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CASE REPORT
Reconstructive

A Synthetic Biodegradable Temporising Matrix in Degloving Lower Extremity Trauma Reconstruction: A Case Report

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Summary: Presented is the case of an obese, 72 year-old diabetic man with a dorsal foot de-gloving injury. Whilst the tendons of extensor hallucis longus, extensor digitorum longus to all digits, and extensor digitorum brevis to hallux and second toe were intact after surgical debridement, none had any covering paratenon. The joint between the medial cuneiform and first metatarsal was open. Reconstructive options were limited by his age and co-morbidities. A novel, completely synthetic dermal matrix (NovoSorb BTM) was applied, after which the patient was discharged home to attend for dressings and review of integration progress as an outpatient. He was allowed to mobilise without limitation. Because of the poor quality of the wound bed (and patient), the material integrated slowly over 9 weeks. Delamination of the matrix, and definitive closure by application of sheet split skin autograft, produced a robust, soft, mobile and excellent aesthetic result, over which he could wear footwear immediately. Clinically, the paratenon-denuded tendons glided under the neo-dermis without tethering to the overlying integrated matrix, allowing a full range of digital movement. This was confirmed on ultrasound examination, which also demonstrated no inflammation or oedema. Already proven in extensive burns, necrotising fasciitis and complex surgical wounds, BTM represents a useful addition to the reconstructive surgeon's toolbox. *(Plast Reconstr Surg Glob Open 2019;7:e2110; doi: 10.1097/GOX.0000000000002110; Published online 2 April 2019.)*

Development of Novosorb Biodegradable Temporising Matrix (BTM) as a dermal substitute began at the Royal Adelaide Hospital, South Australia, initially with human in vitro cellular studies, progressing to small and large animal models, then human pilot trials in pressure sore management and in the reconstruction of free flap donor sites.[1] The observed ability of BTM to resist infection and ability to integrate into large wound beds[2] prompted its use in the reconstruction of postdebridement necrotising fasciitis defects.[3]

With extensive working experience of the application and management of BTM, the reconstruction of a degloving injury of the foot suffered by an elderly, obese diabetic patient with multiple comorbidities was performed because primary split skin grafting (SSG) was unlikely to succeed or provide sufficient robustness and patient suitability for free tissue transfer was compromised by age, comorbidities, and anesthetic safety.

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CASE

An obese, 72-year-old man degloved the soft tissues of the dorsum of his right foot, when it was crushed and sheared between a car door and a metal cupboard in his garage when the car rolled with handbrake failure. He had hypertension and diabetes.

Initial surgery involved extensive soft-tissue debridement of the dorsum of the foot, exposing deep structures, including bone. Dorsalis pedis and posterior tibial pulses were palpable. The avulsed soft tissues were not suitable for replantation as a graft. A vacuum-assisted closure dressing was applied.

The wound bed would not support split thickness skin graft reconstruction without excision of the extensor tendons. The unopposed flexors would then hammer the toes, and his diabetic microangiopathy would subsequently risk damage and ulceration to the skin over the digital

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Fig. 1. Day 0, following debridement of nonviable tissue exposing superior and inferior extensor retinacula, digital extensor expansions (I and II), one of the terminal branches of the superficial peroneal nerve, the terminal branch of the saphenous nerve and the tendons of EHL and EHB, and EDL to all 4 toes. All of the tendons are denuded of paratenon. The joint between the medial cuneiform and the base of the first metatarsal is also open. EDL indicates extensor digitorum longus; EHB, extensors hallucis brevis.

Fig. 2. BTM applied, held with staples on day 4. Pallor over EHL is obvious, but integration has commenced over the rest of the wound.

Fig. 3. Delamination and dermabrasion of the underlying neodermis on day 63; this was followed by fenestrated sheet split skin graft application.

joints, with the potential for open joints requiring amputation later. Despite his age, obesity, and comorbidities, reconstruction by free tissue transfer was discussed with the patient, who was keen to avoid prolonged surgery. BTM was offered as a simple potential solution, to which he was agreeable, and a surgical plan was formulated.

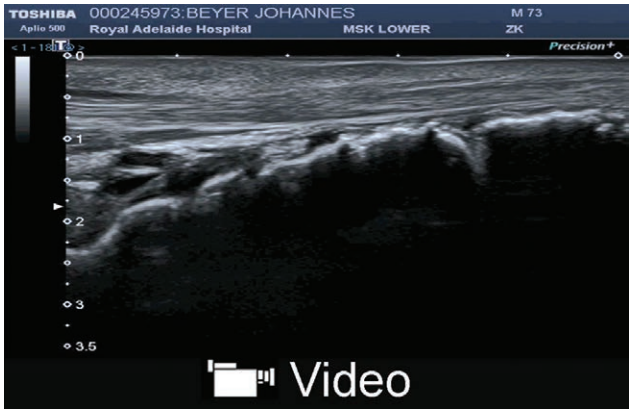
His wound was further debrided under regional anesthesia and BTM applied (Fig. 1) on what we consider to be "Day 0." Four days later, the BTM was showing the early signs of integration (Fig. 2). He was discharged home on day 7 post-BTM application and attended for outpatient dressing changes twice a week to monitor integration.

On day 63, he returned to theater for delamination of BTM (Fig. 3) and definitive coverage with fenestrated sheet split thickness autograft. A small area of breakdown adjacent to the extensors hallucis longus (EHL) tendon required further skin grafting before full healing.

Sixteen months postsurgery, he has a mature, pliable stable scar (Fig. 4) and full range of motion of his toe extensors (first recorded at 9 months) [**see** Video 1, Supplemental Digital Content 1, which displays wound appearance, digital and ankle movement at 9 months (267 days) post-BTM application, and 204 days post graft ap-

Fig. 4. The result at review on day 486.

Video Graphic 1. See video, Supplemental Digital Content 1, which displays wound appearance, digital and ankle movement at 9 months (267 days) post-BTM application, and 204 days post graft application, ***http://links.lww.com/PRSGO/A978***.



Video Graphic 2. See video, Supplemental Digital Content 2, which displays the ultrasound of the unimpeded movement of the EHL tendon deep to the graft over the integrated BTM on day 486, ***http://links.lww.com/PRSGO/A979***.

plication, *http://links.lww.com/PRSGO/A978*]. Recent ultrasound scanning of the healed area demonstrates gliding of the EHL and extensor digitorum longus tendons, with no evidence of tethering deep to the BTM/SSG reconstruction (**see** Video 2, Supplemental Digital Content 2, which displays the ultrasound of the unimpeded movement of the EHL tendon deep to the graft over the integrated BTM on day 486, ***http://links.lww.com/PRSGO/A979***).

DISCUSSION

Degloving injuries of the lower limb are challenging, as extensive tissue damage often curtails reconstructive options. Treatment involves adequate debridement, and, if appropriate, the avulsed skin can de defatted and remain attached, or excised and defatted, to be reapplied as an autograft.[4] If avulsed tissue is unsuitable, autologous skin grafting onto a healthy wound bed is preferred. Adjunctive techniques include closed drainage with compression bandaging, bolstering of grafts, and topical negative-pressure therapy dressings applied over the skin reconstruction of choice.[5,6] However, degloving injuries involving deeper tissues are associated with increased risk of infection and graft loss, particularly in the elderly.[7]

Developments with acellular dermal matrix (Integra, produced by Integra LifeSciences, Plainsboro, New Jersey, USA)) and split skin grafting offer a staged reconstructive option, improving vascularity, contour, and quality of the wound bed before definitive closure. In 7 pediatric patients with lower extremity wounds and exposed tendons, minimal complication and good function were reported with Integra[8] and a study of 21 ankle and foot reconstructions in adult subjects similarly treated following severe soft-tissue trauma, demonstrated fair outcomes at 4 years, according to Foot and Ankle Ability Measures.[9] Tendon glide was, however, not imaged by any modality in these articles, and it was not reported whether the tendons had been traumatically denuded of paratenon before wound reconstruction. Precedence for using a dermal substitute in our case had thus been established.[8,9]

This case involved avulsion of the dermis and subcutaneous tissue, paratenon-denuded extensor tendons, and exposed bone. The rationale for using BTM was based on our extensive experience of the qualities of BTM in establishing a robust tissue layer for encouraging and incorporating split skin graft take. In particular, the preservation of tendon glide had been noted clinically when BTM was used in radial forearm donor site reconstruction.[10] This case differed because paratenon was lost. The ultrasound scan at 16 months demonstrated EHL and extensor digitorum longus tendons gliding freely under the site of the graft repair without evidence of tethering. The normal tendon fibrillary pattern was preserved with no evidence of peritendinous edema, or hyperemia, to suggest inflammation.

This case is published in isolation to illustrate a particular finding (tendon gliding under the material despite lack of paratenon), and readers should reference our previous work for other examples of outcome.[1–3,10] BTM is regulated in the United States under an FDA 510(k) (a regulatory pathway granted by the US Food and Drug Administration prior to a company commercialising its product, where evidence that the medical device intended to be marketed is safe and effective) for use in wounds (excluding deep burns) and can be used now by US surgeons for similar indications. It is fully regulated for use in any wound in Australia and is also available in South Africa, India, Saudi Arabia, and Israel. The authors' understanding is that the cost of the material will vary according to jurisdiction and that costs have not yet been finalized. In Europe, Conformité Européenne marking has not yet been achieved.

CONCLUSIONS

This case reports the successful use of BTM and split thickness skin grafting for a lower limb degloving injury. Ultrasound examination suggests that BTM applied over denuded tendons does not seem to restrict glide or induce tethering.

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