

Endoform<sup>®</sup> helps to stabilize acute surgical wounds

- Endoform<sup>®</sup> allows for the early establishment of vascular networks, providing the healing graft or skin substitute with nutrients and growth factors resulting in robust remodelling and regeneration of the dermis.<sup>1</sup>
- Using Endoform<sup>®</sup> and negative-pressure therapy after surgical intervention for limb salvage can assist in saving these limbs.<sup>1</sup>
- Endoform<sup>®</sup> helps to assist with closure following Moh's excision with no secondary contracture or anatomic distortion.<sup>2</sup>
- Endoform<sup>®</sup> can be used as a substrate for split thickness grafting to aid scaffolding of the neodermis.<sup>3</sup>
- Endoform<sup>®</sup> helps to support, rebalance and stabilize tissue following surgical dehiscence.<sup>4</sup>

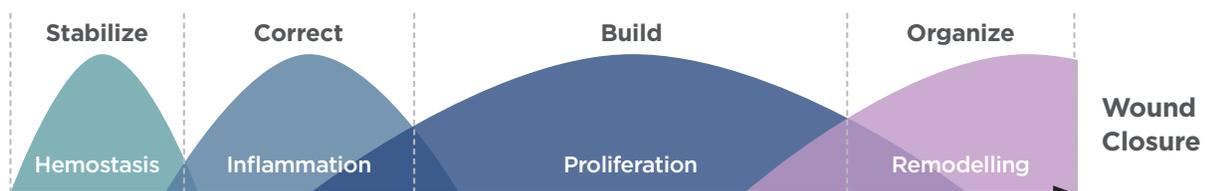


**Wound measurement:**  
1.5 cm x 1.3 cm post excision



*Endoform<sup>®</sup> treatment leads to 100% Re-epithelization and minimal scar contracture.<sup>2</sup>*

Endoform<sup>®</sup> can be used at all phases of wound management





**Natural Dermal Template**



**Antimicrobial Dermal Template**



**References**

1. Silverman, A. (2017). Use of an Ovine Collagen with an Intact Extracellular Matrix (CECM) and negative pressure wound therapy (NPWT) as part of the wound management plan following limb salvage surgical intervention in high risk diabetic foot ulcers. Symposium on Advanced Wound Care - Spring, San Diego, CA.
2. Desvigne, M. N. (2015). Ovine collagen extracellular matrix (CECM)\* Dressing Assisted Closure: For the Acute Wound, Following Mohs Surgical Excision. Clinical Symposium on Advances in Skin & Wound Care. Hyatt Regency New Orleans, New Orleans, LA.
3. Simcock, J. and B. C. May (2013). "Ovine forestomach matrix as a substrate for single-stage split-thickness graft reconstruction." *Eplasty* 13: e58.
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# Ovine collagen extracellular matrix (CECM) dressing assisted nonsurgical closure of the acute wound, following Mohs surgical excision for cancer.

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## Introduction:

CECM is an advanced wound care dressing comprised of non-reconstituted collagen derived from ovine extracellular matrix and it retains the innate biological structure and function of the native extracellular matrix. In vitro studies have shown that CECM exhibits broad spectrum activity against MMPs.<sup>1</sup> CECM may be used for a variety of wound types, one of which is post-surgical wounds. Mohs surgical excision is characterized by the removal of skin cancer with immediate topographic pathologic analysis to ensure all tumor cells are removed. If not, then further excision is performed during that same setting, and repeated until complete tumor excision is confirmed. Mohs surgical excision is performed by dermatology and recommended for skin cancers located in cosmetically sensitive areas on the face. The resulting defects are often large, deep, and may expose underlying cartilage. Closure of these defects can be challenging and often requires the additional expertise of a plastic surgeon. General principles of closure are to replace like tissue with like tissue. This includes local flaps which involves local tissue rearrangement that will require a surgical procedure with anesthesia. Additional incisions are made to create a donor defect to transpose onto the original defect. The donor site is then closed primarily. The result is additional incisions and scars outside of the margin of the original. These procedures must be timely and coordinated with the additional specialist and often are performed the following day. Other options for closure may include primary closure, skin graft or healing secondarily. Primary closure often creates distortion of anatomic landmarks, and skin grafting while it may allow for timely healing, once healed the skin graft often is noticeably different than the surrounding tissue. Healing by secondary intention is an option frequently frowned upon because of the inherent risk of secondary contracture that may distort anatomic landmarks such as the nares, eyes, and or around the mouth. However, a nonsurgical option is the preferred choice for many patients.

## Method/Results:

The use of CECM to assist with closure following Mohs excision was used in 5 patients (N=5). All excisions were performed for basal cell carcinomas on the face (nose 3, forehead 1, lip 1). All patients achieved satisfactory cosmetic closure by 21 days. No infections. No additional surgeries were required. No secondary contracture with anatomic distortion occurred. All patients were satisfied with considerations of cosmetic result, time to heal, and care and treatment required.

## Conclusion:

In summary, in this series of cases CECM provided a non-surgical alternative to surgical flap procedures following Mohs surgical excision. Early experience with CECM dressings to assist with closure for the acute wound following Mohs surgical excision on the face suggests a timely, satisfactory cosmetic result. While further research is needed, early experience resulted in no significant secondary contracture and or anatomic distortion. This differs from what we might expect from secondary healing alone, and suggest further cellular regulation may play a role.

### Case Study 1

Patient: 42-year-old female post Mohs excision left forehead.

#### Past medical history:

- None.

#### Wound treatment:

- CECM dressing applied to wound covered with non-adherent dressing. Antibiotic ointment applied four times a day. Additional CECM applied and non-adherent dressings changed weekly.



Day 1  
1.5 cm x 1.3 cm post excision



Day 1  
CECM covered with non-adherent dressing and antibiotic ointment



Day 7



Day 14



Day 21  
100% Re-epithelization and minimal scar contracture

### Case Study 2

Patient: 75-year-old female status post Mohs excision basal cell carcinoma upper lip.

#### Past medical history:

- Previous skin cancer excisions same location.

#### Wound treatment:

- CECM dressing applied to wound covered with non-adherent dressing. Antibiotic ointment applied four times a day. Additional CECM applied and non-adherent dressings changed weekly.



Day 1  
1.2 cm x 1.2 cm post excision



Day 1  
CECM covered with non-adherent dressing and antibiotic ointment



Day 7  
Defect smaller



Day 7  
CECM cut into confetti-like pieces and applied to wound



Day 7  
Then a whole piece of CECM over the confetti covered with non-adherent dressing and antibiotic ointment



Day 14  
Defect smaller, depth reduced



Day 21  
100% re-epithelized. Minimal scar contracture and no distortion of cupid's bow

### Case Study 3

Patient: 59-year-old female post Mohs excision of basal cell carcinoma on nasal ala.

#### Past medical history:

- Previous basal cell carcinoma.

#### Wound treatment:

- CECM dressing applied to wound covered with non-adherent dressing. Antibiotic ointment applied four times a day. Additional CECM applied and non-adherent dressings changed weekly.



Day 1  
1.0 cm x 1.0 cm post excision



Day 1



Day 21  
100% re-epithelization, minimal scar contracture

### Case Study 4

Patient: 48-year-old male post Mohs excision of basal cell carcinoma on the left nasal tip

#### Past medical history:

- None.

#### Wound treatment:

- Presented with an acute, complex wound with full thickness loss, left tip
- Treatment options discussed were flap repair vs. CECM. Patient requested to use CECM dressing
- CECM dressing applied to wound covered with non-adherent dressing. Antibiotic ointment applied four times a day. Additional CECM applied and non-adherent dressings changed weekly.



Day 1



Day 7



Day 7



Day 14  
100% re-epithelization

### Case Study 5

Patient: 68 year old male with basal cell carcinoma on 2 areas of the nose, nasal sidewall and nasal ala.

#### Past medical history:

- None.

#### Wound treatment:

- Post Mohs surgery resulted in full thickness loss to nasal sidewall and nasal ala
- Surgery performed to close the nasal sidewall defect
- Nasal ala wound left to heal by secondary intention using CECM dressing
- CECM dressing applied to wound covered with non-adherent dressing. Antibiotic ointment applied four times a day. Additional CECM applied and non-adherent dressings changed weekly.



Initial Visit  
2 defects: nasal ala and nasal side wall



Pre-op markings



Post-op



Day 0  
Application of CECM covered with antibiotic ointment and non-stick dressing.



Day 7  
Wound continues to reduce in size. Wound edges are smooth with epithelialization noted



Day 7  
Application of CECM



Day 14  
Defect smaller



Day 14  
Wound edges are smooth with epithelialization noted



Day 21  
100% re-epithelization



Day 21  
100% re-epithelization

Reference: 1. Negroni L, Lun S, May BC. Ovine forehead matrix biomaterial is a broad spectrum inhibitor of matrix metalloproteinases and neutrophil elastase. Int Wound J. 2012 Nov 1; 15(10):1100-1106. \*Endoform dermal template. Distributed by Heptalis Incorporated.



Desvigne, M. N. (2015). Ovine collagen extracellular matrix (CECM) Dressing Assisted Closure: For the Acute Wound, Following Mohs Surgical Excision for cancer. Clinical Symposium on Advances in Skin & Wound Care. Hyatt Regency New Orleans, New Orleans, LA.



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## Ovine Forestomach Matrix as a Substrate for Single-Stage Split-Thickness Graft Reconstruction

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**Keywords:** biomaterial, carcinoma, ovine forestomach matrix, reconstruction, split-thickness graft

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**Objective:** Split skin graft reconstruction of scalp defects often leaves an obvious contour defect. Here, we aimed to demonstrate the use of a decellularized extracellular matrix biomaterial, termed ovine forestomach matrix (OFM), as a substrate for split-thickness skin grafts (STSGs) for scalp reconstruction. **Methods:** Following full-thickness tumor excision, OFM was applied directly to skull periosteum, and then an STSG was applied. Participants were monitored for graft take, epithelialization, and cosmetic outcomes. **Results:** Participants responded well to the procedure with more than 95% graft take in 4 participants, and 100% epithelialization of the grafts after 2 weeks. A 30% graft take was observed in the fifth participant due to local infection and partial necrosis of the graft. Ovine forestomach matrix was remodelled with time and the regenerated dermis was well vascularized and had robust and ordered collagen deposition. **Conclusions:** This series demonstrates that OFM can serve as a temporary dermal scaffold to support an overlying STSG and allow for a single-stage grafting procedure.

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Reconstruction of skin defects may be performed by skin grafting procedures. Full-thickness skin grafts result in a more durable reconstruction due to the larger proportion of dermis placed into the defect than split-thickness skin grafts (STSGs). Because of limited full-thickness skin graft donor sites, STSGs are used in larger defects. Two-stage grafting procedures have been developed whereby a dermal substitute is grafted into the defect under an artificial epidermis, which is subsequently replaced by an STSG. There is a clinical need to replace the relative complexity of 2-stage grafting procedures with robust single-stage procedures without compromising clinical outcomes. However, the feasibility and success of single-stage procedures is dependent on the vascularity of the underlying tissue. To overcome these limitations, collagen-based dermal substitutes have been investigated as temporary substrates for an overlying STSG. This approach creates a composite graft, whereby the underlying dermal substitute is rapidly vascularized and therefore can

support epithelial proliferation of the STSG, leading to closure of the defect and dermal regeneration. The dermal substitute, human acellular dermal matrix (eg, Alloderm) has been investigated for STSG composite grafting in the treatment of burns,<sup>1-3</sup> traumatic skin loss,<sup>2,4,5</sup> and tumor excision.<sup>6-8</sup>

Ovine forestomach matrix (OFM) is a decellularized extracellular matrix biomaterial developed for wound healing and tissue regeneration applications and is cleared by the US Food and Drug Administration for dermal indications. Ovine forestomach matrix comprises mainly collagens I and III arranged as native fibres that retain the 3-dimensional architecture seen in tissue ECM.<sup>9</sup> Additional structural (eg, collagen IV, fibronectin, and elastin), signalling (eg, glycosaminoglycans and heparin sulphate), and adhesion molecules (eg, laminin) are also present. Ovine forestomach matrix is nonantigenic, and it undergoes cellular infiltration and subsequent remodelling leading to regeneration of missing or damaged tissues. In preclinical models, OFM has been shown to be angiogenic and is rapidly revascularized,<sup>10</sup> and in clinical studies, OFM treatment resulted in well vascularized granulation tissue in chronic venous ulcers.<sup>11</sup> These previous findings suggested that OFM may be suitable for composite grafting with STSGs, where clinical success is reliant on the ability for the substrate to rapidly revascularized and provide the requisite nutrients and immune components to the overlying STSG.

## METHODS

### Case studies

The case series was approved by an institutional review board (Upper South A Regional Ethics Committee, New Zealand) and registered with the Australian New Zealand Clinical Trials Registry (<http://www.anzctr.org.au/>). Five participants were selected on the basis of the inclusion and exclusion criteria listed in Table 1 and all tumors were confirmed by pathology prior to the procedure. The procedure was conducted under either local or general anesthetic. A full-thickness excision down to but not including the pericranium was used to remove the tumor and a 5- to 10-mm margin (Fig 1a). Ovine forestomach matrix (Endoform, Mesynthes Limited, New Zealand) was meshed by either hand or a skin graft mesher at a ratio of 1.5:1 (Zimmer) and then trimmed to fit the excisional defect. The material was rehydrated in sterile saline for a minimum of 5 minutes and placed into the defect to contact the underlying periosteum (Fig 1b). An STSG (approximately 0.25-mm thick) was harvested from the thigh of each participant, using either a dermatome (Zimmer Machinery Corporation, Cowpens, South Carolina) or a hand knife. The graft was meshed by hand, cut to fit the defect, and then placed over the OFM, making sure the OFM and STSG were in contact (Fig 1c). A nonadherent dressing (Mepitel, Mölnlycke Health Care, Sweden) was placed over the graft, then a bolster of foam was sutured in place to ensure close contact between the STSG, OFM, and underlying periosteum (Fig 1d). The secondary dressing was removed 7 days following surgery and the graft imaged and evaluated for percentage graft take and epithelialization, based on the total area of the defect. A silver-based hydrogel (Silvasorb; Medline Industries, Inc, Mundelein, Illinois) was used to treat any suspected bacterial infection. The defect was re-dressed using a nonadherent dressing, as required,

and reevaluated weekly for the first fortnight, then monthly or as required. At final review, the healed wounds were assessed for contour defect and scalp mobility by palpation.

**Table 1.** *Inclusion and exclusion criteria*

Inclusion criteria	Exclusion criteria
> 18 years old	Any cutaneous malignancies with metastatic disease
At least 1 nonmelanoma skin cancer without metastatic disease	Diagnosed with malignant melanoma
Malignancies that require full-thickness excision	Systemic malignancy
Postexcision wounds that would normally be reconstructed with a split skin graft	Under suspicion of metastatic disease
Compliant	Pregnant or lactating
Competent	Clinically significant cardiac, pulmonary, renal, hepatic, neurologic, and/or immune dysfunction that may affect wound healing
Tumor located on the scalp, neck, or upper limbs	Known allergy to collagen or ovine (sheep) materials; any previous reaction to a collagen product
	Family or personal history of severe allergies (including asthma, hay fever, and atopic dermatitis)
	Allergies to foods, especially meat products
	Unable to remain in study for 6 mo
	Diabetes mellitus
	Declined, unable, or unwilling to make informed consent
	Not fluent in English or Maori—requires interpreter
	Religious or ethical objections to sheep-derived product
	Previous radiotherapy at the defect site
	Immunosuppressant medication (prednisone >5 mg/d or equivalent)

### Histology and immunohistochemistry

Excised tissues were fixed with 4% formalin, paraffin embedded and stained. Gomoris' Trichrome staining was conducted as previously described.<sup>10</sup> Anti-CD34 immunohistochemistry was conducted as previously described<sup>10</sup> using a mouse antihuman CD34 (Abcam Plc, Cambridge, England) monoclonal antibody. Slides were imaged using a CX-31 microscope (Olympus Imaging America Inc, Center Valley, Pennsylvania) fitted with a DP12 digital camera (Olympus).

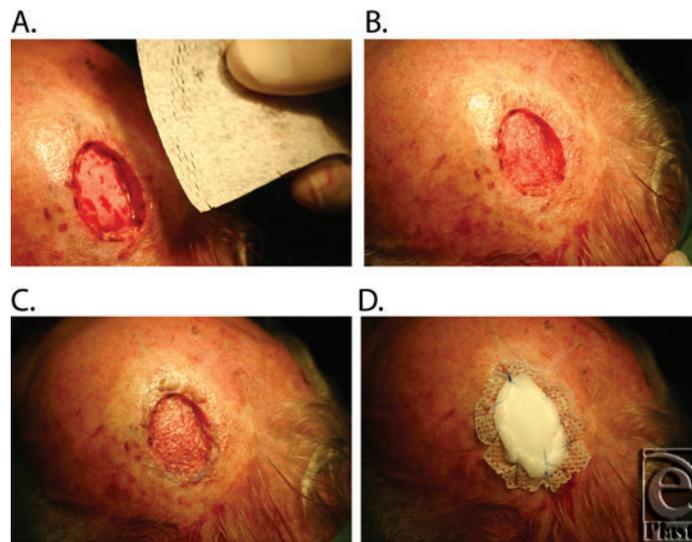
### RESULTS

Participants (B001 through B005) enrolled in the study were all male, 61 to 83 years old, presenting with either an squamous cell carcinoma (SCC) (n = 4) or basal-cell carcinoma (BCC) (n = 1), located on the scalp (Table 2). The tumor size, estimated at enrolment, ranged from 1.2 to 4.6 cm<sup>2</sup>, and tumors had been present for approximately 2.5 to 9

months. Following tumor excision, the full-thickness wounds were approximately 5 to 10 cm<sup>2</sup>. Ovine forestomach matrix could be meshed using a surgical skin graft mesher and once rehydrated was easy to handle and conformed well to the underlying periosteum. One week postsurgery, 4 of the participants had more than 95% graft take (B002, B003, B004, and B005), while the fifth participant, B001, had a 30% graft take. The low graft take in participant B001 resulted from a local infection and partial necrosis of the graft (Fig 2b), which was managed with a silver-containing hydrogel. Complete epithelialization of all grafts occurred in 2 weeks, except for participant B001 where infection delayed complete epithelialization to 8 weeks.

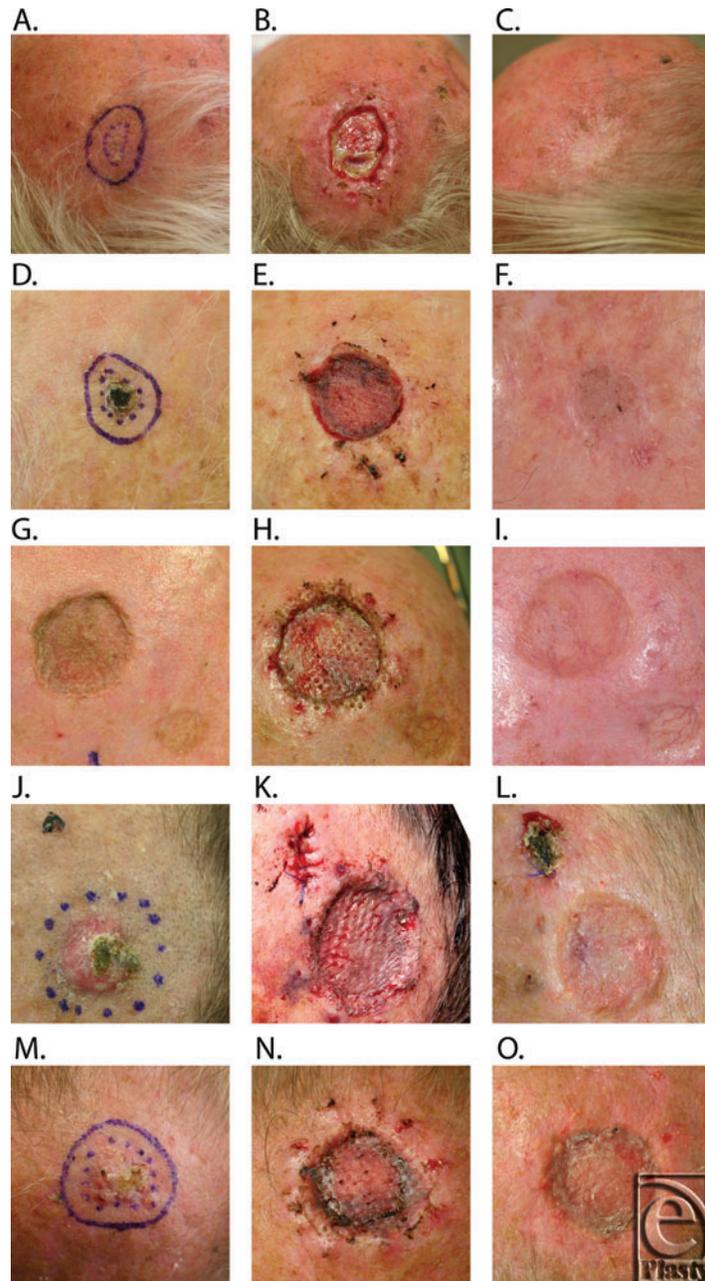
**Table 2.** Summary of participant details and outcomes

Participant	Sex	Age	Tumor location	Age, mo	Type	Area, cm <sup>2</sup>
B001	Male	83	Left vertex scalp	4	SCC	1.5
B002	Male	83	Left anterior scalp	9	BCC	1.2
B003	Male	73	Vertex scalp	8	Previous SCC	16.0
B004	Male	81	Left vertex scalp	2.5	SCC	2.9
B005	Male	61	Left vertex scalp	6	SCC	4.6



**Figure 1.** Representative images of the tumor resection and single-stage split-thickness grafting. (a) Excisional defect following tumor excision and meshed OFM prior to rehydration. (b) Rehydrated OFM cut to size and placed within the defect to conform to the underlying periosteum. (c) Meshed STSG in contact with the underlying OFM. (d) Secondary dressings secured to the perimeter of the excision.

Participants B001, B002, and B003 were available for long-term follow-up (Fig 2). The epithelium remained stable throughout follow-up (minimum follow-up of 6 months, range 7-9 months). Regenerated dermal tissues were well vascularized, elastic, and mobile over the underlying periosteum. Contour defects were judged to be mild via subjective observation.



**Figure 2.** Representative images of the study participants B001 (2.A., 2.B., 2.C.), B002 (2.D., 2.E., 2.F.), B003 (2.G., 2.H., 2.I.), B004 (2.J., 2.K., 2.L.), and B005 (2.M., 2.N., 2.O.), prior to tumor excision (2.A., 2.D., 2.G., 2.J., 2.M.) and 1 week following surgery (2.B., 2.E., 2.H., 2.K., 2.N.). Surgical site following healing; 2.C., 40 weeks; 2.E., 16 weeks; 2.I., 16 weeks; 2.L., 4 weeks (prior to reexcision); 2.O., 4 weeks (prior to reexcision).

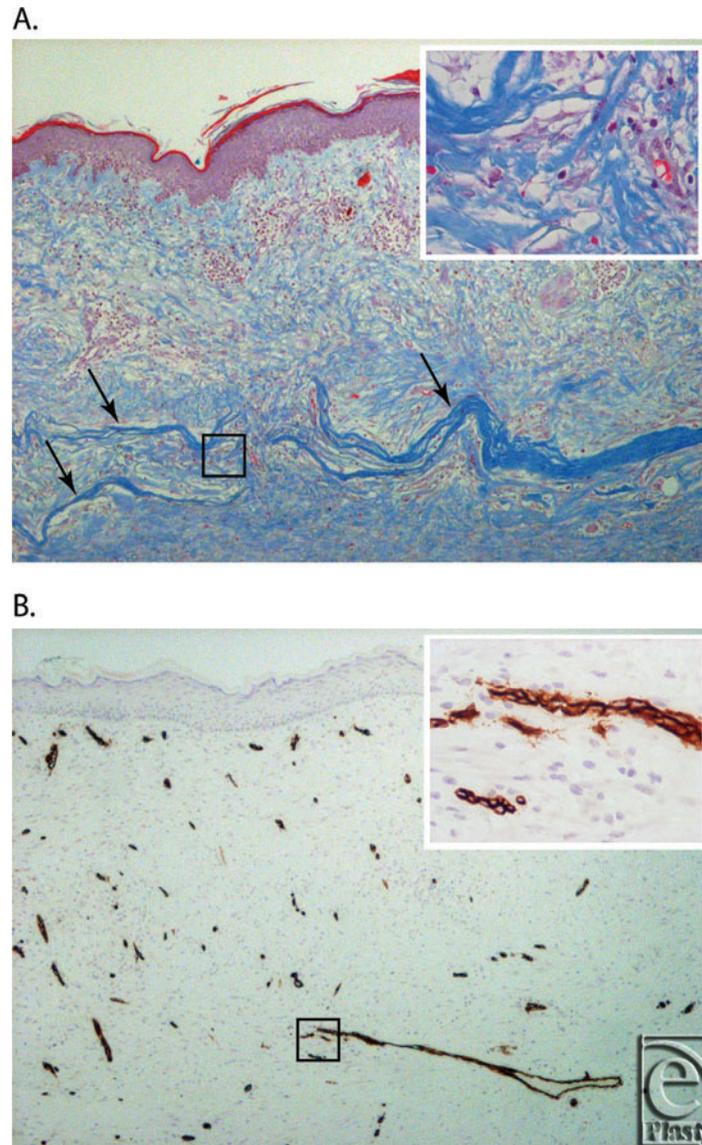
Two of the participants (B004 and B005) had the original surgical site further excised 4 weeks postsurgery to gain adequate ( $>1$  mm histological margin) excision of the tumors at the deep margin. The subsequent procedure excised the original graft as well as the margins and underlying periosteum leaving exposed skull. Therefore, the defects were closed with scalp rotation flaps. The excised tissues containing the original graft were fixed, stained, and imaged (Fig 3a). Remnants of the matrix was evident in both B004 and B005 appearing as compact blue collagen fibers that were distinct from collagen of the regenerating dermis. The matrix was evident in the upper sections of the regenerating dermis, immediately beneath the superficial dermis from the STSG. Matrix fragments were infiltrated with fibroblasts and immune cells, including multinuclear giant cells (MNGCs) macrophages and lymphocytes. The immune response in B005 was greater than that in B004, with mononuclear cells and MNGCs associated with the remodelled matrix. Both patients had a well-vascularized dermal layer with dense well-organized collagen bundles and spindle-shaped fibroblasts (Fig 3a). A fully formed keratinized stratified squamous epithelial layer was present and dermal papillae extended into the epithelial layer. An extensive network of blood vessels was present within the regenerating dermis, as evidenced by anti-CD34 immunohistochemistry (Fig 3b).

## DISCUSSION

Scalp reconstruction is especially challenging given the limited blood supply of the underlying calvaria, the relatively thin cutaneous tissue, and the lack of redundant skin. Split-thickness skin grafts take well on the underlying periosteum; however, this leaves an obvious contour defect. Skin flaps and expanders have been traditionally used, but these approaches are complicated by the minimal laxity of the scalp and the complexity of these multistage procedures. As an alternative, collagen-based biomaterials that function as temporary dermal scaffolds have become increasingly useful as part of a single- or 2-stage procedure for surgical reconstruction. These materials allow direct grafting to the underlying calvaria, usually following removal of the outer portion of exposed bone to allow vascularization of the dermal scaffold.<sup>7,12,13</sup> There are a few examples in the literature where dermal scaffolds have been used directly in contact with exposed pericranium to support an STSG,<sup>8</sup> and to our knowledge this is the first report of a xenogenic dermal scaffold being used in this fashion. The current composite grafting procedure allows for a single-stage procedure to be completed, therefore reducing increased costs associated with multiple procedures and longer term wound management. Results from the 5 participants enrolled in the current study indicate that clinical outcomes from this approach were not compromised, though further controlled studies are warranted.

Previous preclinical studies have shown OFM is remodelled, and importantly the remodelling phenotype resolves with time, with concomitant deposition of new tissues.<sup>10</sup> This is consistent with the known inflammatory response invoked by decellularized extracellular matrix-based biomaterials, namely remodelling as characterized by an immunomodulatory M2 macrophage phenotype rather than acute inflammation.<sup>14</sup> The current study provided a rare opportunity to microscopically examine a snapshot of the remodelling of OFM following human implantation, be it with a limited sample size. As has been seen previously in *in vivo* studies,<sup>10,15</sup> the inflammatory response to OFM included the recruitment of a number

of immune modulatory cells, including lymphocytes, macrophages, and MNGCs. Long-term resolution of the remodelling inflammatory response in participants was evidenced by the robustness of the regenerated dermis and absence of any wound breakdown.



**Figure 3.** (a) Gomori's Trichome stain of the excised graft from B004, 4 weeks postgraft (4× magnification). Arrows indicate the intact fragments of OFM. Insert shows a 40× magnification of the area indicated by the black square. (b) CD34 immunohistochemistry of the excised graft from B004, 4 weeks postgraft (4× magnification). Insert shows a 40× magnification of the area indicated by the black square.

While the current application of this procedure was in the reconstruction of tissue deficits following tumor resection, there is the potential for this approach to be applied to the treatment of burns and traumatic skin loss. This initial study also suggests OFM as a candidate substrate for autologous cell seeding, whereby suspensions of dermal cells (eg, keratinocytes or fibroblasts) or stem cells (eg, bone marrow or adipose-derived stem cells) are applied to the substrate. This strategy has many similarities to the composite STSG procedure described here, as it relies on rapid vascularization of the underlying dermal scaffold to support the transplanted cells.

### Acknowledgements

The authors would like to acknowledge the clinical research assistance of Viki Robinson and the Pathology Department of Hutt Valley Hospital for histology and immunohistochemistry. B.C.H.M. is a shareholder in Mesynthes Limited.

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## CASE STUDY 2 | Surgical Dehiscence

Sex:	Male
Co-morbidities:	Non-insulin dependent diabetes Hypertension
Wound Type:	Surgical dehiscence
Wound Location:	Lateral heel
Wound Age:	12 weeks
Previous Treatments:	Compression Enzymatic debrider Sharp debridement (wound edge resection)
Secondary Dressing:	Non-adherent dressing Rolled gauze Compression therapy Offloading pressure device
Outcomes:	Granulation tissue at Week 7
Endoform applications:	9



Week 0:

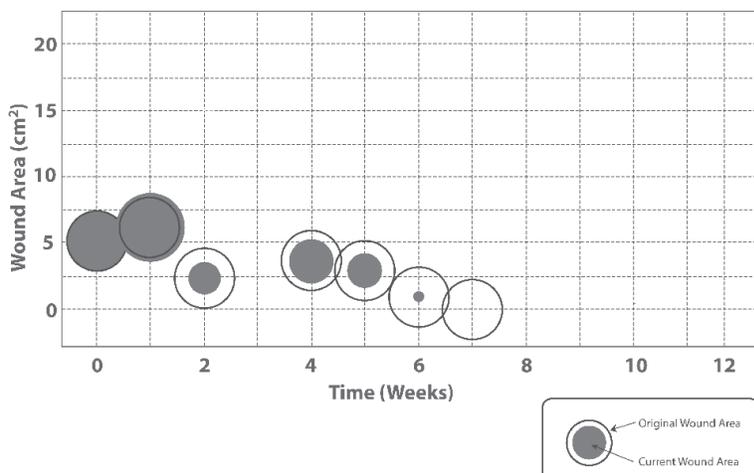


Week 5:



Week 7:

Wound area over time



## Initial Preparation

The wound was surgically debrided down to viable tissue and irrigated with hypochlorous acid solution and treated with an enzymatic debriding agent and compression. The wound was assessed for visible signs of infection (i.e., absence of swelling, pain, purulent drainage, or tracking into the deep tissue planes). The wound had to remain free of infection to start using the Endoform dermal template. Enzymatic debriding treatments were stopped at this time.

## Endoform dermal template Application

Using aseptic technique, Endoform dermal template was trimmed to roughly overlap the wound margins, placed on the wound bed and rehydrated with sterile saline. Following hydration, the color of the dressing changed from white to opaque. Light pressure was applied to the dress ensure that it conformed to the underlying wound bed. The dressing was covered with a non-adherent secondary dressing. Compression stockings, exudate control and offloading were used as required.

## Follow-Up

The patient received weekly follow-up, during which time the wound was debrided as required and irrigated to remove loose material. The Endoform dermal template was reapplied on a weekly basis. Changes in the wound granulation tissue, epithelial tissue and wound dimensions were monitored and recorded using digital photography. The wound was monitored for a further four weeks.

## Observations

In approximately three days, the dressing had adhered to the underlying wound bed. After seven days, the dressing was completely integrated into the wound bed. In some cases, only remnants of the dressing remained as an off-white gel that was allowed to remain in place during subsequent applications of Endoform dermal template.

### Case provided by:

Liden BA, Ward BR, May BCH; Early Clinical Findings From The Use Of Endoform Dermal Template (Ovine Forestomach Matrix) To Treat Recalcitrant Wounds; Presented at Symposium on Advanced Wound Care, April 14-17, 2011 Dallas, TX.

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