



Caveats and Technique for the Reconstruction of Burn Contractures Using an Artificial Dermis in a Tropical Burns Centre

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Abstract

There is a paucity of data on the use of dermal substitutes in a tropical burns centre, as its use was previously complicated by a high infection rate in the Southeast Asian region, further hindered by high costs. We hence describe our successful experience with a bi-layered artificial dermis (Pelnac™) and thin split-thickness skin graft (STSG) in treating post-burns hypertrophic scars and contractures when a lack of donor sites precluded reconstruction with traditional locoregional flaps. A two-staged procedure comprising artificial dermis and STSG was used to reconstruct full thickness wounds after excision of burn contractures over 11 sites (5 patients) - three wrists, three necks, two ankles, one elbow, one chin, and one ear auricle. Time to skin grafting was 18.4 days, with a 100% STSG take. One wound (9%) developed hypertrophic scarring around its border but the rest healed with a pliable consistency and satisfactory cosmetic outcome. Full range of motion was restored in treated scars located over joints. No infective complications were encountered. We demonstrate that a bi-layered artificial dermis with STSG may be used reliably in a tropical burns centre with no infective complications, whereby a consistent technique contributes greatly to its success.

Keywords: Burn contracture; Artificial dermis, Scar, Reconstruction

Introduction

After initial wound healing is achieved, patients with extensive burn injuries often suffer a second blow in the form of hypertrophic scarring, keloid formation and consequent scar contractures. These scars frequently cause functional impairment necessitating surgical release and reconstruction. Further more, scarring may cause physical discomfort in the form of pain or itch, and negatively affect a patient's emotional wellbeing and social functioning [1]. These late complications pose a significant challenge in extensively burned patients who lack healthy donor sites for traditional reconstructive methods such as local or regional flaps after scar release.

Dermal substitutes have yielded good results in acute and reconstructive burn wounds, of which the use of Integra® is among the most widely reported [2-5]. Integra® however has been associated with infective complications [4,6,7]. This, combined with a high product cost, has resulted in the near absence of Integra and other dermal substitutes in the armamentarium of burn treatment in Southeast Asia for the last decade.

Pelnac™ (Gunze Corp., Osaka, Japan) is a dermal regeneration template first described in 1990 [8] as a modification of the "artificial skin" developed by Yannas et al. in the 1980s [9]. There is a paucity of evidence for the use of Pelnac™ in the existing literature, particularly in the setting of a tropical burn centre.

We thus present our experience with the treatment of hypertrophic burn scars and scar contractures using Pelnac™ in patients where donor sites were limited. We describe a consistent surgical technique which contributed to a successful outcome, with no infective complications in our tropical burn center.

Materials and Methods

Patients

5 patients were enrolled in the study after informed consent was obtained. Medical records were reviewed for patient demographics and details of the initial burn injury. Pre- and post-operative

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Table 1: Patient and wound characteristics.

Patient	Age (years)	Gender	Ethnicity	Aetiology of burn injury	Extent of initial burn injury (% TBSA)	Location of wound	Time to STSG coverage (days)	Duration of follow-up (months)
1	26	M	Chinese	Flame	68	Right wrist	19	25
2	35	M	Indian	Flame	70	Bilateral ankles Left elbow Right wrist	14	4
3	31	M	Indian	Flame	50	Chin Anterior neck Anterior chest	23	4
4	55	M	Chinese	Chemical	60	Right auricle Left wrist	17	10
5	46	F	Malay	Flame	46	Left neck	19	6

photographs were obtained. All patients underwent excision of hypertrophic burns scars and reconstruction with a bi-layered artificial dermal template (Pelnac™), followed by thin split thickness skin grafting (STSG) from December 2015 to August 2016. Treatment details that were considered were as follows: location of burns scar, time to STSG, complications, post-operative scar consistency and functional outcomes. Patients were followed up prospectively after surgery.

Surgical technique

Areas of hypertrophic scarring were excised sharply down to healthy underlying subcutaneous tissue to release all scar contractures. Wounds were washed and meticulous hemostasis achieved. Pelnac™ was prepared according to the standard manufacturer's guidelines. Prior to application, Pelnac™ was first immersed in sterile saline solution, trimmed to the shape of the wound and then placed over the wounds with the atelocollagen sponge layer in contact with the wound surface. The peripheries of the Pelnac™ material were secured to the wound edges using vicrylrapide™ 5-0 absorbable sutures. Quilting sutures were placed. Negative pressure woundtherapy (NPWT) dressing was then applied over Pelnac™. This was replaced with foam dressings after 7 days for better patient comfort and cost management. An STSG (9:1000th of an inch) was then applied and secured with either a NPWT dressing or a proflavin tie-over bolster dressing. Wounds were inspected five days after STSG.

Results

A total of 11 hypertrophic burns scars and contractures in 5 patients were treated at our tropical burns centre using the consistent method described above. The mean age of our patients was 38.6 years (range 26 to 55 years). The aetiology of their burn injuries were flame burns in four patients and chemical burns in one patient. Hypertrophic scars and scar contractures located over three wrists, three necks, two ankles, one elbow, one chin, and one ear auricle were treated. Patient and wound characteristics are detailed in Table 1. All scars had developed over previous areas of deep partial to full thickness burns. Scars that extended over joints had previously resulted in a reduction in a loss of range of motion and functional impairment. Patients were followed up for a mean of 9.8 months (range 4 to 25 months).

There were no instances of wound infection after Pelnac™ application. All wounds were ready for grafting with a single application of Pelnac™. The presence of a well-vascularised neodermis with a reddish hue was used as the indicator of a suitable bed for skin grafting. The mean time to application of the split thickness skin graft was 18.4 days (range 14-23) days, with a 100% rate of STSG take. None of the wounds required further debridement or secondary procedures.



Figure 1: Pre-operative appearance of bilateral ankle scars (Patient 2). Thick scars over the medial (A, D) and dorsal (B, C) aspects of bilateral ankles resulted in contractures and limitation in ankle dorsiflexion, plantarflexion and eversion. Walking was limited by pain and the restricted range of motion of the ankle joint.

At two months' follow up, one (9.1%) of the wounds located over a wrist had developed hypertrophic scarring around the border of the skin graft. This however did not significantly affect the range of motion of the underlying joint or the pliability of the graft itself. The rest healed well and the resultant scars remained flat, soft and pliable. The colour of the scars was also found to remain similar to the site from which the STSG was harvested. At 6 months' follow-up, keloid scarring had partially recurred in the wound of a second patient (9.1%). Secondary contraction had occurred in 2 wounds (18.2%) although the consistency of the skin remained soft. The rest of the wounds remained pliable. Where treated scars were located over joints, the patients experienced no restriction of movement.

Case Presentation

Patient 2 was a 35-year-old man of Indian ethnicity involved in an industrial accident, sustaining flame burns to 70% of his total body surface area (TBSA) that were deep dermal to full thickness. He required repeated burn wound excisions and skin cover with autografts, allografts, cultured epithelial autografts and micrografts. His prolonged recovery was complicated by pneumonia, acute kidney injury and septic shock. Hypertrophic scarring developed over most wounds but surgical release of those over the volar aspect of his right wrist, left elbow and bilateral ankles figure 1 was planned as they were causing functional restrictions. All affected areas were excised down to healthy subcutaneous tissue before Pelnac™ was applied (Figure 2). When healthy neodermis had formed on the wound beds (Figure 3), a thin split-thickness skin graft was applied. At four months' follow-up, all treated areas maintained a soft, pliable texture with a good range of motion that allowed the patient to stand and walk without restriction (Figure 4).

Patient 4 was a 55-year-old man who sustained chemical burns to his face, trunk and upper limbs requiring excision and split thickness



Figure 2: Wound appearance after excision of scars and application of Pelnac™. Pelnac™ was cut to fit the size of the defect following excision of the offending scars. The edges were secured using vicrylrapide™ 5-0 sutures and quilting sutures were applied.



Figure 3: Wound appearance before application of STSG. A reddish hue indicated the presence of a healthy, well-vascularised neodermis that would allow for the STSG to take successfully.

skin grafting. He developed hypertrophic scarring and meatal stenosis of his right auricle that was causing hearing loss and was difficult to clean. Thick scarring over the radial aspect of his left wrist, thumb and radial snuffbox restricted wrist flexion and pincer grip (Figure 5). The wrist scar was excised till adequate range of motion was achieved (Figure 6) and Pelnac™ applied. Scar release and meatoplasty of his right auricle were performed, after which the pre-auricular wound was resurfaced with Pelnac™. He regained a good range of motion in his left hand after the skin grafts had taken (Figure 7).

Discussion

Hypertrophic scarring has been found to develop in up to 70% of burns wounds [10] and poses a significant challenge to reconstruction, especially in patients with extensive burns, as was the case in our series with a mean TBSA involvement of 58.8% (range 46%-70%). Our experience adds to the existing evidence that Pelnac™ is an efficacious alternative to conventional treatment methods of burns scars and contractures. Recently, Widjaja et al. described their results with Pelnac™ in the treatment of complex wound defects [11]. To our knowledge, ours is the first series to focus on the use of Pelnac™ in the treatment of hypertrophic burns scars and scar contractures in a tropical burns centre.

Pelnac™ consists of an inner atelocollagen layer derived from porcine tendon, reinforced by another silicone film for mechanical strength. After placement over the wound bed, the soft collagen sponge conforms well, even on wounds to irregular surfaces. The



Figure 4: Post-operative wound appearance. The patient regained a full range of motion in both his ankles, allowing him to stand and walk comfortably. The treated areas remained soft and pliable, with the STSG retaining the colour of the donor site.



Figure 5: Pre-operative appearance of left wrist and thumb scars (Patient 4). The thick, hypertrophic scars over the radial and dorsal aspect of this patient's wrist and thumb resulted in a limitation in wrist extension, flexion and thumb pincer grip.



Figure 6: Wound appearance after contracture release. Scars that were causing functional restriction were excised sharply down to healthy underlying fat (A) and the adequacy of release was assessed intra-operatively before the application of Pelnac™ (B).

pores of the atelocollagen sponge are infiltrated with cellular tufts of fibroblasts and capillaries as the original network of collagen and glycosaminoglycans are degraded, forming a well-vascularised neodermis on which a thin STSG may be placed. Wound beds that



Figure 7: Post-operative appearance after healing of STSG. The patient regained a good range flexion and extension in the wrist, as well as pincer grip after the STSG had healed.

were resurfaced with this dermis-like tissue has been shown to have significantly less post-operative contracture compared to controls. The use of atelocollagen instead of in soluble bovine collagen used in Integra® minimises the antigenicity of the material, and as a consequence the inflammatory response that can result in rejection and failure [8,12].

We found that these beneficial properties of Pelnac™ translated to successful outcomes in our series. Asians, especially those with darker pigmentation have a greater tendency for hypertrophic scar and keloid formation compared to Caucasians [13], compounding the challenge of managing patients with extensive burns in our population. We were able to achieve fairly good results with Pelnac™ even in these patients, with most treated areas remaining soft and pliable up to 25 months after skin graft placement. In our series, no infective complications were encountered. This gives it a compelling advantage over Integra®, which has been shown to have microbial colonisation or infection as a common post-operative complication [4]. A part from the intrinsic properties of Pelnac™, we believe that the consistent use of negative pressure wound therapy (NPWT) acted as an effective barrier to infection and reduced seroma and hematoma accumulation which could contribute to a higher infection rate. In addition, Pelnac™ offers benefits comparable to that of other dermal substitutes such as Integra® at more than half the cost at our institution, making it an attractive alternative in our practise.

Apart from a reduction in infective complications, NPWT has been associated with improved outcomes when used in combination with dermal substitutes, including a higher elasticity of scars compared to wounds treated with dermal substitutes alone [14]. Studies have also demonstrated an accelerated incorporation of artificial dermis with NPWT [15-17]. The mean time to grafting in our series was 18.4 days (14-23 days). We believe the consistent use of NPWT in all our patients contributed to the absence of infection and a shorter duration to STSG application. The use of NPWT also allowed for patients to be managed in the outpatient setting without the concerns of a breach in wound sterility or inadvertent shearing of the artificial dermis from the wound bed.

Despite the many advantages of using Pelnac™ in the treatment of hypertrophic scars, we did notice a fair amount of wound contraction in 18% (n=2) of the wounds, although the scars remained flat and soft with retention of the skin colour of the STSG donor site (patient 3–chinwound, patient 4–pre-auricular wound). This is consistent with the results of Hur et al. [17] who demonstrated that wounds resurfaced with artificial dermis (Matriderm) contracted to 85% of the original graft size 6 months following grafting. Partial recurrence of keloid scarring occurred in 9% (n=1) of the wounds in a patient with a known tendency to keloid formation. The efficacy of Pelnac™ in these patients remains questionable from our study.

This study represents our initial experience with Pelnac™ which has shown to be a promising alternative in the management of burns scar contractures in patients with a shortage of donor sites. It is limited by small patient numbers and lack of randomisation, resulting in an inability to draw definitive conclusions from this study alone. Larger, prospective, long-term studies with formal outcome evaluation using validated scar assessment tools are required to establish the use of Pelnac™ in the armamentarium of dermal substitutes for the treatment of burns scars. How the results of Pelnac™ compare with other established dermal substitutes such as Integra® also remains to be answered.

Conclusion

In conclusion, Pelnac™ application followed by a thin STSG in a two-stage procedure is an efficacious and technically simple method of burns scar reconstruction when healthy donor sites are lacking. Infective complications may be avoided when it is used in combination with NPWT.

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