Meek micrografting history, indications, technique, physiology and experience: a review article

Aims: Traumatic loss of skin, particularly in major burns, requires skin grafting to repair the tissue. For a large burn, where donor sites are limited, the skin graft may need to be expanded. In addition, rapid wound closure is a large factor in successful recovery and is usually achieved by debridement and skin grafting. Micrografting was introduced by Meek and involved dividing the skin into small pieces, allowing for up to a tenfold skin expansion.

Methods: We conducted a review of the literature, searched via Medline, Pubmed and Embase (from 1958 to June 2017), searching to identify studies and reports of micrografting. We searched using the Medical Subject Headings (MeSH) 'micrograft', 'micrograft technique', 'Meek', 'Meek technique', 'Parker Cicero', 'major burn treatment' and 'mesh skin graft'.

Results: We analysed 24 articles in which the description and modifications presented by the micrograft technique were presented, along with evidence that supports or rejects its use. The consensus was for the use of micrografting in burns of >30% total body surface area (TBSA). On poor wound beds, the evaluation of re-epithelialisation had greater success due to low metabolic demands and greater skin coverage compared with control groups ($p<0.005$). Comparing the 'mesh' with 'Meek' group, the micrograft group had fewer surgeries (10 versus 19.75), shorter average length of hospital stay (51 days versus 120.5 days; $p<0.05$).

Conclusions: Micrografting can be used where there is poor bed vascularity (such as in patients with diabetes), with higher success due to low metabolic demand. This is recommended for major burns, >30% TBSA, with inadequate donor sites and comorbidities, such as diabetes. However, disadvantages include a 'polka dot' appearance on healing and the fact the initial surgeries, creating the micrograft squares, are labour-intensive.

Declaration of interest: The authors have no conflicts of interest to declare.

major burns • Meek • micrografting • skin coverage • total body surface area

With our knowledge of fluid, electrolyte balance and burn pathophysiology, the death of severely burned patients during the early phase of treatment is now a rarity. However, lack of autograft donor sites is increasingly encountered as a limiting factor in achieving wound closure and poses a great challenge for burns surgeons. To overcome this problem, various methods of treatment have been suggested in the past, such as postage stamp grafting,[1] mesh grafting,[2] intermingled auto- and homograft transplantation,[3,4] alternating strips of auto- and homograft transplantation,[5] microskin grafting,[6] and the Meek technique.[7,8]

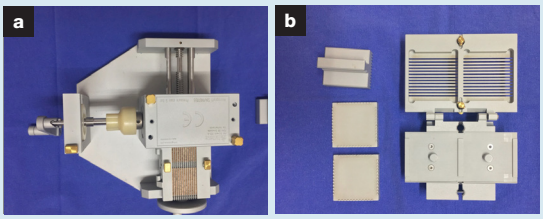
History

Micrografting, a skin coverage method used in burns patients, may improve morbidity. The first description of this procedure was in a newspaper article, from 13 December 1953, titled '*Forsyth native Performs Rare Skin Grafting*'; it referred to Cicero Parker Meek, pinoneer of the technique, as a 'young doctor'. Meek graduated from the Medical College of Georgia, Augusta, US. After graduation, he did his residency in South Carolina and was identified with that state for the rest of his life. The procedure, presented for the first time by Meek in 1958, used a partial-thickness skin expansion device, called a micrograft, invented before the mesh technique.[9] The original case report was of a 14-year-old female admitted to the Aiken County Hospital with burns, involving approximately 25% of her total body surface area (TBSA), on the abdomen, thighs and hands. After debridement, microdermagrafting was performed 24 days after the burn. The results left Meek to conclude that microdermagrafting could be performed successfully on humans that were badly burned.[7] Meek's second case report was of a 37-year-old female, admitted to hospital in July 1958, suffering from second and third degree burns, covering approximately 80% TBSA. Streptokinase-streptodornase jelly was used before the microdermgrafting.[10] However, this method was forgotten following the introduction of mesh skin graft.[9,11]

In September of 1964, James Tanner and Jacques Vandeput published 'the mesh skin graft' using the

***Eduardo Camacho Quintero**,[1] MD, Wound Care Specialist, Past President Mexican Association of Wound Care and Wound Healing; **Jesús Francisco Escrivá Machado**,[1,2] MD, Resident; **Roger Andres Damian Robles**,[1,3] MD, Resident
***Corresponding author email:** drcamacho@telmexmail.com
1 Division of Plastic and Reconstructive Surgery, National Medical Centre 20 of November. México City. **2** Fourth Grade, Division of Plastic and Reconstructive Surgery, National Medical Centre 20 of November. México City. **3** Third Grade, Division of Plastic and Reconstructive Surgery, National Medical Centre 20 of November. México City.

Fig 1. Modified Meek–Wall dermatome (**a**) and the cork device (**b**)



mesh dermatome, generating an expansion three times its original length, allowing a 30% TBSA burn wound to be covered with a 10% TBSA donor site.[2,12]

Although the mesh graft technique was a major breakthrough in burns surgery, it did not fulfil expectations, with grafts failing to expand to the expected size even with advances in skin graft technology. Using the mesh graft II dermatome (Zimmer) for split skin graft expansion, the expected 3:1 and 1.5:1 expansion rates were evaluated for true clinical expansion.[12] In 1.5:1 expanded grafts (n=101), the actual expansion was 1.2:1, and in 3:1 expanded grafts (n=60), actual expansion was 1.5:1.[12] Furthermore, the mesh grafts require the presence of suitable donor sites and re-epithelialisation may be delayed with expansion ratios of greater than 1:6.[11] During this time, the Meek micrograft was forgotten, until the 1990s when it was readopted and improved by physicians at the Red Cross Hospital in Beverwijk, North Holland.[9]

The Meek grafts techniques

The device used in Meek's first case in 1953 had a 13-blade cutter, driven by an electric motor. In addition, flat plates of cork were described as carriers for the transplant. Initially, Meek saturated small (1/16in=4mm) skin islets in plasma and then transferred them by hand to parachute silk which he transplanted directly onto the wound bed. This technique was registered at the US Patent Office under the name 'microdermatome'. In 1993, the modified Meek technique was first published by Kreis et al.[11] with a special glue spray for adhering split-thickness skin grafts (STSG) to plates of cork, as well as modified nylon pleats (in place of the parachute silk originally used by Meek); this facilitated the procedure and increased its acceptance. A week after the autograft transplantation, the Meek nylon pleats could be carefully removed and the allograft skin could be transplanted over the adherent but non-confluent skin islets (Fig 1).[2,9,11,13]

The modified method uses a square piece of cork, measuring 42x42mm, which is covered with an STSG autograft, dermal side placed down, then soaked with 0.9% saline solution and placed in a special cutting machine that contains 13 circular blades (Fig 2a–c). The cork plate with the STSG passes through the machine, where the rotating blades cut through the graft (but not

Fig 2. The Mesh graft technique. The graft is stretched over a piece of cork measuring 42x42mm which is covered with a split skin autograft (**a**) and, dermal side down, covered with 0.9% saline solution (**b**). The cork device with the graft (**c**). Meshing of the graft is achieved using the modified Meek–Wall dermatome (**d**). The graft is cut into 196 3x3mm squares (**e**), sprayed with an adhesive dressing spray and allowed to dry for 5–10 minutes (**f**). The graft is placed on the prefolded polyamide gauze (**g**). Expansion: the gauze is pulled out by firm traction on all four sides (**h**). Final expansion (**i**)

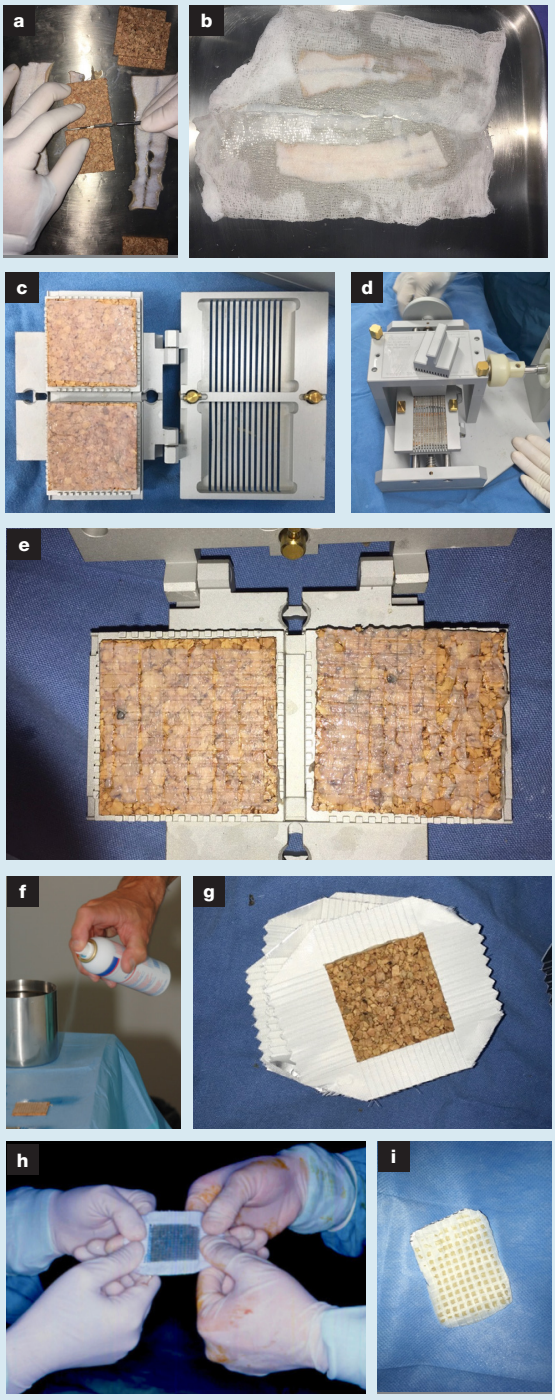


Fig 3. Application of the gauze, graft side down, secured with surgical staples

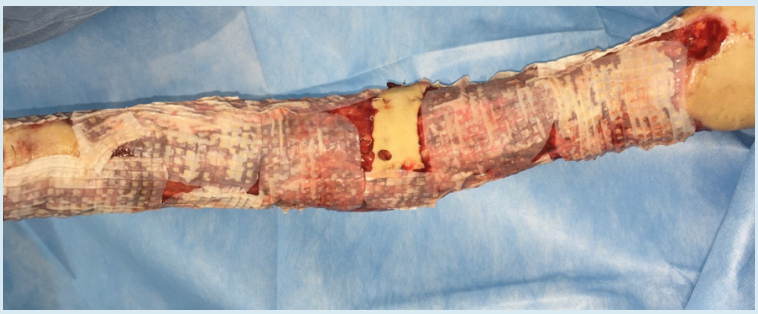
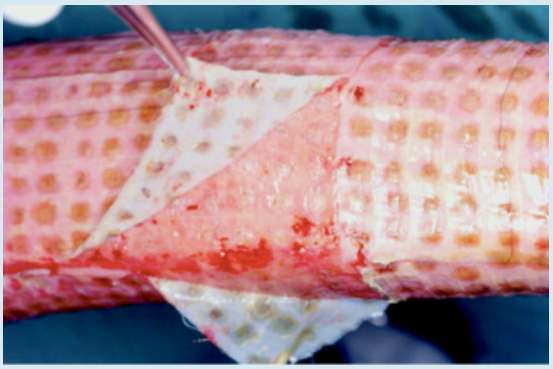


Fig 4. Dressings removed after six days



the cork) (Fig 2d). Thus, the STSG is cut into 14 stripes, each one 3mm wide. After the first pass, the cork is rotated 90° and passed through the machine once more, cutting the STSG into 14x14=196 pieces of 3x3mm (Fig 2e). The epidermal upper surface of the STSG is then sprayed with an adhesive dressing spray and allowed to dry for 5–10 minutes. After the cork is pressed onto a prefolded polyamide gauze on an aluminium foil backing into 14x14 square pleats (the size of which corresponds to the size of the cuts in the graft) it is then gently removed, leaving the graft islands on the gauze. The gauze is pulled out by firm traction on all four sides, until the pleats become entirely unfolded. Finally, the aluminium backing is peeled off, leaving the expanded gauze with the separated autograft islands ready for grafting. After trimming the margins, or folding them down, the gauze is applied, graft side down, to the wound bed and secured with surgical staples (Fig 2f–i and 3).

After about six days the grafts should have grown sufficiently into the wound bed to allow removal of the gauze, leaving the autograft islands *in situ* on the wound bed. The grafts are then covered with a non-adherent sheeting to prevent any movement during daily dressing changes. After a further 5–6 days the sheeting is removed. Daily dressings are continued until re-epithelialisation is complete.[2,7,9,11,13 14] (Fig 4).

The mesh technique

Described by Lanz in 1971,[15] meshing can be performed by hand, or more consistently, by machine. Smaller perforations in STSG that allow expansion ('micromeshing') can be created by passing the skin through a mesher with the 1:1.5 dermatome or meshing with a blade through the surface. Ratios of 1:1.5 and 1:3 are commonly used, although it has been shown that these may equate to actual expansion ratios of only 1:1.2 and 1:1.5 respectively.[15]

Patient selection for micrografting

We conducted a comprehensive review of the literature searched via Medline, Pubmed and Embase (from 1958 to June 2017), to identify studies and reports of micrografting. We searched using the Medical Subject Headings (MeSH) 'micrograft', 'micrograft technique', 'Meek', 'Meek technique', 'Parker Cicero', 'major burn treatment' and 'mesh skin graft'. Limits were set to English, Spanish and Portuguese. The Cochrane Library did not include relevant articles. The search retrieved 26 articles. We analysed and excluded all articles that did not present the experience of micrografting Meek treatment in patients. We found seven articles that used the technique[7,10,11,16–19] and which we analysed (Table 1).

Analysis of these seven studies,[7,10,11,16–19] shows us that micrografting is indicated for use in major burns (>30% TBSA), and where there are insufficient donor sites able to provide the required amount of skin graft.[13]

The most extensive surface burns report was of 37 people who underwent 68 grafting procedures using the modified Meek micrografting technique. The mean age of patients was 34-years-old (range: 8–80 years). TBSA burn was 72.9% (range: 40–97%), of which third degree burns comprised 41% (range: 10–90%).[17]

The youngest and oldest patients reported having a graft using the Meek technique were four years of age (TBSA 67%, full-thickness 60%) and 80-years-old (TBSA 22–97%%, full-thickness 10–90%),[11,17] both of these were caused by a flame[11,17](Table 1).

The true expansion rate

The expansion ratios required are more than 1:6 and meshed skin grafts become even more unreliable beyond this ratio. The discrepancy between the theoretical expansion ratio and the actual expansion ratio obtained with mesh grafts presents a problem as the STSG shrinks after harvesting, due to the elasticity of the skin. Most of the grafts did not reach a 1.5 expansion rate (p=0.001), and no meshed graft reached a 3:1 expansion—a significant number did not even reach an expansion of 1.5:1.[20]

There is a statistically significant difference (p=0.00l) between the obtained and expected expansions. The limitations of mesh grafts have prompted interest in the Meek micrografting technique.[13,20–22]

Mesh versus Meek

The expansion rate depends on a number of factors related to the skin graft's quality and the recipient

Table 1. Studies identified as using the Meek technique

Author	Year/ country	#	Age	% TBSA	%FTBA	Aetiology	Expansion rate	LOS (days)/ epithelialisation	Complications
Meek[7]	1958/Aiken South Carolina	1	14	25	NS	NS	1/16 inch square	NS	NS
Meek[10]	1963/Aiken South Carolina	1	37	80	NS	NS	NS	NS	NS
Kreis et al.[11]	1993/ Netherlands	10	31 (4–52)	64 (43–83)	47 (22–71)	NS	1:9	89 (range: 10–143 days) The mean rate of re-epithelialisation observed during the fifth week after operation was 90% (70–100%)	One patient died of respiratory failure associated with severe inhalation injury
Lari et al.0[19]	1998–1999/ Kuwait	17	24 (13–42)	74% (50–85)	56% (33–78)	Flame	1:6	The mean rate of re-epithelialisation was 90% at the end of the fourth week	Two patients died on day eight and day 11 post-burn; respiratory failure due to severe inhalation injury
Hsieh et al.[17]	2008/ Taiwan	37	34 (8–80)	72.9 (40–97)	41 (10–90)	Flame 33 Chemical 3 Electrical 1	1:9	The viability of the graft as assessed on the 10th day was generally in the range of 90–95%	Mortality was 10.8%; adult respiratory distress syndrome and massive upper gastrointestinal haemorrhage caused three deaths
Mennon et al.[18]	2013/ Australia	7	43 (2–12)	45.7 (30–70)	NS	NS	1:4	50.7 (43–74) In conjunction with cultured epithelial autograft	Two patients had confirmed infections at the site of graft loss, with *Staphylococcal spp*.
Kok et al.[16]	2015/ NS	4 vs 4 STSG	NS	>> 30 %	NS	NS	1:12	The micrograft group had fewer surgeries (10 versus 19.75), shorter average length of hospital stay (51 versus 120.5 days)	Disadvantages include 'polka dot' appearance

#—number of patient; TBSA—total body surface area; FTBA—full total burn area; LOS—length of hospital stay; NS—not specified; STSG—split-thickness skin graft

wound bed. It is particularly important, when grafting large surface areas, to accurately estimate the required donor site based on the technique used: planning an operation with a 1:3, a 310cm^2 STSG harvested can achieve coverage of up to 493cm^2 with a mesh graft or 927cm^2 with a micrograft mesher. The Meek technique (with true expansion ratios from 1:3 to 1:9) requires only about half of the graft surface compared with the mesh graft method (Fig 6).[2,9,11,12,23,24]

This may result in overestimation of the true expansion rate by 55%, and may require consequent adaptation of the operative procedure when addressing large surface areas. Micrografting allows for the use of small skin remnants and mimics the true expansion rate used by 86.5–99.8% when using expansion rates of 1:3 and above.[23]

When comparing the 'mesh' with 'Meek' group, the 'Meek' group had much fewer surgeries (10 versus

Fig 6. The graft surface area required to cover a 100cm^2 burn wound with a meshed graft and compared with the Meek technique. The vertical axis represents the graft surface, while the horizontal axis shows the expansion ratio

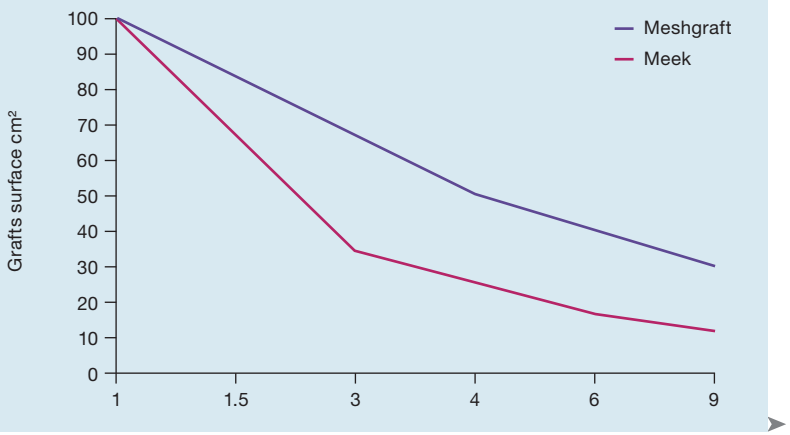
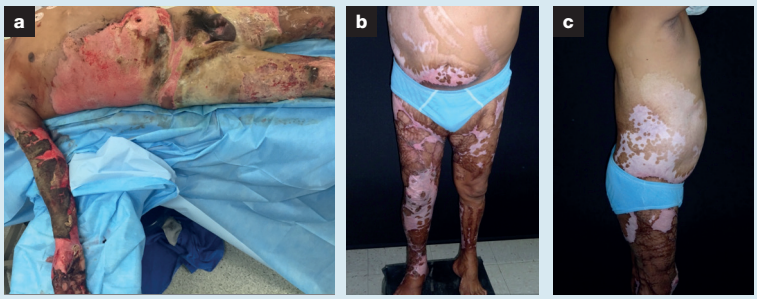


Fig 7. A 62-year-old man was admitted because of a burn wound from a gas stove. The total body surface area burned was 30%, with 18% full-thickness (**a**). The borders between full-thickness and partial-thickness were not sharp. 'Polka dot' appearance (**b** and **c**)



19.75), a shorter average length of hospital stay (51 days versus 120.5 days), and less allograft used for each TBSA% burns (115.7cm^2 versus 356.5cm^2) with overall lower patient costs.[16] These statistically significant improvements are >50% ($p<0.05$). Complete re-epithelialisation with the Meek procedure was seen 7–10 days following the graft: 1:4, 2–3 weeks: 1:6, one month: 1:9.[16,24,25] Another study showed the viability of the Meek technique as assessed on day 10 and was in the range of 90–95%.[17]

The disadvantages of the Meek technique include a 'polka dot' appearance on healing, not seen with the mesh technique. Furthermore, the initial surgeries are relatively labour-intensive in creating the micrograft squares (Fig 7).

Poor wound beds

Micrografting has higher success on poor (infected and/or with poor vascular supply) wound beds due to low metabolic demands and greater skin coverage expansion ratio (1:12).[16,17] Evaluation of re-epithelialisation showed that the surface of the grafted wounds was 77.9±10.9% regenerated by day 10 compared with 28.9±4.6% in ungrafted wounds ($p<0.005$). By day 14, grafted wounds were fully epithelialised. We found that the ungrafted wounds were 28.9±4.6% epithelialised on day 10, 49.1±11.4% epithelialised on day 14, 87.1±7.1% re-epithelialised on day 18, and fully healed by day 21, one week later than the transplanted wounds.[25] By day 14, grafted wounds were fully epithelialised. The migration and proliferation process of the grafted micrografts was similar to the observations made in the healthy model (Fig 8).[23]

Physiology of micrograft

In wounds with micrografts, the healing process is driven by proliferation and migration of the keratinocytes. Micrografts of a certain size (0.8x0.8mm) initially survive by diffusion of wound fluid rather than neovascularisation, and this process is supported by the environment created. Micrografts survive and proliferate independent of orientation and contribute to re-epithelialisation of the wound.[26]

The number of vessel/mm^2 in the subepidermal plexus of the transplanted micrograft are increased ($p<0.005$) on days 10 and 14 when compared with control wounds.[25] No statistical difference was observed on days 21 or 123 after transplantation. Untransplanted wounds displayed a significantly lower number of rete ridges copmared with normal skin ($p<0.01$). The number of rete ridges per linear mm has often been used as an indicator of the strength of the dermal-epidermal junction. In healthy normal pig skin, we found 7.6±1.8 rete ridges/mm, 21 days after transplantation. There was no statistically significant difference between transplanted wounds (5.7±1.9 rete ridges/mm) and normal skin. Ungrafted wounds displayed a significantly lower number of rete ridges (4.7±1.6 rete ridges/mm) than normal skin ($p<0.01$). On day 123, the number of rete ridges in the regenerated epithelium was 4.6±1.4 in micrograft-transplanted wounds and 4.2±1.9 in untransplanted

Fig 8. Bar charts showing re-epithelialisation of wounds from healthy subjects (left) and people with diabetes (right) ***p<0.005

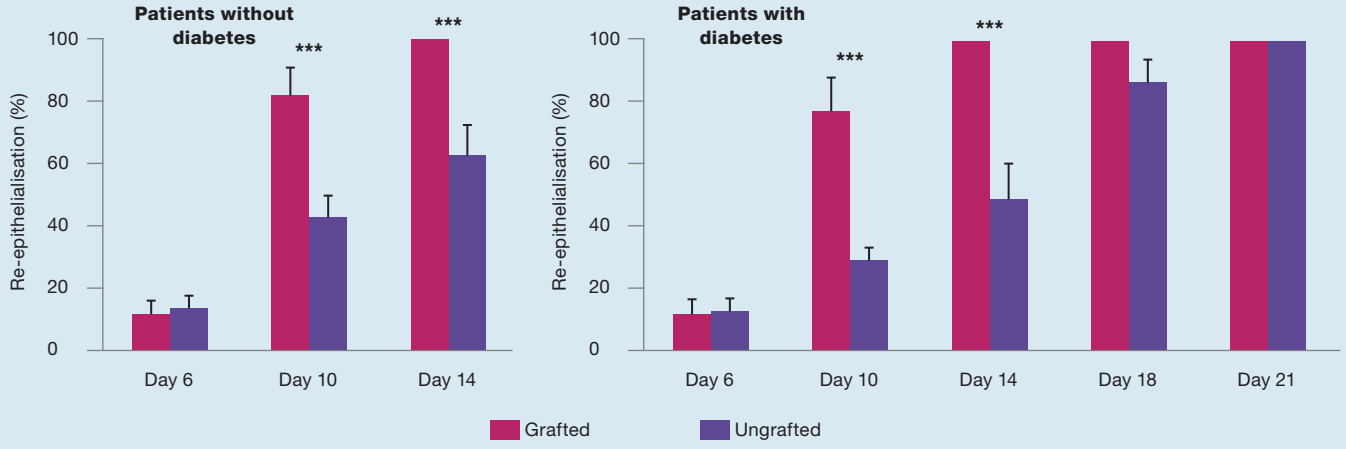
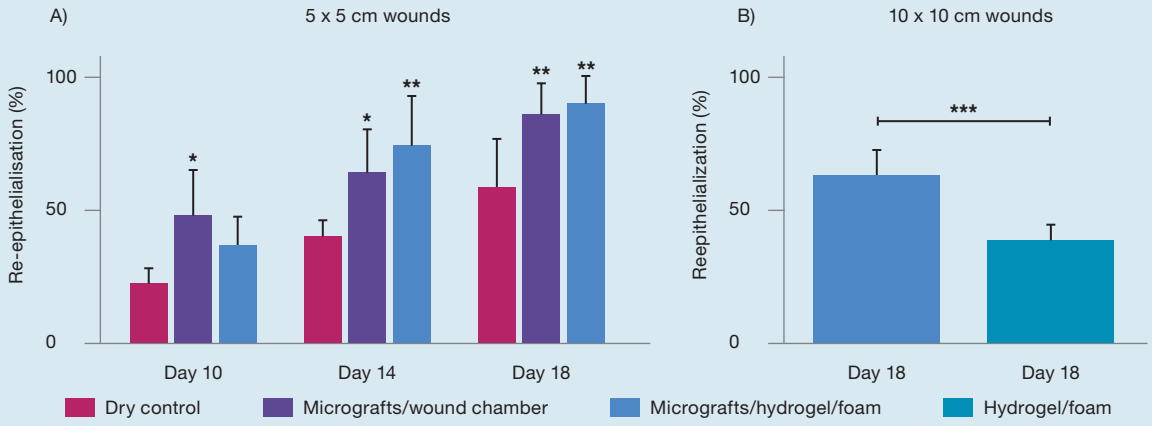


Fig 9. Re-epithelialisation of full-thickness wounds. (**a**) Diagonal cross-sections of 5x5cm wounds were evaluated with regard to re-epithelialisation on postoperative day 10, 14 and 18. Transplantation of micrografts resulted in a significantly higher percent re-epithelialisation. There were no significant differences between micrograft transplanted wounds covered with a wound chamber or moist dressings. (**b**) Diagonal cross-sections of 10x10cm wounds were evaluated with regard to re-epithelialisation on postoperative day 18. Transplantation of micrografts resulted in a significantly higher percent re-epithelialisation. *p<0.05, **p<0.01 ***p<0.005



wounds; both were significantly lower than that of normal skin.[25] Micrografts showed significantly reduced surface area compared with dry controls (p<0.01).[26] On day 10 after wounding, the surface area of 5x5cm wounds treated with micrografts and moist dressings, micrografts and wound chambers, and dry controls were 71.5±10.5%, 60.0±13.0% and 86.2±13.7% of the original wound surface area, respectively. Both groups treated with micrografts showed significantly reduced surface area compared with dry controls (p<0.01). On day 14, wounds covered with moist dressings, wound chambers and dry controls were 58.4±8.6%, 51.1±10.7% and 71.1±6.2%, respectively. The wound chamber treated group showed a significantly reduced surface area compared with dry controls (p<0.01). On day 18, wounds covered with moist dressings, wound chambers and dry controls were 54.9±9.8%, 44.2±9.3%, and 45.2±16.5%, respectively. There were no statistically significant differences at this time point (Fig 9).[25,26]

Grafted wounds treated with a hydrogel and foam dressing had greater epithelialisation on day 14 and day 18 than gauze-covered control wounds (p<0.05 and 0.01 respectively).[26]

Conclusion

The Meek modified technique is a lifesaving method that revolutionised major burns care, and which is recommended for the treatment of major burns (>30%TBSA burns). Micrografting can be used when there is poor bed vascularity, such as in patients with diabetes, with a greater success rate due to low metabolic demands.

In comparison with the Meek technique, the application of widely used meshed grafts requires more procedures in cases of severe burns. A high graft uptake and a sufficient amount of donor graft contribute to the overall opinion that the Meek technique is the most effective way to deal with the patients' skin. Overall, the Meek method turns out to be less time-consuming than meshing, especially in case of large burns. **JWC**

References

1 Gabarro P. New method of skin grafting. BMJ 1943; 1(4301):723–724. https://doi.org/10.1136/bmj.1.4301.723
2 Tanner JC Jr, Vandeput J, Olley JF. The mesh skin graft. Plast Reconstr Surg 1964; 34:287–292. https://doi.org/10.1097/00006534-196409000-00011
3 Gang RK, Hamberg H, Arturson G, Hakelius L. Histological studies of intermingled transplantation of autografts and allografts in rabbits. Burns 1980; 8:80–85
4 Yang CC, Shih TS, Chu TA et al. The intermingled transplantation of auto and homografts in severe burn. Burns 1980: 6(3):141–145. https://doi.org/10.1016/0305-4179(80)90056-X
5 Jackson D. A clinical study of the use of skin homografts for burns. Br J Plast Surg 1954; 7(1):26–43. https://doi.org/10.1016/S0007-1226(54)80004-X
6 Lin SD, Lai CS, Chou CK et al. Microskin autograft with pigskin xenograft overlay: a preliminary report of studies on patients. Burns 1992; 18(4):321–325. https://doi.org/10.1016/0305-4179(92)90155-N
7 Meek CP. Successful microdermagrafting using the Meek-Wall microdermatome. Am J Surg 1958; 6(4):557–558
8 Sheridan RL, Chang P. Acute burn procedures. Surg Clin North Am 2014; 94(4):755–764. https://doi.org/10.1016/j.suc.2014.05.014
9 Ottomann C, Hartmann B, Branski L, Krohn C. A tribute to Cicero Parker Meek. Burns 2015; 41(8):1660–1663. https://doi.org/10.1016/j.burns.2015.06.013
10 Meek CP. Extensive severe burn treated with enzymatic debridement and microdermagrafting: case report. Am Surg 1963; 29(1):61–64
11 Kreis RW, Mackie DP, Vloemans AW et al. Widely expanded postage stamp skin grafts using a modified Meek technique in combination with an allograft overlay. Burns 1993; 19(2):142–145. https://doi.

org/10.1016/0305-4179(93)90038-A
12 Peeters R, Hubens A. The mesh skin graft—true expansion rate. Burns 1988; 14(3):239–240. https://doi.org/10.1016/0305-4179(88)90047-2
13 Kreis RW, Mackie DP, Hermans RP, Vloemans AR. Expansion techniques for skin grafts: comparison between mesh and Meek island (sandwich-) grafts. Burns 1994; 20(I Suppl 1):S39–S42. https://doi.org/10.1016/0305-4179(94)90088-4
14 Tempelman FRH, Vloemans AFPM, Middelkoop E, Kreis RW. The Meek-Wall Micrograft Technique. In: Surgery In Wounds. Téot L, Banwell PE, Ziegler UE. (eds). Springer-Verlag Berlin Heidelberg, 2004
15 Henderson J, Arya R, Gillespie P. Skin graft meshing, over-meshing and cross-meshing. Int J Surg 2012; 10(9):547–550. https://doi.org/10.1016/j.ijsu.2012.08.013
16 Kok YO, Chong SJ, Liang WH et al. Revolutionizing major burns management with micrografting – improved healthcare costs, time and burns resources. Plast Reconstr Surg 2015; 136(4 Suppl):64. https://doi.org/10.1097/01.prs.0000472360.79962.7a
17 Hsieh C-S, Schuong J-Y, Huang WS, Huang T. Five years experience of the modified Meek technique in the management of extensive burns. Burns 2008; 34(3):350–354. https://doi.org/10.1016/j.burns.2007.05.005
18 Menon S, Li Z, Harvey JG, Holland AJ. The use of the Meek technique in conjunction with cultured epithelial autograft in the management of major paediatric burns. Burns 2013; 39(4):674–679. https://doi.org/10.1016/j.burns.2012.09.009
19 Lari AR, Gang RK. Expansion technique for skin grafts (Meek technique) in the treatment of severely burned patients. Burns. 2001; 27(1):61–66
20 Peeters R, Hubens A. The mesh skin graft, true expansion. Burns Incl Therm Inj. 1988; 14(3):239–240
21 Ming-Liang Z, Zhi-De C, Chang-Ye W, Cheng-Hui F. Microskin grafting in the treatment of extensive burns: a preliminary report. J Trauma Inj Infect Crit Care 1988; 28(6):804–807. https://doi.org/10.1097/00005373-198806000-00014
22 Vandeput J, Nelissen M, Tanner JC, Boswick J. A review of skin meshers. Burns 1995; 21:364–370
23 Lumenta B, Kamolz L, Keck M, Frey M. Comparison of meshed versus MEEK micrografted skin expansion rate: claimed, achieved, and polled results. Plast Reconstr Surg 2011; 128;(1):40–41. https://doi.org/10.1097/PRS.0b013e318217463a
24 Ye S-J, Pang S-G, Azhang W-Z et al. Application experience of meek skin-piece making technique on large area deep burning. Chinese Journal of Injury Repair and Wound Healing 2007; 2(1):10–13
25 Hackl F, Bergmann J, Granter S et al. Epidermal regeneration by micrograft transplantation with immediate 100-fold expansion. Plast Reconstr Surg. 2012; 129(3):443e–452e. https://doi.org/10.1097/PRS.0b013e318241289c
26 Hackl F, Kiwanuka E, Philip J et al. Moist dressing coverage supports proliferation and migration of transplanted skin micrografts in full-thickness porcine wounds. Burns 2014; 40(2):274–280. https://doi.org/10.1016/j.burns.2013.06.002