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The use of the Meek technique in conjunction with cultured epithelial autograft in the management of major paediatric burns☆

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ABSTRACT

Background: The management of major paediatric burns remains challenging, in part due to limited donor sites. Skin graft expansion facilitates rapid closure of the burn wound, reducing the risk of sepsis. We reviewed our unit's experience with a combined modified Meek technique and cultured epithelial autograft (CEA).

Methods: A retrospective chart review over a seven year period from April 2004 to April 2011 was conducted of patients whose burns were treated with Meek and CEA.

Results: The Meek technique was combined with meshed split skin grafts and CEA to either donor, graft site or both in 7 cases. One case had Meek skin grafts alone with cultured cells applied to both donor and graft sites. There were two scald burns and five flame burns, with total body surface area ranging from 30% to 70%. Mean length of stay was 51 days (range 41–74 days). The average number of surgical procedures undergone to obtain good coverage was 3.3. There were small (1–3%) areas of breakdown in six cases which received regrafting. Two of these patients had confirmed wound infections. All patients had varying degrees of hypertrophic scarring (HTS) but remained well at follow up.

Conclusions: The Meek technique facilitates high expansion ratios, allowing for a greater area of skin coverage. Epithelialisation in the burn wound appeared to be enhanced by the application of CEA. The Meek technique in combination with CEA would appear a useful additional option in achieving wound closure in the severely burned paediatric patient.

1. Introduction

Early excision and debridement, improved management of burns shock and prompt enteral feeding have all contributed to the enhanced survival following severe burns in children [1,2]. Over the years, the surgical approach to these complex burns has changed substantially [1,3,4]. Limited donor site availability, however, remains a problem when trying to achieve rapid burn wound closure [1]. The development of bioengineered dressings, including Biobrane® (Smith and Nephew, Mount Waverley, Victoria), as temporary skin substitutes allows burn wound closure to be achieved once the child has been resuscitated [5]. Whilst helping to reduce

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the risk of sepsis, such dressings eventually require replacement with autograft [5].

In extensive burns, meshed split skin grafts (SSG) can be used to cover large surface areas [6]. At expansion rates of greater than 1:4, however, the meshed graft can be difficult to handle, leaves substantial areas of uncovered wound in the interstices and may result in a cosmetically unsatisfactory ''string-vest'' appearance in the long-term [5,7].

The use of cultured epithelial autograft (CEA) cells was first described by Rheinwald and Green in 1975 [8]. The first report of its use in paediatric burns patients was in 1984 by Gallico et al. [9]. Whilst initial reports were encouraging, there remains limited data of its use in paediatric burns surgery. Meuli and Raghunath extensively compared the results of previous reports and found that the functional results obtained from CEA appeared similar to the ones after conventional grafting in terms of wound contraction, hypertrophic scarring, and skin stability [10].

The Meek technique was developed by C.P. Meek in 1958 and can achieve expansion rates of up to 1:9 [11]. Once harvested and placed on a cork board, donor skin is cut into 196 squares 3 mm × 3 mm in size using the unique Meek–Wall microdermatome. These micro-grafts, after spraying with an adhesive Leukospray® (BSN Medical, Charlotte, NC), are attached to a nylon aluminium backing which may then be stretched both horizontally and vertically to achieve the desired expansion ratio [11].

The Meek technique lost favour with the advent of meshed SSG in the 1960s, before being reintroduced in 1993 by Kreis et al. who found this technique to be superior to meshed SSG when higher expansion rates were used in adult patients with major burns [6,12]. Subsequently its use has been combined with CEA to accelerate burn wound closure, although there remain few reports of this approach and only one case in a child [13,14].

We reviewed our unit's experience using the Meek technique in combination with CEA in the management of major paediatric burns.

2. Materials and methods

2.1. Study design and setting

The Burn Unit (BU) at our institution represents the sole paediatric centre of the Severe Burn Injury Service (SBIS) of the state of New South Wales (NSW) and the Australian Capital Territory, serving a total population of approximately 7.6 million. Whilst our BU treats over 1000 new patients each year, only a minority (<5%) will suffer severe burns of greater than 30% total body surface area (TBSA).

A retrospective chart review was performed of all major burns patients admitted between April 2004 and April 2011 that had been treated with Meek micrografts in conjunction with CEA. Data collected included patient details, mechanism, TBSA burnt, length of stay (LOS), graft type, areas sprayed with CEA, complications and outcome.

The study was approved by our institution's Ethics Committee.

2.2. Cell culture method

A blood sample was collected for autologous serum isolation. A split skin biopsy from the patient's flank or leg, depending on the availability of unburned skin, of 2 cm × 2 cm was taken using an aseptic technique and a Goulian blade. The biopsy was placed into a sterile jar containing transport medium and delivered to the SBIS Skin Laboratory in a chilled container.

The biopsy was washed several times with phosphate buffered saline (PBS) and treated at 37 °C with dispase and trypsin/EDTA solutions respectively to separate the epidermal and dermal layers. Keratinocytes were then isolated and cultured using a modification of the method described by Green et al. [15].

Using this methodology, 1 ml of CEA suspension contained at least 5×10^5 ml^{-1} of keratinocytes and delivered by a spray would cover up to 100 cm^2 of a burn wound.

2.3. Operative technique

2.3.1. Debridement

All patients underwent initial debridement between day 1 and day 4 with tangential excision using Goulian blades. Five out of seven patients underwent multiple debridement sessions, with two major burns (65% and 70% TBSA) requiring three and four debridement sessions respectively. Immediately prior to grafting, wounds were further debrided with Versajet® (Smith and Nephew, Mount Waverley, Victoria) or Goulian blades. Haemostasis was maintained with topical 1:10,000 adrenaline, pressure and elevation.

2.3.2. Meek autografts

Split skin autografts were taken using the hand held Meek Dermatome® (Humeca, Enschede, Holland) and placed on damp cork squares dermis side down. This was placed on the carrier block which is locked into the Meek Mesher® (Humeca). Using the crank, the block was passed though the mesher in which a series of blades cut it into 3 mm parallel strips. The block was then turned 90° and passed through the mesher again, cutting the SSG into 196 small 'postage stamp'

Fig. 1 – Case 7, 40% TBSA flame burn in a 9 year old girl to illustrate Meek SSG with nylon backing.

squares measuring 3 mm × 3 mm. This was then sprayed with an adhesive. A crimped nylon/aluminium backing with pre-folded in pleats was placed on top and held firmly for a few seconds. The cork was then removed, leaving the graft, dermis side up, visible. Using firm traction on all four sides, the aluminium was stretched so that the grafts remained evenly spaced whilst achieving good coverage of the wound. The aluminium backing was then removed and the graft with the nylon backing was placed dermis side down onto the prepared wound bed and secured with staples (Fig. 1). The nylon backing was then removed after day 7–10 and the resultant rate of epithelisation determined.

2.3.3. *Conventional meshed autografts*

Where available, donor sites were utilised for standard meshed split skin grafts, expanded to a ratio of 1:1.5–1:2. These were placed on the patient dermis side down and secured with staples in the standard manner.

2.3.4. *Cell application*

Once delivered from the lab, the cells were stored in fridge until ready for use. The cells were contained in 5 ml spray top syringe tubes, which were available seven to 10 days post biopsy. CEA cells were sprayed either over grafted sites, limbs or donor sites. The syringe was held approximately 15 cm from the surface and firm pressure onto the plunger allowed an even delivery of cells.

2.3.5. *Dressings*

Following initial debridement, burns were dressed with Acticoat® (Smith and Nephew), Mesorb® (Molnlycke Heath Care, Frenchs Forest, NSW) and crepe or plastic adhesive dressing such as OpSite® (Smith and Nephew). Dressings remained in situ until the next debridement session or after seven days. Grafted and cell sprayed areas were dressed in Jelonet® (Smith and Nephew), Webril® (Covidian Healthcare, North Ryde, NSW) and crepe.

3. Results

A total of seven cases were identified over the study period where the Meek technique and meshed SSG were used in addition to CEA to either donor, graft or both sites (Table 1). There were 2 scald burns and 5 flame burns, all deep dermal to full thickness, with a mean TBSA of 50% (range 30–70%). The average age of patients treated was 6.1 years (range 2–12 years).

The average number of surgical procedures to obtain good coverage was 3.3 and the mean LOS was 51 days (range 41–74). There were small areas (1% - 3%) of graft loss in all cases which underwent regrafting. Two patients had confirmed infections at the site of graft loss, both with *Staphylococcal* sp. In a further three patients, CEA had not been applied to the areas of breakdown.

Table 1 – Patient details.

	Age	Mechanism/ depth	TBSA	Type of graft	Day of graft	Site grafted or sprayed with CEA	LOS	Complications
Case 1	5	Flame-DD/FT	65	Meek Meek SSG	D12 D19 D27	Back, left arm/thigh Chest, legs + CEA to donor SSG hand	53	*Staphylococcal* sp. infection Hyper-granulation leg Regraft SSG <1% D33
Case 2	5	Flame/FT	35	Meek SSG SSG	D10 D14 D19	Thighs, buttock, back various sites CEA to thighs	49	MRSA head, right leg regraft D19
Case 3	4	Scald/DD/FT	45	Meek SSG SSG	D10 D14 D19	Back Buttocks, leg + CEA SSG chest, arm + CEA	43	Left thigh regraft SSG <1% D32 No contractures, quiescent HTS
Case 4	12	Flame-FT	35	SSG MEEK 	D1 D11 D22	Right arm SSG Post thighs meek Lower leg SSG 1:2 Ant thighs SSG + CEA	49	Thigh hyper-granulation regraft SSG 2% D40
Case 5	2	Scald-DD/FT	70	Meek Meek SSG	D14 D28 D45	Chest/abdo/arms/leg +CEA Legs Meek Patchy regrafts to legs	74	HTS Regraft 3% D45
Case 6	6	Flame-DD/FT	30	SSG Meek	D7 D11	Chest/hand/neck Chest + CEA, arms	41	Neck contracture (no cells), quiescent HTS D32 regraft 3%
Case 7	9	Flame-DD/FT	40	Meek SSG	D11 D22	Back/buttocks/thigh meek CEA to donor, thigh ungrafted Chest/abdo/ant left thigh	46	left thigh regraft 1% D35

DD – deep dermal, FT – full thickness, HTS – hypertrophic scarring, TBSA – total body surface area, SSG – split skin graft, CEA – cultured epithelial autografts, LOS – length of stay.

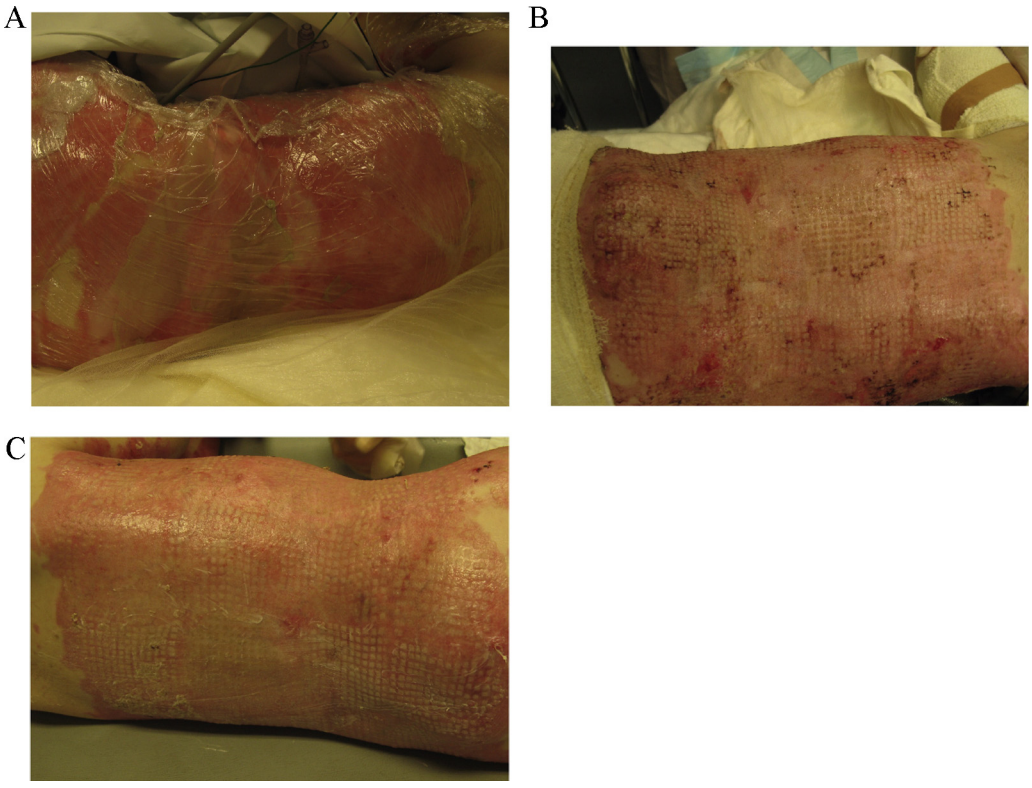

Fig. 2 – Case 1, 65% TBSA flame burn in a 5 year old boy. (a) At presentation. (b) Day 18 post burn and eight days after Meek SSG. (c) Day 28 post burn.

Areas that the Meek grafts were used included the lower limbs in five; back/buttocks in four; the chest/abdomen in three and upper limbs in three (Figs. 2 and 3). The average time post burn injury to first application of CEA was 17 days. CEA was applied over all grafted sites in four cases; in two cases to the lower limbs only and in one to the donor sites alone.

Mean initial wound closure occurred on day 9 post injury, with mean final wound closure on day 34. One patient developed contractures in the lower limbs, in an area in which CEA had not been applied, which was managed with physiotherapy and pressure garments alone. All patients had varying degrees of hypertrophic scarring (HTS), but remained well at follow up. There were no deaths.

4. Discussion

Although first described in 1958, the complexity and labour intensive nature of the Meek technique let to its replacement in the 1960s following the introduction of what has become conventional meshing by Tanner et al. in 1964 [6,11]. The modifications introduced by Kreis et al. in 1993, including the use of a compressed air dermatome and aluminium foil backing, reduced the intricacy of the technique [12]. Whilst conventional meshed SSG may be expanded to ratios of 1:4 and above to cover extensive areas, such widely spaced mesh remains challenging to handle and leaves the burn wound in the interstices essentially uncovered [12,16].

Once familiar with the modified Meek technique, we have found it to offer a number of advantages over highly expanded conventional meshed SSG for children with major burns. First, the grafts, once secure on the backing, become very easy manipulate. Secondly, the expansion ratio can be tailored or adjusted even after the skin has been meshed, allowing flexibility as the grafting procedure progresses. Thirdly, this system allows expansion ratios of up to 1:9, much greater than conventional meshing. Finally, perhaps crucially in children with restricted donor sites, even small pieces of SSG, which using conventional techniques might have been wasted, may be successfully meshed into micro-grafts.

Our experience, with excellent take and relatively low rates of sepsis, whilst undoubtedly being multifactorial in origin, have also be reported by other burns surgeons in adults [12,13,17,18]. Typically in these reports in adults the burn wound may be 90% healed within a period of three to five weeks following the burn injury in patients with major burns [13,17]. This suggest a particular role for the modified Meek technique in the burns patient following delayed presentation or transfer, perhaps with established sepsis, with potentially reduced graft loss as a result of infection compared with conventional techniques. Whilst the additional costs associated with its unique dermatome and mesher need to be considered, together with that of the associated disposables, these costs may be offset by savings from improved graft take and earlier discharge in more complex cases with major burns [13].

Initially introduced as a skin substitute for patients with severe burns, CEA was associated with several practical

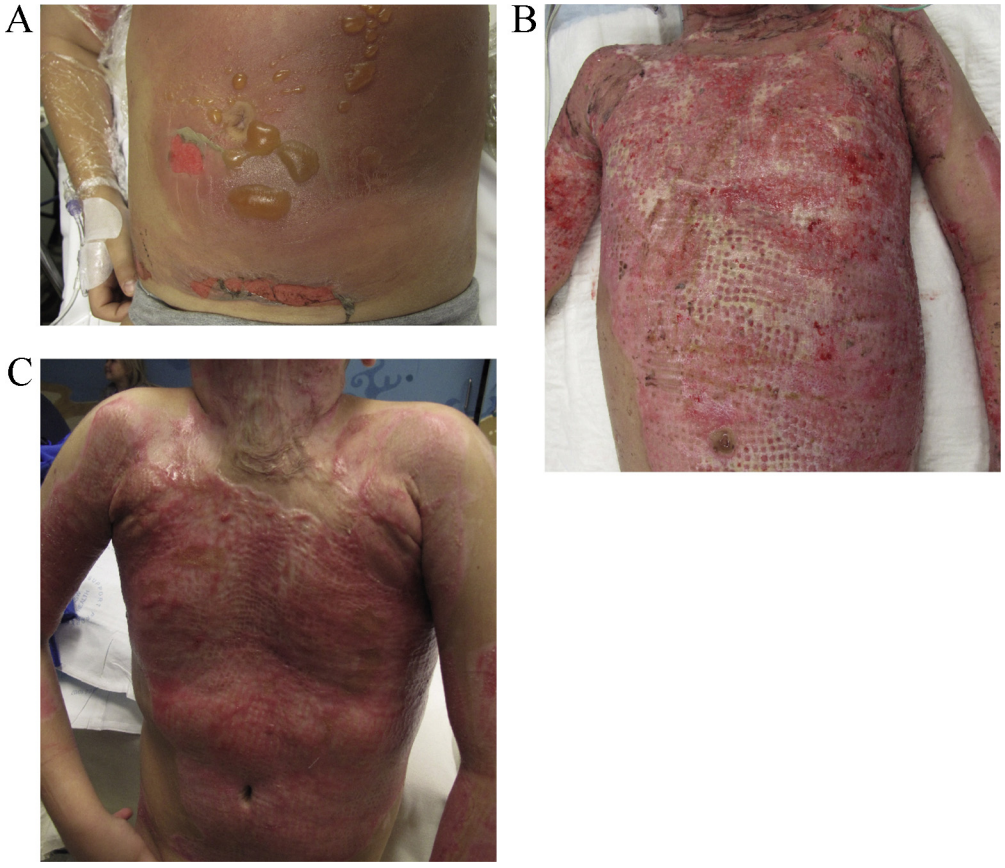

Fig. 3 – Case 2, 35% TBSA flame burn in a 5 year old boy. (a) At presentation. Despite initially relatively benign appearance, this burn rapidly progressed to a predominantly deep partial/full thickness burn as might generally be expected from this mechanism of injury. (b) Day 18 post burn and seven days post Meek SSG. (c) Day 61 post burn: note development of HTS.

problems, including difficulties in handling and graft fragility leading to loss through shear forces and blistering [19,20]. In addition, the lead time for culture of graft sheets was typically around four weeks from the time of skin biopsy [21]. Subsequently, the use of CEA suspension applied in the form of a spray, which can generally be provided within two weeks, in conjunction with meshed autograft has provided a more suitable role for CEA [22].

Just as CEA has been used successfully with conventional meshed SSG in both adults and children, its use, at least in adults with major burns treated with the modified Meek technique, has also been reported [13,23,24]. Dorai et al. reported a series of nine patients in 2008, of which one patient was a child with 22% deep dermal burns [14].

Our experience using these combined techniques has been generally positive, with a mean culture time of 17 days, an epithelialisation rate of 95% at four weeks with a median LOS of 51 days. In addition, we observed no cases of blistering or scar contracture in those sites treated with both the modified Meek technique and CEA [17,22]. Unfortunately, the problem of HTS remains and does not appear to be influenced by the combination of these techniques [13].

These results need to be viewed in the context of the relatively small number of patients in this series, however, with the TBSA burnt not necessarily of the same severity as seen more often in adult burns centres. Our small sample size, together with differences in the mechanism of injury and sites grafted, precluded objective comparison between those patients grafted solely with conventional and modified Meek techniques versus CEA combined with conventional and modified Meek techniques. Our promising initial results lead us to suggest that future studies, perhaps between several paediatric burns centres, might help define the place of these different surgical modalities in achieving burn would closure in children with major burns.

5. Conclusions

Meek autograft in conjunction with sprayed CEA appears a useful additional technique in achieving burn wound healing in the paediatric patient with severe burns. CEA sprayed areas did not develop contractures although HTS remained a clinical problem. A prospective evaluation of these combined techniques compared to conventional meshed autograft with sprayed CEA would facilitate determination of its place in the treatment of patients with major burns.

Conflict of interest statement

These authors have no conflicts of interest to declare.

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