

## Clinical Experience in Staged Primary Reconstruction of Deep Facial Burns Utilizing Composite Dermal/Epidermal Replacement with Cryopreserved Allografts and Ultra-Thin Autografts

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### ABSTRACT

Facial burns are among one of the most challenging injuries for burn surgeons. The general consensus in deep facial burn management is early excision and thick autografting for the purpose of minimizing scarring and optimising the outcome by providing adequate dermal substitution template. However, there exist alternative non-conventional modalities of dermal substitution that would improve the recipient outcome without much compromising autologous donor site dermis. The aim of the present study was to present and objectively evaluate a staged protocol for primary deep facial burn reconstruction consisting of early excision and composite dermal/epidermal replacement with cryopreserved allografts (dermal template) and ultra-thin autografts (epidermal sheet). For this purpose, 24 consecutive patients (10 females and 14 males) admitted to the Burn Unit in Ain Shams University (January 2006 – January 2008) for acute burns with deep facial involvement, were enrolled in a prospective clinical study. The mean age was  $22 \pm 4.6$  years. Burns were 14 (58.3%) flames, 6 (25%) scalds, 2 (8.3%) chemical and 2 (8.3%) electrical injuries, with a mean % TBSA of  $26 \pm 2.4$  (Lund and Browder). Only 16 (66.6%) patients had successfully completed the adopted protocol with 100% uptake of composite allograft/autograft skin. 14 (87.5%) subjects presented 3-months later for objective evaluation of functional and aesthetic outcome according to the criteria set by Vancouver Scar Scale (VSS). The overall mean score was  $3.2 \pm 1.4$ . In conclusion, composite dermal/epidermal replacement with cryopreserved allografts and autologous epidermal sheets showed promising results as an alternative therapeutic modality to thick autografting for primary deep facial burn reconstruction. The protocol combines the advantage of minimizing facial scarring by providing adequate dermal substitution template, as well as the reduced incidence of donor site morbidity, thereby maintaining the potential of repeated donor re-harvesting for the purpose of re-surfacing large burns. However, further controlled studies are needed for the purpose of objective comparison with the other modalities of composite facial burn reconstruction by the concept of dermal regeneration template, namely the use of the bio-engineered artificial dermis [Integra®] and the lyophilised acellular human dermis [Alloderm®]. This would enable to come to the most suitable strategy that would optimise the long-term outcome of primary deep facial burn reconstruction without eventually increasing the potential of donor site morbidity.

### INTRODUCTION

Management of facial burns remains one of the greatest challenges in burn care. The impact of aesthetic and functional outcome of such injuries is critical to the patient's self esteem and ability to re-integrate into the society. Facial burns are very common, occurring in at least 30-50% of minor to moderate burns and over 50% of large burns. In view of the difficulty and complexity of wound care, these critical injuries routinely require hospitalisation [1-4].

Planning therapeutic strategies in facial burns depends primarily on accurate estimation of burn depth and plays a crucial role in optimising the cosmetic and functional outcome. It is generally agreed about conservative strategy for the management of partial-thickness facial burns. The goals are eventually to prevent infection and provide maximum tissue preservation, thereby promoting spontaneous autologous re-epithelialisation. However, there appear to be no consensus on the appropriate protocol in the armamentarium of conservative therapy for partial-thickness facial burns. Reviewing the literature revealed an obvious ongoing dilemma about whether to apply an open (moist exposure) concept through topical antimicrobials, or alternatively, a closed (moist occlusive) strategy through diverse membranous dressings and skin substitutes [2,5-13].

On the otherhand, managing full-thickness facial burns on conservative basis is being nowadays considered an obsolete protocol in the view of many burn surgeons. In several clinical trials on deep facial burns treated conservatively, there was an obvious associated prolongation of hospital stay, increased potential of infection, patient discomfort, as well as marked compromise of cosmetic and functional outcome upon late autografting on

facial granulations. Therefore, early excision and grafting has become over the recent years the strategy of choice for deep facial burns in many burn centres. For the purpose of minimizing facial scarring and thereby optimizing the cosmetic and functional outcome, there is obviously the need for adequate dermal substitution following excision. Such essential issue is basically achieved through the harvesting of thick split- or near full-thickness autografts [14-22]. However, there exist alternative scenarios that would enable to provide adequate dermal substitution without the jeopardy of much autologous donor site dermis. This would probably improve the overall cosmetic and functional outcome at recipient site without increasing the potential of donor site morbidity. In the present study, a staged protocol for primary deep facial burn reconstruction consisting of composite dermal/epidermal replacement with cryopreserved allografts (dermal template) and ultra-thin autografts (epidermal sheet) is presented, evaluated and discussed.

## PATIENTS AND METHODS

The study included 24 acutely burned adult patients admitted to the Burn Unit in Ain Shams University (January 2006 – January 2008), with the aim to objectively evaluate a staged protocol for primary deep facial burn reconstruction consisting of early excision and composite dermal/epidermal replacement utilizing cryopreserved allografts (dermal template) and ultra-thin autografts (epidermal sheet). 10 patients were females and 14 patients were males. The mean age was  $22 \pm 4.6$  years. Burns were 14 (58.3%) flames, 6 (25%) scalds, 2 (8.3 %) chemical, and 2 (8.3%) electrical injuries. The mean % TBSA was  $26 \pm 2.4$  (Lund and Browder) [23]. All subjects had mixed pattern facial involvement with partial- and full-thickness burn areas. A written consent was obtained prior to submission for the protocol of the study.

Patients enrolled had primary facial burn reconstruction on two stages with exception of the eyelids, which were separately managed on one stage of excision and thick autografting. In the first stage, full-thickness burn areas were excised and covered with cryopreserved allografts (dermal template) within the 1<sup>st</sup> postburn week. For the purpose of optimising the cosmetic outcome, pre-operative excision markings were made with respect to the guidelines of facial aesthetic units. Therefore, small unburned or partial-thickness burn areas in the periphery of a facial aesthetic unit were involved in pre-operative excision markings. Excision was

tangentially performed down-to-viable tissue, followed by thorough haemostasis using 1:100.000 nor-epinephrine prior to coverage with allografts. Cryopreserved allografts (from living donor volunteers) were allowed to warm up in 0.9% normal saline before being applied and fixed with staples to excised areas. They were then covered with vaseline gauze, moist sterile cotton dressings and outer compression facial garments. Allografts were inspected 72-hourly for dressing and assessment of uptake.

The second stage of facial burn reconstruction was undertaken 10-14 days following primary excision and allograft (dermal template) application. This lag interval was for the purpose of allowing enough time for adequate vascularization and integration of allogenic dermal template prior to autografting. The second stage consisted of dermabrading the allogenic epidermis and immediate application of ultra-thin autografts (epidermal sheet). Dermabrasion was done using the electric dermabrator (Aesculap, PA, USA) and was stopped once allogenic dermis has been exposed. Non-meshed ultra-thin autografts (epidermal sheet) [0.004-0.008 inch.; 0.1-0.2mm] were harvested with the electric dermatome (Aesculap, PA, USA), then transferred on vaseline gauze as carrier and immediately applied to exposed allogenic dermis. They required no fixation sutures or staples; instead, they were secured with a layer of moist sterile cotton dressing and outer compression facial garments. Autografts were inspected 72-hourly for dressing and assessment of uptake.

Subjects enrolled were submitted 12-weeks postoperatively for long-term assessment of cosmetic and functional outcome of composite dermal/epidermal facial burn reconstruction on the basis of Vancouver Scar Scale (VSS) [24]. Data were collected, analysed and statistically evaluated.

## RESULTS

Twenty-four consecutive acutely burned patients with deep facial involvement were enrolled in a prospective clinical study conducted at the Burn Unit in Ain Shams University during the period from January 2006 to January 2008. The aim was to objectively present and evaluate primary deep facial burn reconstruction by a staged protocol consisting of early excision and composite full-thickness dermal/epidermal replacement utilizing cryopreserved allografts (dermal template) and ultra-thin autografts (epidermal sheet). Out of the 24 subjects enrolled, 4 patients (16.6%) died (2 from inhalation-induced ARDS and 2 from sepsis-

induced MOF). In 4 patients (16.6%), allografts failed to integrate (2 from haematoma formation and 2 from wound infection). In the remaining 16 patients (66.6%) who were able to complete the protocol of the study, the uptake of composite allograft/autograft was essentially 100% (Fig. 1).

Out of the 16 patients who had essentially completed the protocol of management, two subjects (12.5%) didn't present for re-evaluation of the outcome 12-weeks postoperatively. The remaining 14 subjects (87.5%) were submitted to full objective assessment of cosmetic and functional

outcome on the basis of Vancouver Scar Scale (VSS). This scar index gives scores for four main criteria, namely pigmentation (normal, hypo-, hyperpigmentation), vascularity (normal, pink, red, purple), texture (normal, soft, yielding, firm, banding, contracture) and height (normal, <2mm, 2-5mm, >5mm). Statistical analysis revealed a score of 2 in two subjects (14.2%), 3 in four subjects (28.5%), 4 in six subjects (42.8%) and 5 in two subjects (14.2%). The overall mean score was  $3.2 \pm 1.4$  (Figs. 2,3). Table (1) illustrates a detailed description of 12-weeks cosmetic and functional assessment based on VSS.

Table (1): Descriptive criteria (VSS) in 14 subjects.

Parameter	Finding	N value	Percentage (%)
Pigmentation	Normal (0)	1	7.1
	Hypo- (1)	5	35.7
	Hyper- (2)	8	57.1
Vascularity	Normal (0)	10	71.4
	Pink (1)	4	28.5
	Red (2)	0	0
	Purple (3)	0	0
Texture	Normal (0)	1	7.1
	Soft (1)	12	85.7
	Yielding (2)	1	7.1
	Firm (3)	0	0
	Banding (4)	0	0
	Contracture (5)	0	0
Height	Normal (0)	4	28.7
	<2mm (1)	9	64.2
	2-5mm (2)	1	7.1
	>5mm (3)	0	0

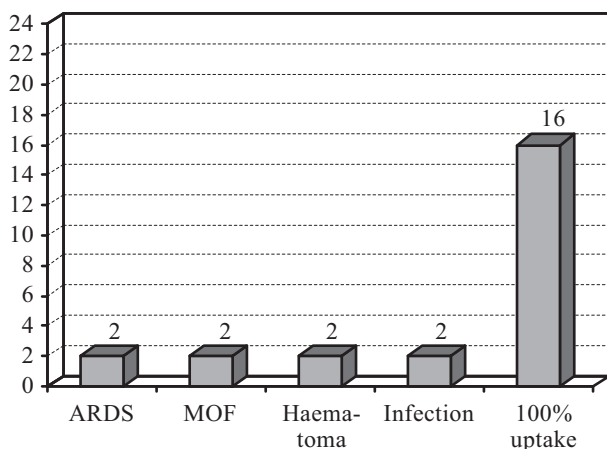


Fig. (1): Short-term outcome of management of deep facial burn in 24 consecutive patients.

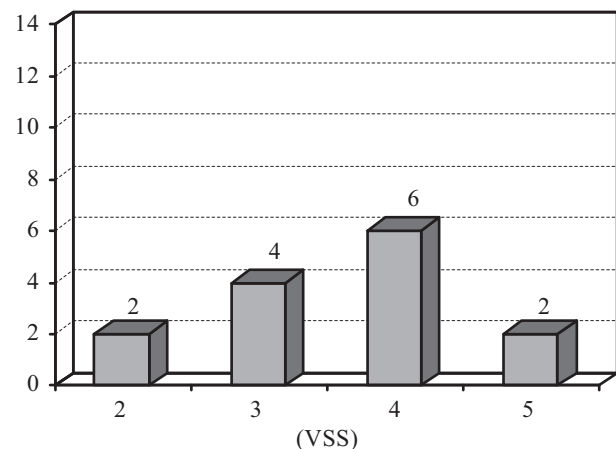


Fig. (2): Results of 12-weeks assessment of cosmetic and functional outcome in 14 subjects based on (VSS). Overall mean score =  $3.2 \pm 1.4$ .



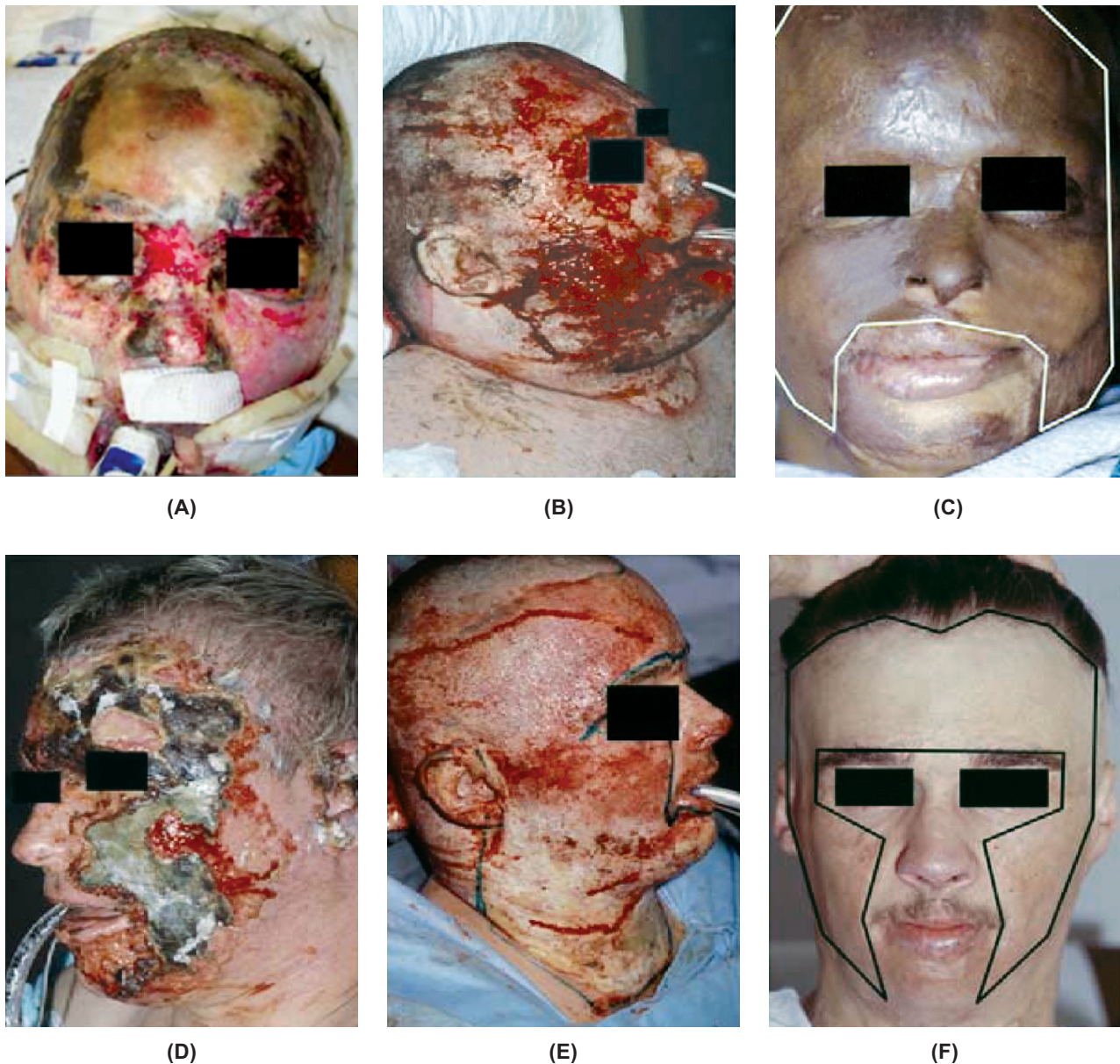


Fig. (3): Left (above, below): Deep facial burn. Middle (above, below): Primary excision with respect to the guidelines of facial aesthetic units. Right: 12-weeks outcome of staged reconstruction with composite allograft/autograft replacement; above: VSS = 4, below: VSS = 2.

## DISCUSSION

Facial burns are among one of the most devastating injuries to human kind. The extensive scarring that often occurs might eventually end up with serious functional, aesthetic and psychological impacts on burn victims. On the one hand, extensive scarring may lead to functional problems such as oral incontinence, impaired neck mobility and stiffness, as well as potential corneal problems. On the other hand, even if no such functional impairment exists, it may cause unpleasant results due to distortion of facial aesthetic units and limited

facial expression with a tight mask-like sensation to the face. Additionally, a disfigured face can induce severe psychological problems, thereby significantly lowering patient's self-esteem, quality of life and prospects of social re-integration. Therefore, optimizing the outcome in facial burn reconstruction requires both competent burn team and innovative therapeutic modalities [22,25-27].

Over many years of burn practice, early excision and thick autografting have been considered the procedure of choice for primary deep facial burn reconstruction. However, despite the fact that thick

autografts were supposed to provide enough dermal template that would minimize facial scarring, yet the results were often deceiving. In many instances, there was an evident compromise of the outcome especially with regard to colour match, texture, and junctures between grafted aesthetic units as well as those between grafted and non-grafted areas. Moreover, harvesting thick autografts is associated with increased potential of delayed healing and donor site morbidity that would eventually impair the chance of repeated donor re-harvesting for the purpose of re-surfacing of large burns. All these drawbacks were up to the extent of obliging many burn surgeons to re-consider abandoning early excision of deep facial burns [1,28-30]. It also became obvious that there is the urge to explore alternative modalities of facial dermal substitution that would help to optimize the outcome and in the meantime obviate the need for thick autograft harvesting with its potential hazards.

In this study, a staged protocol for primary deep facial burn excision and reconstruction utilizing composite dermal/epidermal replacement with cryopreserved allografts (dermal template) and ultra-thin autografts (epidermal sheet) was presented, evaluated and discussed. Short-term results showed 100% uptake of composite allograft/ autograft in 16 out of the 24 patients enrolled (66.6%). In the remaining 8 subjects (33.3%), completion of the protocol deemed unlikely due to death from ARDS and MOF in 4 patients (16.6%), or failure of integration of allografts as a result of haematoma and wound infection in the other 4 patients (16.6%). Long-term (12-weeks) assessment was conducted on 14 subjects (87.5%) on the basis of VSS and revealed satisfactory aesthetic and functional outcome with an overall mean score of  $3.2 \pm 1.4$  [24]. Despite the already proven potential of allograft skin in providing permanent dermal substitution without immunosuppression [10,12,31-33], yet reports in the literature concerning its use in deep facial burn reconstruction are scarce. This is probably multifactorial and can be attributed to many considerations including patient inacceptance, religious and legal problems that hinder its availability, complexity and cost of processing/storage procedures, in addition to recent evolvement of alternative modalities of dermal substitution in the armamentarium of facial burn management. These are namely the bio-engineered artificial dermis (Integra®) and the processed acellular human cadaver dermis (Alloderm®), which nowadays constitute the main alternatives to allograft skin as concerns the issue of dermal substitution following primary deep facial burn excision [34,35].

Integra® is a bilaminar structure consisting of a layer of cross-linked bovine collagen and chondroitin-6-sulphate with an outer temporary silastic layer. Since its introduction, it has been widely used as a dermal substitute following primary deep burn excision. Klein and colleagues emphasized its use in facial burn reconstruction in a study in 2005 and they were able to demonstrate superior results to conventional re-surfacing with thick autografts. Like with allograft skin, Integra® requires two stages with an interval of at least 10-14 to allow adequate vascularization and integration into recipient tissue prior to definitive ultra-thin autograft coverage. For instance, considering the many obstacles that are related to the use of allograft skin (harvesting, processing, storage) and the skill required for the task of down-to-dermis dermabrasion, should the use of Integra® be a relatively more simple procedure [34].

Alloderm® is a processed freeze-dried acellular human cadaver dermis. Unlike both allograft skin and Integra®, it can be applied and immediately covered with autologous epidermal sheets, thus providing a single-stage composite dermal / epidermal replacement following primary deep facial burn excision. In a study by Calcutt and colleagues in 2006, Alloderm® proved to provide a dermal substitute that has at least the same thickness of thick split- and near full-thickness autografts, thus combining the benefit of optimizing the outcome at recipient site and that of reduced potential of donor site morbidity. It was also emphasized that Alloderm® should be of particular importance whenever it is unfeasible to harvest thick autografts for deep facial burn re-surfacing, such as in extremes of age (thin skin) or in patients with large burns where repeated donor site re-harvesting is invariably required [35].

In conclusion, the study showed promising results with using allograft skin as dermal substitute in combination with ultra-thin autograft as epidermal sheet for staged primary deep facial burn excision and re-surfacing. Such composite dermal/epidermal replacement combines the advantage of adequate dermal substitution that minimizes facial scarring and that of reduced potential of donor site morbidity. Thus, it can be applied as a reliable alternative therapeutic modality to conventional thick split- and near full-thickness autografting in the armamentarium of primary deep facial burn reconstruction. However, further controlled studies are needed for the purpose of comparing allograft skin versus the other available modalities of dermal substitution, namely the artificial dermis Integra® and the processed acellular human dermis



Alloderm®. The criteria of evaluation should include patient acceptance, cost-benefit ratio and eventually objective short- and long-term assessment of cosmetic and functional outcome. It is also possible that dedicated research in the field of fibroblast culture might lead to innovative modalities of dermal substitution that would help to further improve the overall outcome of primary deep facial burn reconstruction.

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