafting over the pedicle has also been described as a step during the inset of the “Sandwich Fascial Anterolateral Thigh Flap” [18]. Among them, a retrospective case-control study published by Kovar et al. [4] revealed no statistical difference between the group of patients treated with a skin graft over the pedicle in complication rate and, in particular, in incidence of flap failure. Other studies advocate the use of STSG as a transient coverage of post-traumatic exposed vessels [3, 6]. In this cases the STSG is applied over vessels as biological medication to avoid their exposure and is changed every two days until a more stable coverage is planned. We think that this possibility may be useful if it represents only a temporary phase of a reconstructive plan adopted in an acute phase. However, similar to the technique we have described, careful post-operative management is essential.

Despite its feasibility, skin grafting over the pedicle requires certain precautions to be taken in the post-operative period. For post-operative management of STSG on the pedicle, it is paramount to maintain graft’s moisture. Desiccation of the graft can cause its shrinkage and reduction of the intake, resulting in increased pressure on the vessels or their exposure. The use of lidocaine gel has the double advantage of retaining moisture and continuously releasing lidocaine onto the vessels acting as a vasodilating agent and preventing vasospasm [19].

Based on our experience, we think that the skin graft must be split thickness and meshed. By using a STSG, the primary contracture of the graft is minimised and further reduced by the meshing. Thus, the graft can be placed smoothly to cover the pedicle of the flap. Meshing the graft can further reduce tension, allowing the STSG to expand if oedema occur and prevent the accumulation of fluid and so the formation of hematomas between the graft and the vessels [21]. Due to the secondary contraction of the STSG

[20], tissues around the pedicle will inevitably shrink, and the pressure over the pedicle will increase during the next weeks. For this reason, the long term patency of the pedicle that has been skin grafted cannot be guaranteed. Even if other authors have reported the use of a FTSG [4], we think that only a thin STSG should be used for two reasons. Firstly, recruitment of a thin STSG is easier than an FTSG and furthermore, no external pressure can be applied to the pedicle and therefore tie over must be avoided, reducing the intake rate of the graft. In comparison, a thin STSG placed gently on the vascular surface is more likely to survive. Secondly, the FTSG is more elastic due to its pronounced primary contraction, and could possibly constrict the pedicle if applied too tightly over it. In absence of a tie-over dressing over the skin graft, if the FTSG does not completely survive, it will become an infection source which may cause thrombosis of the pedicle.

We suggest the use of STSG only on the pedicle of fasciocutaneous flaps, where the maturation of the flap occurs before the secondary contraction process of the STSG. The utility of the skin graft over the pedicle is to reduce the pressure on the pedicle that can develop if a direct skin closure is attempted under tension, while providing protection. External pressure on the pedicle can cause the flap’s venous system and anastomosis to collapse, leading to thrombus formation and venous occlusion. If this happens before the flap matures, it will result in impaired venous drainage and thus flap’s congestion and failure.

In alternative to STSG some authors [21] advocated the use of an acellular dermal matrix (ADM) (Integra®, Integra LifeSciences, Plainsboro, New Jersey) for pedicle coverage. Although this seems to be an interesting alternative, in the study 3 out of 10 patients (30%) developed an hematoma around the pedicle requiring surgical revision, much higher than reported in the literature [22]. Tension on skin closure was not assessed and pedicle coverage with ADM was offered prospectively to all patients. Thus, without a control group it is difficult to know whether there is any real benefit to this technique. Another thing to consider is the cost of the ADM, which is much higher than a simple STSG. The higher rate of hematoma may be related to the nature of the product used: the silicone layer, although it can be perforated, does not allow drainage like a STSG that has been meshed, and a compression garment cannot be used because of the pedicle as well.

The limitation of this study is that it is a retrospective case series report without a control group. A prospective randomized case control study may be necessary to evaluate the best closure technique. Such study can be difficult to design since the evaluation of tension during the pedicle coverage is assessed only in the latest phase of the surgery. Moreover, there may be also ethical issues. If a tension is

encountered, the surgeon must decide to close directly the skin over the pedicle with the possible risk of flap failure. We think that this type of study can only be simulated using animal model in which a flap, defect and skin closure tension on the pedicle can be standardized and thus two equal groups can be made: direct closure vs. STSG on the pedicle.

Every effort should be made to adequately cover the pedicle with a flap, such as using local flaps with a back graft to the donor site, however, this is not always possible. The correct planning of the flap remains fundamental. STSG should be considered only as the last option for a tension-free closure in case of an unpredictable situation.

Conclusions

The pedicle is the most important part of a flap, especially in the early post-operative period. Ensuring its patency is essential to guarantee the survival of the flap. In this scenario, factors such as external pressure on the pedicle and exposure of the vessels resulting in desiccation must be avoided. To overcome this problem, when tension is detected in the closure of the skin near the pedicle, a direct suture should be avoided, and a STSG is a simple way to achieve pedicle coverage and prevent vessels desiccation while reducing external pressure over the pedicle. Our study, in accordance with the literature, supports the safety of this technique when direct closure of the skin above and near the pedicle is not possible.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Prof. Hung-chi Chen, Dr. Shih-Heng Chen and Dr. Jonathan Velazquez-Mujica. The first draft of the manuscript was written by Dr. Leonardo Garutti and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Declarations

Ethical approval As this is an observational study, conducted in accordance with the Declaration of Helsinki, no ethical approval was required. This was confirmed by the local Ethical Committee of the hospital.

Patient consent Consent for participation in the study was obtained from the patients during the follow-up visit.

Competing interest The authors have no conflicts of interest to declare.

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