

Use of Biodegradable Temporizing Matrix for Donor and Recipient Site Wound Healing in Delayed Reverse Sural Flap: A Case Report

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ABSTRACT

Introduction: Reconstruction of distal third leg soft tissue defects is challenging, particularly in patients with multiple co-morbidities. Whilst the reverse sural artery (RSA) flap remains a viable reconstructive option, flap failure due to torsion, congestion, and necrosis persists.

Case Presentation: This case report presents a patient who underwent a staged RSA flap surgery, with initial application of a biodegradable temporising matrix (BTM) over both the donor site and the heel defect. This was performed with three aims: to create a physical interface as an adjunct to surgical delay; to improve donor site granulation tissue quality in preparation for skin grafting; and to establish a granulation tissue layer over the bony defect to promote a granulating wound bed suitable for definitive reconstruction.

Conclusions: The application of BTM appeared to facilitate an effective adjunct to surgical delay and improved flap donor site contour. This case report suggests that the use of BTM across both donor and recipient site wound beds may represent a feasible and promising adjunct in staged RSA flap reconstruction, though further studies are required to substantiate these findings.

INTRODUCTION

Reconstruction of soft tissue defects in the distal third of the leg is a technically demanding procedure, particularly in patients with multiple co-morbidities^{1,2}. The relative scarcity of local soft tissue, combined with poor regional vascularity, predisposes this anatomical zone to complications^{3,4}. On top of that, timely and reliable soft tissue coverage is critical not only for wound closure but also for the prevention of deep infection, protection of underlying hardware, and optimisation of fracture healing outcomes.

The reverse sural artery (RSA) flap is a well-established reconstructive option. Its versatility makes it particularly suited to patients who are not ideal candidates for microsurgical reconstruction⁵. This flap offers several advantages over free tissue transfer: relative technical simplicity¹, shorter operative time [6], lower donor site morbidity^{1,6,7}, and preservation of the major vascular axes of the

lower limb^{1,8}. Flap delay has been shown to improve flap viability⁷. However, complications including marginal necrosis, partial flap loss, and total flap failure - attributable to pedicle torsion, venous congestion, or hypoperfusion, have reported rates of up to 33%^{2,9,10}. In addition, donor sites requiring skin grafting have been associated with scar contracture, dysaesthesia, and aesthetic problems¹¹.

The biodegradable temporising matrix (BTM) is an inexpensive, fully synthetic dermal template that comprises of biodegradable polyurethane foam designed to promote the growth of a new neodermis^{12,14}. BTM has been employed in various tissue reconstructive settings, most notably for deep burn injuries and wounds unsuitable for immediate skin grafting^{12,15}. Following delamination, BTM-treated wounds have demonstrated consistent granulation and increased tolerance of infections¹³. To the authors' knowledge, the use of BTM to assist donor site wound healing for RSA flaps remains poorly described in the literature.

This case report describes a novel staged RSA flap technique in which BTM is applied to both the bony recipient defect and the flap donor site at the time of the initial procedure. prior to the definitive flap inset at the second operation. We present the clinical course of one patient who underwent this staged approach and discuss the proposed rationale, observed outcomes, and limitations of the technique.

CASE STUDY

The patient is a 62-year-old Chinese lady, previously pre-morbidly independent and community ambulant. Her past medical history included hypertension, hyperlipidemia, type 2 diabetes mellitus, and stage 3 chronic kidney disease. She was admitted to our institution for an avulsion fracture of her posterior calcaneum after a fall with overlying soft tissue compromise of the heel and posterior ankle. After multiple surgical debridements with application of negative pressure wound therapy (NPWT) and confirmation of negative bacterial cultures, she was planned for calcaneal fracture fixation with headless screws and soft tissue reconstruction.

In view of her multiple co-morbidities, RSA flap was chosen as the reconstructive modality given the increased risk associated with prolonged microsurgical procedures. Prior to reconstruction, the Orthopaedic Surgery team applied an external circular

frame for heel offloading and ankle immobilization. Intraoperatively, the right heel wound measured 12 x 5 cm with exposed bone. Following fixation of her right calcaneal fracture with headless screws, BTM was then applied directly over the bony defect to establish a vascularised scaffold in anticipation of flap inset.

The RSA flap was then designed and elevated, leaving 2 skin bridges (Figure 1). Atraumatic soft clamps (non-crushing clamps used to temporarily occlude skin bridges) were applied to the skin bridges and indocyanine green angiography (ICG) was performed, which showed good perfusion to 80% of the flap in 30 minutes and 100% upon release of medial clamps (Figure 2). The lateral skin bridge was then incised, and the medial skin bridge was preserved to provide supplemental vascularity to the flap's distal tip. BTM was applied to the base of the donor site as an interface between the flap and gastrocnemius muscles to prevent revascularization of the flap from the base and promote delay of the RSA flap, whilst simultaneously providing the vascularized scaffold for future skin grafting (Figure 3).

Post operatively, the patient underwent right lower limb angioplasty performed by the vascular team and dual antiplatelet therapy (aspirin and clopidogrel) was commenced. NPWT dressings were applied at -125 mmHg with foam interface dressings and changed every 7 days in the ward between operative

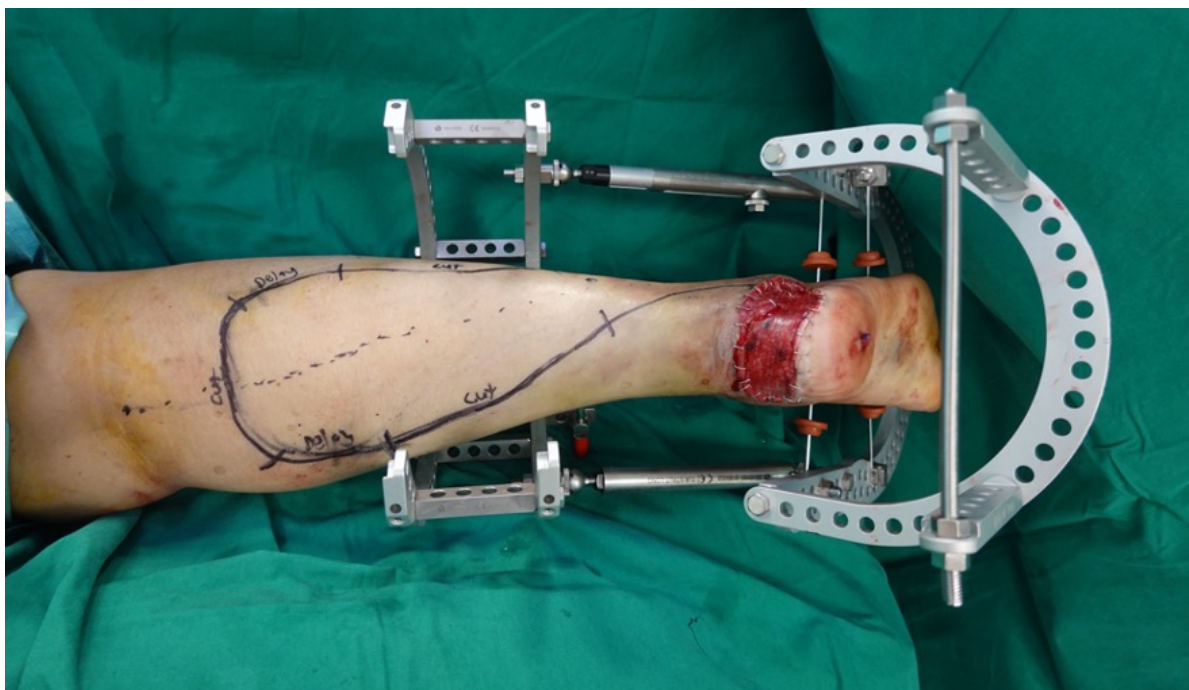


Fig. 1 — Application of external fixator; placement of BTM over the recipient site and planning of the flap incision. Cutaneous perforators are marked to ensure adequate vascular supply to the flap.

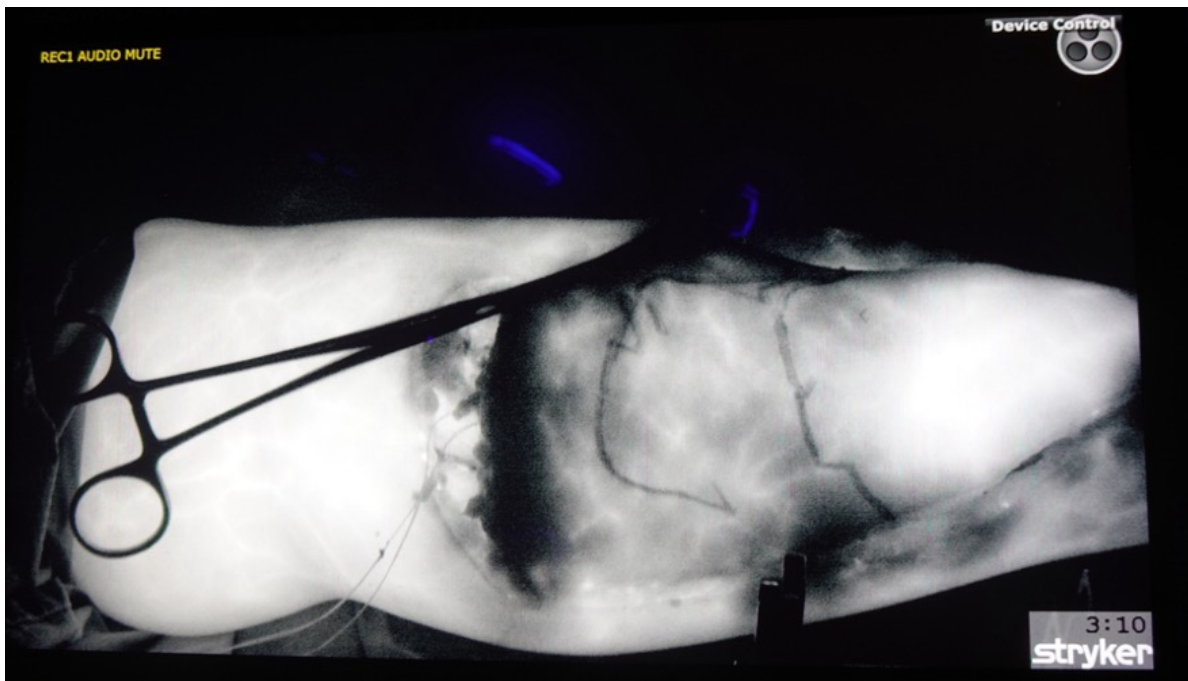


Fig. 2 — Following flap elevation, atraumatic clamps are applied to both skin bridges and indocyanine green (ICG) angiography is performed to ensure adequate perfusion before partial bridge division.

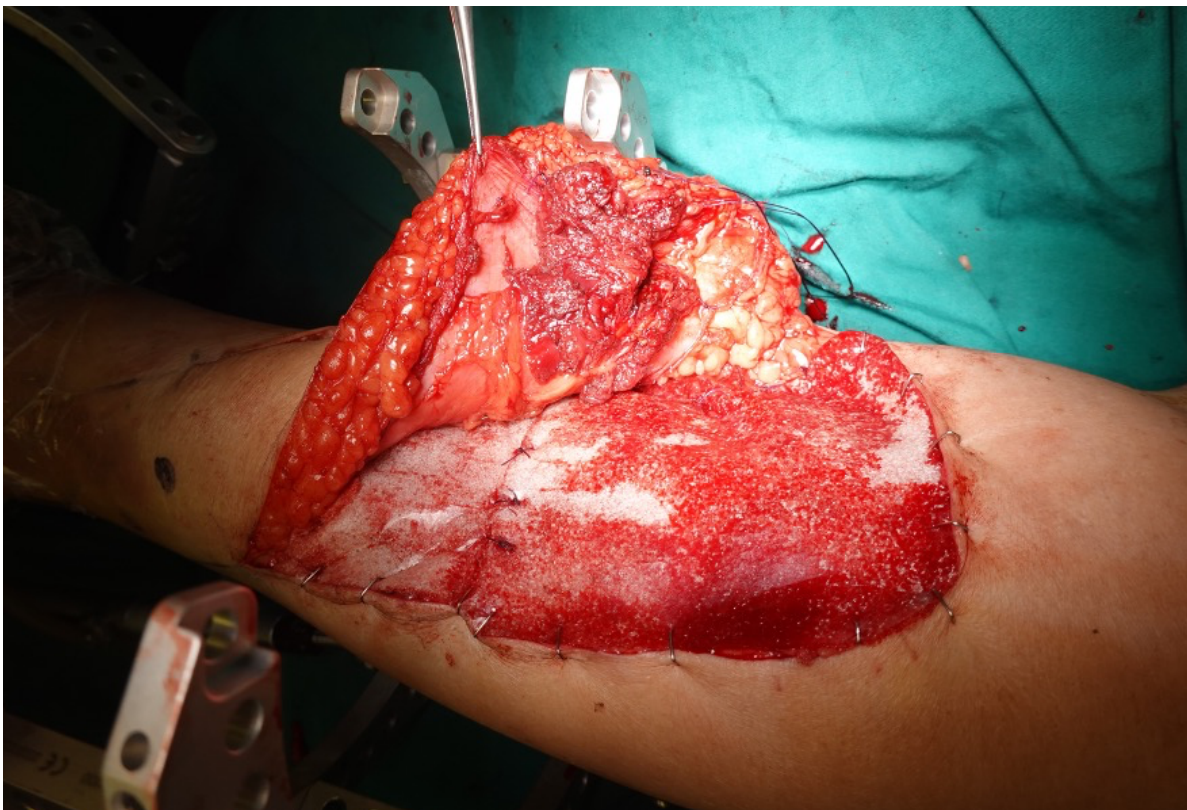


Fig. 3 — Integration of BTM to the donor site as a protective barrier between the flap and the wound bed.

stages. The medial skin bridge was divided in clinic by post-operative day 8. BTM was left undisturbed at both sites until delamination at the second-stage procedure, in keeping with the manufacturer's

recommended protocol. The patient then underwent a second stage procedure 6 weeks later, comprising of division, transposition and inset of flap with delamination of BTM, and split thickness skin

DISCUSSION

grafting of the donor site. Intraoperatively, it was shown that the flap was 95% viable, with distal 1cm rim showing congestion. Following delamination of BTM at both the donor and recipient sites, well-vascularised granulation tissue was observed. The skin graft was applied to donor site followed by flap inset (Figure 4).

The post-operative course was complicated by partial thickness flap loss over the distal 2 cm of the flap which was initially managed with serial dressing changes. The patient subsequently required a further return to theatre for debridement of necrotic tissue and skin grafting to the residual flap deficit. The wounds were noted to have fully healed by postoperative day 16 following regular wound care (Figure 5). The external circular frame was eventually removed, and patient was transferred for rehabilitation to a community hospital and was subsequently discharged. At subsequent clinic reviews, fracture union was confirmed radiologically, and the patient was able to ambulate without walking aids with no new wounds. Notably, no significant contour deformity of the calf was observed, and the patient reported no scar-related symptoms (Figure 6).

This case report describes a staged RSA flap technique incorporating dual application of BTM to both the recipient defect and the flap donor site. The clinical outcomes observed, including adequate flap viability, well-vascularised granulation tissue formation after BTM delamination, and satisfactory donor site healing, are consistent with existing literature on the efficacy of BTM in facilitating tissue reconstruction^{13,15}. However, given the inherent limitations of a single case report and the presence of significant confounding factors, the mechanistic roles attributed to BTM should be regarded as plausible hypotheses rather than demonstrated effects.

The proposed advantages of this technique may be summarised as follows. First, the technique provides a physical interface between the flap under-surface and the wound bed, potentially limiting early revascularisation and thereby facilitating the delay process; this may also simplify flap dissection at the time of the second-stage procedure. Second, BTM application to the donor site may contribute to improved aesthetic and functional contour of the calf following skin grafting, by creating

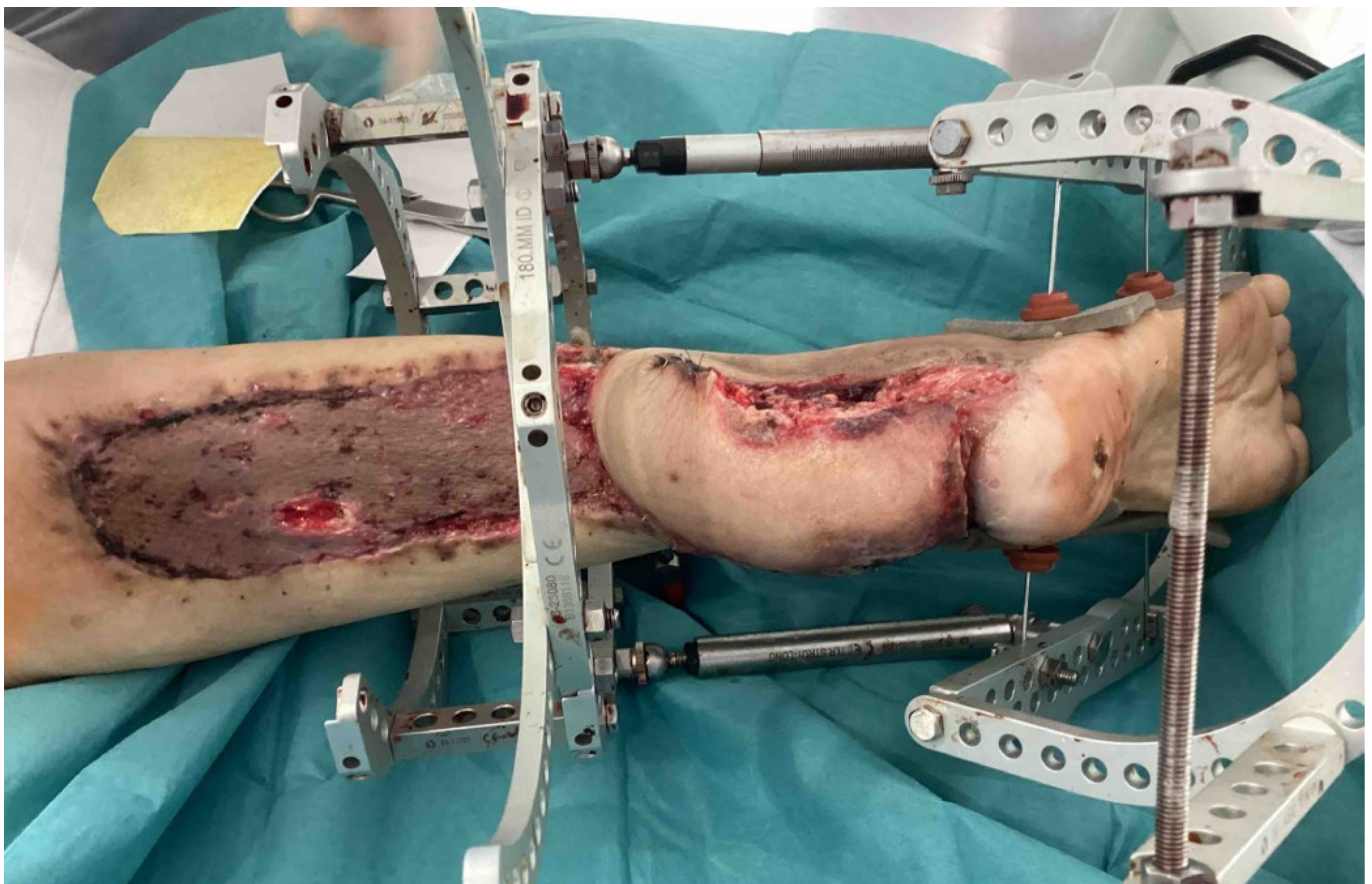


Fig. 4 — Wound inspection 1.5 weeks post inset. There is a small area of partial flap necrosis at the distal tip within a non-critical area.



Fig. 5 — Wound fully healed by post operative day 16.

an intermediate layer of neo-dermis. Third, the quality of the granulation tissue bed generated may allow the use of thinner split-thickness skin grafts and facilitate graft take at the donor site. Fourth, BTM application to the recipient site may provide a safeguard against partial flap necrosis, ensuring that in the event of distal flap compromise, an adequate granulation tissue base exists to support secondary skin grafting. These proposed mechanisms are, however, speculative in the absence of comparative data and should be evaluated prospectively.

While previous studies have explored various dermal matrices (such as Integra, Matriderm, and AlloDerm) to reduce donor site morbidity in flaps like the radial forearm free flap, there is currently no literature regarding the use of BTM for the delayed RSA flap¹⁶⁻¹⁸. BTM appeared to be beneficial in this case for the reasons outlined above; however, this observation must be interpreted with caution given the multiple confounding factors present.

A significant confounding factor in this case is that the patient underwent lower limb angioplasty for peripheral vascular disease, with subsequent commencement of dual antiplatelet therapy. Angioplasty-based revascularisation has been shown to improve free flap survival¹⁹, and it is plausible that improved arterial inflow similarly contributed to the satisfactory outcome observed in this case. The

relative contributions of BTM application, surgical delay, and angioplasty-mediated revascularisation cannot be isolated from one another in this single case. This represents a critical limitation that must be acknowledged, and the favourable outcome should not be attributed solely to the use of BTM.

Furthermore, the postoperative course was not uncomplicated. Partial-thickness flap loss at the distal tip necessitated a return to theatre for debridement and skin grafting, reflecting the well-documented limitations of the RSA flap in high-risk patients^{2,9}. This outcome serves as an important reminder that the described technique does not fully mitigate the risks inherent to RSA flap reconstruction, and any conclusions regarding its safety and efficacy must be interpreted with appropriate caution.

The RSA flap is frequently employed in patients who are not suitable candidates for free tissue transfer, including those with diabetes mellitus, peripheral vascular disease, chronic kidney disease, and cardiac comorbidities². Surgery in this population has traditionally been associated with suboptimal outcomes, and some patients may ultimately require amputation — a procedure associated with considerable functional and psychosocial morbidity. Recent advances have shifted the focus toward limb salvage strategies, including free and locoregional soft tissue reconstruction, as preferred alternatives to

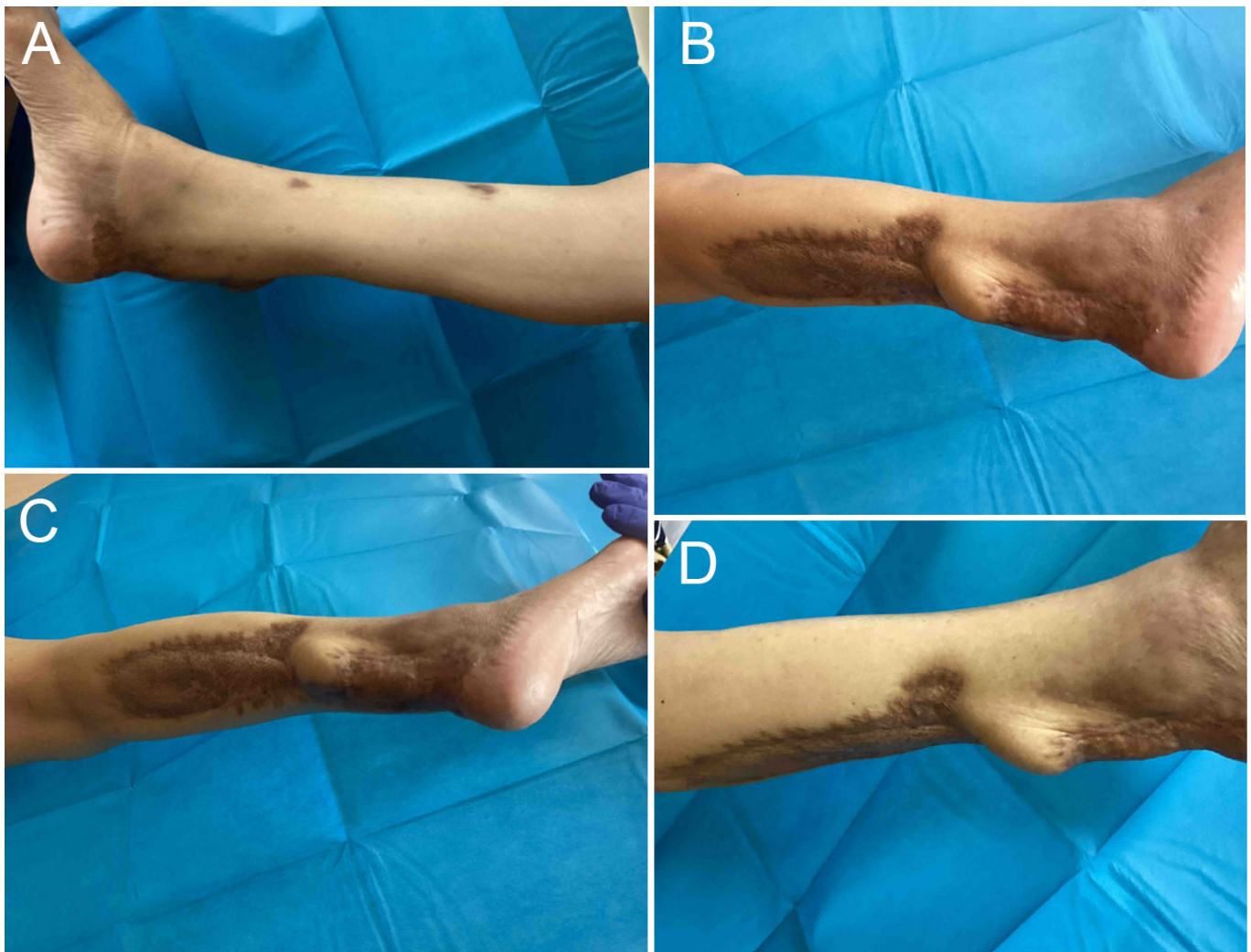


Fig. 6 — Clinical review in 9 months post operatively showing no prominent contour deformity of her calf. (A–D) Multiple views of the donor site at different angles.

primary amputation. Nevertheless, the risk of partial or total flap failure remains elevated in this cohort due to atherosclerotic disease, microvascular dysfunction, and susceptibility to infection^{2,9}.

The importance of early and reliable soft tissue coverage in distal lower limb trauma extends beyond wound closure. Adequate soft tissue management is integral to infection prevention, protection of underlying fixation hardware, and optimisation of fracture healing. Various reconstructive strategies have previously been described for high-risk patients, including external fixation techniques such as the Ilizarov method to facilitate wound closure when flap reconstruction is not feasible²⁰ and the Papineau open cancellous bone grafting technique for managing infected bony defects²¹. The combination of BTM and the staged RSA flap may represent a useful addition to this reconstructive armamentarium, particularly where microsurgical options are precluded.

The use of a circular external fixator in conjunction with the reverse sural artery flap presents specific technical considerations. Boopalan and Jepegnanam²² have previously described the technical feasibility of reverse sural flap coverage performed within the constraints of a ring fixator frame, demonstrating that the presence of circular fixation need not preclude this reconstructive option. Their experience is directly relevant to the present case, in which an Ilizarov-type circular frame was applied for heel offloading prior to flap reconstruction, and supports the viability of this combined orthoplastic approach in high-risk patients.

The optimal interval for flap delay remains a subject of debate, with most published series reporting intervals of between two and four weeks^{23–25}. These periods are considered sufficient to allow vascular remodelling and collateralisation, thereby enhancing flap perfusion at the distal tip. In this case, preservation of the medial skin bridge until postoperative day 8 was

intended to provide supplemental vascularity during the early delay period. A further four to five weeks elapsed prior to the second-stage procedure, allowing additional neovascularisation and integration of the BTM-treated wound beds. This extended delay was intentional, aiming to maximise perfusion before definitive flap transposition. Whether this interval is optimal in the context of BTM application warrants further investigation.

It is also pertinent to consider other surgical modalities aimed at reducing donor site morbidity in reverse RSA flaps. One notable alternative is the adipofascial variant of the flap, which preserves the overlying skin at the donor site, thereby avoiding the need for donor site skin grafting. However, while adipofascial flaps mitigate donor site morbidity, they may lack the robust soft tissue bulk required for deep heel defects as skin graft is often required at the recipient site. Techniques such as venous superdrainage and supercharging have also been described to address venous congestion and improve distal flap perfusion.

There are some limitations of this technique. The primary concern with RSA flaps remains venous congestion rather than arterial insufficiency. Whilst surgical delay of flap inset is intended to promote vascular remodelling through a relative ischemia, which helps to increase vessel size, reorientation, and promote angiogenesis, to improve arterial blood supply²⁶, its efficacy in promoting venous return is still debatable. The staged approach also imposes additional burden on both the patient and the surgical team, including multiple operative episodes, prolonged dressing changes, and extended flap monitoring. Nonetheless, this approach may be particularly valuable in patients at high risk of flap compromise, in whom the granulation tissue bed generated by BTM provides a clinically relevant fallback should distal flap necrosis occur.

Further studies can explore the use of this novel staged technique in a prospective study with a larger cohort and investigate its effectiveness in improving both arterial and venous supply, alongside any other potential caveats that need to be taken note of.

CONCLUSION

This case report describes a staged RSA flap technique incorporating dual application of BTM to both donor and recipient site wound beds in a high-risk patient with a distal lower limb defect. The observed outcomes — including satisfactory flap viability,

well-vascularised granulation tissue formation, and acceptable donor site healing — suggest that this approach may represent a feasible and promising adjunct to staged RSA flap reconstruction. However, these findings must be interpreted in the context of a single case complicated by partial flap necrosis and a significant confounding revascularisation procedure. The proposed mechanistic effects of BTM remain speculative and require validation in prospective studies with larger patient cohorts.

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REFERENCES

1. Price, M.F., et al., Reverse sural artery flap: caveats for success. *Annals of plastic surgery*, 2002. 48(5): p. 496-504.
2. Tu, Y.-K., et al., Reconstruction of ankle and heel defects by a modified wide-base reverse sural flap. *Journal of Trauma and Acute Care Surgery*, 1999. 47(1): p. 82-88.
3. Tripathee, S., et al., How Safe Is Reverse Sural Flap?: A Systematic Review. *Eplasty*, 2022. 22.
4. Pinsolle, V., et al., Soft-tissue reconstruction of the distal lower leg and foot: are free flaps the only choice? Review of 215 cases. *Journal of plastic, reconstructive & aesthetic surgery*, 2006. 59(9): p. 912-917.
5. Ciofu, R., et al., Reverse sural flap for ankle and heel soft tissues reconstruction. *Journal of Medicine and Life*, 2017. 10(1): p. 94.

6. Schmidt, K., et al., The reverse sural artery flap—How do modifications boost its reliability? A systematic analysis of the literature. *JPRAS open*, 2020. 26: p. 1-7.
7. Kneser, U., et al., Delayed reverse sural flap for staged reconstruction of the foot and lower leg. *Plastic and reconstructive surgery*, 2005. 116(7): p. 1910-1917.
8. Afifi, A.M., et al., The reverse sural flap: modifications to improve efficacy in foot and ankle reconstruction. *Annals of plastic surgery*, 2008. 61(4): p. 430-436.
9. De Blacam, C., et al., Risk factors associated with complications in lower-extremity reconstruction with the distally based sural flap: a systematic review and pooled analysis. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 2014. 67(5): p. 607-616.
10. Parrett, B.M., et al., Risk analysis for the reverse sural fasciocutaneous flap in distal leg reconstruction. *Plastic and reconstructive surgery*, 2009. 123(5): p. 1499-1504.
11. Oh, S.W., S.O. Park, and Y.H. Kim, Resurfacing the donor sites of reverse sural artery flaps using thoracodorsal artery perforator flaps. *Archives of Plastic Surgery*, 2021. 48(06): p. 691-698.
12. Cheshire, P.A., et al., Artificial dermal templates: a comparative study of NovoSorb™ biodegradable temporising matrix (BTM) and Integra® dermal regeneration template (DRT). *Burns*, 2016. 42(5): p. 1088-1096.
13. Solanki, N.S., et al., A consecutive case series of defects reconstructed using NovoSorb® Biodegradable Temporising Matrix: Initial experience and early results. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 2020. 73(10): p. 1845-1853.
14. Frost, S.R., A. Deodhar, and G.J. Offer, A novel use for the biodegradable temporizing matrix. *European Journal of Plastic Surgery*, 2022. 45(6): p. 1015-1020.
15. Greenwood, J.E., B.J. Schmitt, and M.J. Wagstaff, Experience with a synthetic bilayer biodegradable temporising matrix in significant burn injury. *Burns Open*, 2018. 2(1): p. 17-34.
16. Shah R, Rodrigues R, Phillips V, Khatib M. The use of artificial dermal substitutes for repair of the donor site following harvesting of a radial forearm free flap: A systematic review. *J Plast Reconstr Aesthet Surg*. 2024 Jan;88:501-516. doi: 10.1016/j.bjps.2023.11.046. Epub 2023 Nov 30. PMID: 38101265.
17. Rowe NM, Morris L, Delacure MD. Acellular dermal composite allografts for reconstruction of the radial forearm donor site. *Ann Plast Surg*. 2006 Sep;57(3):305-11. doi: 10.1097/01.sap.0000221622.41450.60. PMID: 16929200.
18. Di Giulio R, Dicorato P, Kaciulyte J, Marinari N, Conversi F, Mazzocchi M. Donor Site Wound Healing in Radial Forearm Flap: A Comparative Study Between Dermal Substitute and Split-Thickness Skin Graft Versus Full-Thickness Skin Graft Primary Coverage. *Ann Plast Surg*. 2021 Jun 1;86(6):655-660. doi: 10.1097/SAP.0000000000002777. PMID: 33661229.
19. Jang, Y.J., et al., Successful lower extremity salvage with free flap after endovascular angioplasty in peripheral arterial occlusive disease. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 2014. 67(8): p. 1136-1143.
20. Dauwe J, Declerck E, Verhulst K, Lammens J. Soft tissue defect closure using an Ilizarov frame: a case series. *Acta Orthop Belg*. 2024 Jun;90(2):287-292. doi: 10.52628/90.2.10777. PMID: 39440505.
21. Boonen M, Ginckels L, Tuerlinckx G, Lammens J. Papineau-irrigation technique: an alternative treatment of fracture-related infectious soft tissue defects. *Acta Orthop Belg*. 2023 Dec;89(4):651-658. doi: 10.52628/89.4.12193. PMID: 38205756.
22. Boopalan PR, Jepegnanam TS. Reverse sural flap cover within a ring fixator. *Acta Orthop Belg*. 2010 Oct;76(5):684-8. PMID: 21138227.
23. Tosun Z, Ozkan A, Karaçor Z, Savaci N. Delaying the reverse sural flap provides predictable results for complicated wounds in diabetic foot. *Ann Plast Surg*. 2005 Aug;55(2):169-73. doi: 10.1097/01.sap.0000170530.51470.1a. PMID: 16034248.
24. de Rezende MR, Saito M, Paulos RG, Ribak S, Abarca Herrera AK, Cho ÁB, Mattar R Jr. Reduction of Morbidity With a Reverse-Flow Sural Flap: A Two-Stage Technique. *J Foot Ankle Surg*. 2018 Jul-Aug;57(4):821-825. doi: 10.1053/j.jfas.2017.11.020. Epub 2018 Mar 1. PMID: 29503140.
25. Kneser U, Bach AD, Polykandriotis E, Kopp J, Horch RE. Delayed reverse sural flap for staged reconstruction of the foot and lower leg. *Plast Reconstr Surg*. 2005 Dec;116(7):1910-7. doi: 10.1097/01.prs.0000189204.71906.c2. PMID: 16327603.
26. Fisher, J. and M. Gingrass, Basic principles of skin flaps. *Textbook of Plastic, Maxillofacial, and Reconstructive Surgery*. Baltimore: Williams and Wilkins, 1997: p. 19-28s

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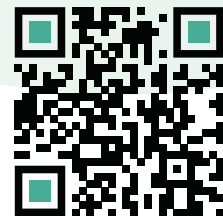
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