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ORIGINAL PAPER

Versatility of dermal regeneration templates in the treatment of burn sequelae

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Abstract

Background The management of burn sequelae is a major challenge for every plastic surgeon. The benefits of Integra® Dermal Regeneration Template in the management of burn injuries have been well documented but there is still a paucity of data regarding its use in reconstructive procedures. The aim of this study is to evaluate its effectiveness in the surgical treatment of post-burn scars.

Methods We performed a retrospective review of burn patients with major burn sequelae treated with Integra® at our hospital during 2016–2017 period. A modified Vancouver Scar Scale (mVSS) was used to provide a more objective measurement of burn scars. All patients were submitted to a two-stage procedure. The first one consisted in complete excision of the lesions and implantation of Integra and the second one in resurfacing the neodermis with a split thickness skin graft.

Results The average wound size covered with Integra was 741.6 cm^2. Follow-up ranged from 9 to 16 months. There were no early complications. In all cases, we achieved satisfactory cosmetic results with significant improvements in functionality and quality of life. mVSS score post-op was significantly lower than pre-op in all patients.

Conclusions Our results suggest that Integra is a very versatile tool for the treatment of burn sequelae. It yields good cosmetic and functional results in most cases with very little donor site morbidity. We believe that Integra should be viewed as one of the best current options for reconstructive procedures in burn patients.

Level of Evidence: Level IV, therapeutic study.

Keywords Integra · Dermal template · Scar contracture · Burn sequelae · Keloid

Introduction

For many years, the primary objective in the initial treatment of major burn patients was to save or sustain the life of burn victims [1]. This is still true today but hypertrophic scarring, keloid formation and contracture leading to disability and deformity continue to be challenging late complications of burn injuries [2].

Despite early and vigorously installed scar prevention regimens including physiotherapy, occupational therapy, pressure garments and splints, post-burn reconstructive surgery is quite often mandatory to solve problems refractory to conservative measures [3].

Anatomical sites such as the head/neck, hand/wrist and axilla are most likely to develop scar contractures [2, 4]. Post-burn neck contracture and hypertrophic scarring can cause functional limitation and aesthetic disfigurement. In male patients, recurrent chronic folliculitis involving the bearded area can exacerbate the problem [5]. Adults with contractures of the neck are often restricted in their ability to eat

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Table 1 Modified Vancouver Scar Scale

	Feature	Score
Vascularity	Normal	0
	Pink	1
	Red	2
	Purple	3
Pigmentation	Normal	0
	Hype-pigmentation	1
	Mixed-pigmentation	2
	Hyper-pigmentation	3
Pliability (elasticity)	Normal	0
	Supple (flexible with minimal resistance)	1
	Yielding (giving way to pressure)	2
	Firm (inflexible, not easily moved, resistant to manual pressure)	3
	Banding (rope-like tissue that blanches with extension of the scar)	4
	Contracture (permanent shortening of scar, producing deformity or distortion)	5
Height	Flat	0
	< 2 mm	1
	2–5 mm	2
	> 5 nnm	3
Pain	None	0
	Occasional	1
	Requires medication	2
Itchiness	None	0
	Occasional	1
	Requires medication	2

and swallow or to perform functions such as safely driving a car. The primary goals of contracture release and scar revision are thus to restore function and prevent further permanent impairment. An important secondary goal is to provide an optimal cosmetic outcome [2].

Among the techniques used for contracture release and burn reconstruction are excision and direct closure for small wounds, split-thickness and full-thickness skin grafts, local flaps (e.g. Z-plasty), regional flaps, free flaps and tissue expansion.

The areas of the initial burn wounds and the repeated harvesting of grafts during the acute phase of burn injury result in insufficient amounts of healthy skin for burn reconstruction [6], thereby creating a critical limitation for most reconstructive techniques. Whereas split-thickness skin grafts are useful, the lack of full thickness of dermis can compromise both function and appearance. Therefore, a synthetic skin substitute that augments the native dermis in split-thickness skin grafts could improve durability and function without increasing donor-site morbidity [7].

We present our experience of using Integra® (Integra LifeSciences Corp., Plainsboro, N.J.) in the surgical treatment of burn sequelae patients.

Methods

We evaluated retrospectively the clinical files of 3 burn patients (1 male, 2 females) operated at our unit during 2016–2017 period. Patient charts were reviewed with attention to wound etiology, size and location, skin graft take, time interval from injury to placement of integra and placement of integra to split thickness skin graft and complications. The modified Vancouver Scar Scale (mVSS, Table 1) [8] was used to assess the scar quality, pre- and post-operatively.

All patients had extensive sequelae from fire burn. All patients were submitted to a two-stage procedure. In all patients was applied Integra® dermal regenerative matrix.

All procedures were performed under general anaesthesia. Surgical technique and post-op procedures: The lesions

Fig. 1 Pre-operative: right **a** and left **b** view

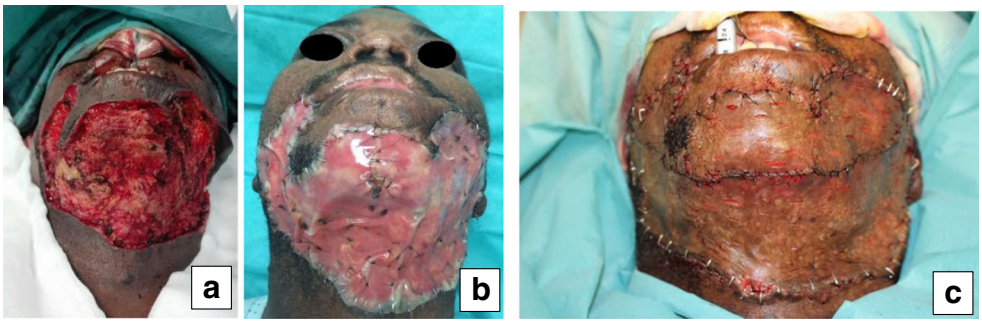

Fig. 2 First surgical stage: **a** keloid excision. **b** Dermal regeneration matrix; second surgical stage: **c** split thickness skin graft

Table 2 Main outcomes

	Time from injury until time of surgery	Time between surgeries (weeks)	Wound size (cm^2)	Follow-up (months)	Complications
Case 1	5 months	3	300	15	None
Case 2	49 years	2	1300	12	Residual areas of integument instability
Case 3	18 months	4	625	19	Hypertrophic scarring

were excised deep into normal subcutaneous tissue to achieve complete release of the scar. Contracted areas were slowly and gently extended to the maximum possible. After meticulous haemostasis by electrocautery, the bilaminar artificial matrix was applied unmeshed and tailored to cover the open wounds and secured with surgical staples. The artificial skin was applied with slight tension to prevent wrinkling and to maintain adequate apposition with the recipient bed. A dressing consisting of a single layer of vaseline gauze covered with octenidin-soaked gauze was applied. When needed, the Integra was immobilised with a soft neck collar.

Routine checking of dressing was done every third post-operative day or as needed to assess vascularization status and to monitor for the development of small hematomas or infection.

When the neo-dermis completely matured (peach coloured surface), the silicone layer of the template was removed and replaced with a thin split thickness skin graft (harvested with an electric dermatome). A petrolatum gauze and octenidine based dressing were applied afterwards. In Case 1 and 3, a static cervical splint was applied post-operatively.

Immediately after wound healing (usually between the 14th and 20th post-operative day), the patients started an intensive rehabilitation program consisting of physiotherapy, pressure garments and face masks (cases 1 and 3).

Case series

Case 1

A 30-year-old male, African descent, suffered extensive second and third degree fire burns, approximately 30% TBSA. His cervical region was healed by second intention. When he presented for revaluation, 5 months after the initial injury, he had developed a massive cervical keloid associated with recurrent infection (folliculitis) (Case 1, Fig. 1).

He underwent marginal extra-lesional excision of the keloid down to normal subcutaneous tissue and the entire area was resurfaced with Integra bilaminar dermal matrix (Case 1, Fig. 2a, b). At the second stage, the silicone layer was removed and a sheet split thickness skin graft (harvested from the left thigh) was applied to the neo-dermis (Case 1, Fig. 2c). The graft was manually fenestrated to allow for drainage. The patient used an elastic collar for

Table 3 mVSS score pre and post-op

Modified VSS	Pre-op	Post-op
Case 1	10	2
Case 2	9	4
Case 3	10	5

Fig. 3 15 months post-operatively

the neck for post-surgical elastic compression for 3 weeks and after that he used an "open face" head and neck garment daily.

Case 2

A 60-year-old female, Caucasian, presented to our department with multiple retractile scars and unstable tegument in her cervical region, thorax and abdomen caused by a major fire burn when she was 11 years old (Case 2, Fig. 4). She was submitted to multiple skin grafts during infancy/adolescence.

She also had respiratory problems and back pain due to the significant kyphoscoliosis she developed because of the extensive scarring in her thorax.

She was submitted to "en bloc" excision of thorax and abdominal scarred tissue (Case 2, Fig. 5a) and coverage with Integra at the first stage (Case 2, Fig. 5b). At the second stage, we removed the dermal matrix outer layer and she was submitted to a meshed (1:3) split thickness skin graft over the entire area (Case 2, Fig. 5c). The donor area was the dorsum since it was the only anatomic region devoid of scars.

Case 3

A 38-year-old female, African descent, presented to our department 18 months after suffering a very serious fire burn, approximately 70% TBSA. Amongst other lesions, she developed an extreme neck contracture, with fusion of the mandibular region to the lower cervical area (Case 3, Fig. 7).

She was submitted to excisional release of all cervical scar tissue (Case 3, Fig. 8a) and coverage with a large patch of Integra (Case 3, Fig. 8b) applied with a compressive cervical garment for better contact with the wound bed and to keep a 90° angle between mandible and neck. In the post-operative period, she had enteral feeding through a nasogastric tube.

Fig. 4 Pre-operative photos

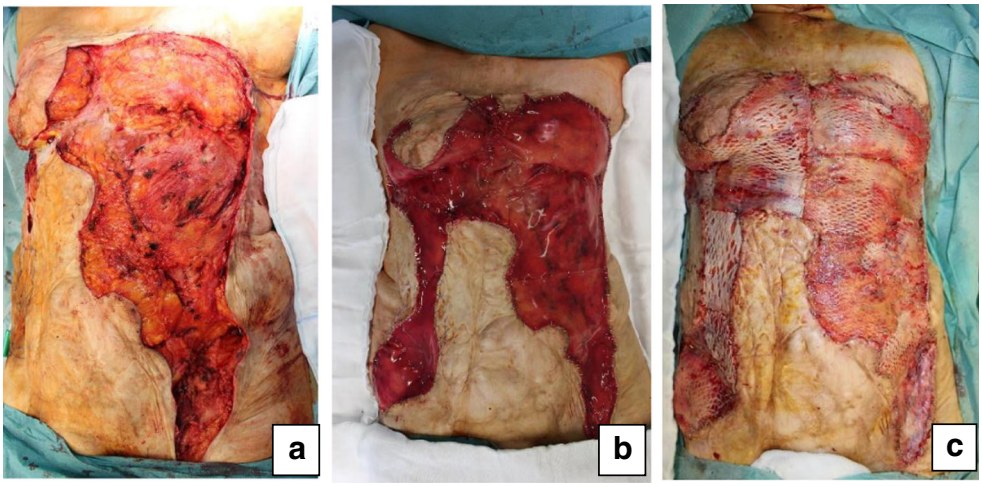

Fig. 5 **a** Scar excision; **b** Integra placement; **c** second stage: split thickness skin graft

Fig. 6 12 months post-operatively

Fig. 7 Pre-operative photo

The second operation took place 4 weeks later. After the silicone layer removal, the defect was covered with a sheet split thickness skin graft harvested from the thighs. At the end of the operation, a thermo moldable cast was applied to the cervical region to maintain the extension.

Results

The interval between surgeries varied from 2 to 4 weeks. The average wound size covered with Integra was 741.6 cm^2. Follow-up ranged from 12 to 19 months. There were no early complications (haematoma, seroma, infection) (Table 2).

In all cases, we achieved satisfactory cosmetic results with significant improvements in functionality and quality of life. The grafts healed completely and uneventfully. mVSS score post-op was significantly lower than pre-op (Table 3).

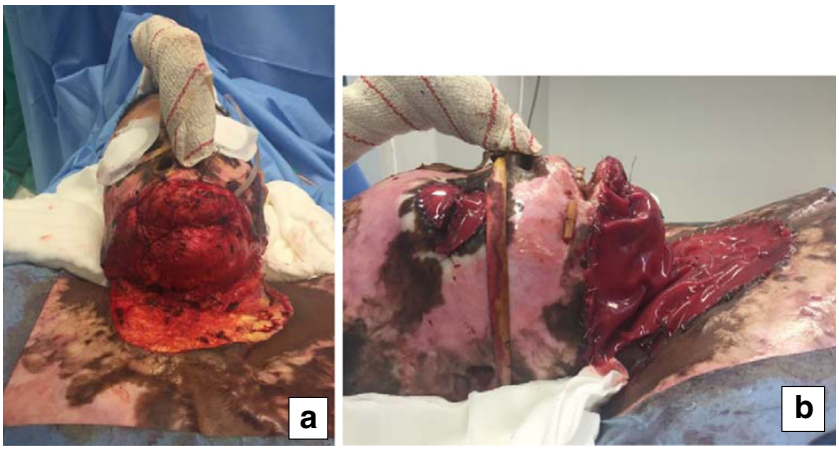

Fig. 8 **a** Scar release; **b** placement of Integra

In the first case, 15 months post-op the skin is stable, the cosmetic outcome is very good, the keloid has not recurred nor has the patient experienced any episodes of folliculitis (Case 1, Fig. 3).

In case 2, the patient expressed great improvements in her chest mobility and breathing and referred a significant reduction of back pain. The skin graft healed completely, and the cosmetic outcome was acceptable although she remains with residual areas of skin instability (Case 2, Fig. 6).

In case 3, the patient is able to extend her neck until 100° and to eat and drink without constraints. Although the scar partially recurred, it is softer than before and functionally not significant (Case 3, Fig. 9).

Discussion

The most common and clinically significant complications after severe burn injuries are skin contractures leading to decreased range of joint motion and joint deformities. The management of scarring and contractures involves multiple treatment techniques, including splinting, positioning, serial casting and surgical management [9].

The most common reconstructive techniques involve releasing the contractures with multiple excisions or using skin grafts. Local flaps, regional flaps and skin expansion are other options available, but they are useful only in small to moderate areas of scar contracture and the surrounding skin has to be healthy. The use of free flaps can produce very good results but they still may need multiple procedures, high surgical skills and are associated with a significant risk of failure and donor site-morbidity [4]. Patient comorbidities and associated injuries may also preclude this kind of reconstruction [10].

Regarding to keloids, surgical excision remains the mainstay for the treatment of these lesions. When used as the sole form of therapy, the recurrence rate is very high but when combined with adjuvant therapies it significantly improves [11].

For patients with insufficient high-quality skin graft donor sites, dermal regeneration templates are the best alternative for dermal replacement since full-thickness graft is not an option [2] and widely meshed skin leads to scar formation over the interstices (that heal by secondary intention). That produces a bad cosmetic outcome, especially in those with pigmented skin [12].

The amount of dermal tissue determines the resistance to contracture. There is an inverse relationship between the

Fig. 9 18 months post-operatively

thickness of the dermis and graft contraction; therefore, full-thickness grafts are less prone to contracture than split thickness grafts [2, 13].

Integra is a synthetic dermal substitute composed of two layers. The inner layer of bovine collagen matrix and chondroitin-6-sulfate allows the ingrowth of autogenous vasculature and fibroblasts and subsequent histological transformation to a neodermis [14]. Following biodegradation of the bovine collagen, the resultant neodermis has been shown to resemble normal dermis both histologically and biomechanically with absence of scar tissue [12, 14]. The outer silicone layer acts as an external barrier while this process is taking place, resembling human epidermis [5].

When applied after keloid excision, this neodermis seems to provide a symptom-free and recurrence-free treatment, thanks to the replacement of the diseased "keloidogenic" dermal layer [15].

The most frequent post-operative complication of this reconstructive option is infection [2, 4, 7]. The dermal matrix is not vascularized and relies on the local blood flow, so it is prone to bacterial colonization and infection, especially when old scars are released [12]. Nonetheless, its impact in the dermal template and skin graft take is modest and no significant negative effects were seen on range of motion, function or recurrence rates [2]. A clean wound bed at the time of the excision, a careful haemostasis and a close monitoring of Integra take are some of the most important preventive measures.

Regarding the clinical cases showcased in this paper, all patients had a significant paucity of healthy skin since they had suffered extensive burns and many previously uninjured anatomic regions were used as donor sites for skin grafts. For that reason, we opted not to use full thickness skin grafts but instead use a combined technique, with a dermal template and a split thickness skin graft.

In our case series, the results were considered very satisfying for all patients, functionally and cosmetically. The patient of case 3 developed a partial recurrence of the neck contracture, although she had good cervical mobility and her scar was fairly soft. Hunt J. et al. [5] have reported a very high recurrence rate of contracture (> 50%) after this kind of reconstruction. Nonetheless, we still think it is a good option since it allowed a significant improvement in such a difficult field. We feel that the immobilisation in the early post-operative period and then the use of adequate compressive garments are essential for the success of the treatment.

In summary, our results suggest that Integra is a very versatile tool for the treatment of burn sequelae. It yields good cosmetic and functional results in most cases with very little donor site morbidity. We believe that Integra should be viewed as one of the best current options for reconstructive procedures in burn patients.

Compliance with ethical standards

Funding This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest Luís Mata Ribeiro, Rafaela Serras, Íris Brito, Ana Guerra, Nuno Maria, Joaquim Bexiga and Maria Manuel Mendes declare that they have no conflict of interest.

Informed consent Informed consent for medical photographies and medical records was obtained from all individual participants included in the study.

Ethical approval For this type of retrospective study formal consent from a local ethics committee is not required.

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