

Use of Ovine Forestomach Matrix in the Treatment of Facial Thermal Burns

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ABSTRACT

Introduction. Thermal burn injuries are common, devastating medical emergencies that are challenging to manage. Timely and effective treatment is paramount to both short- and long-term patient outcomes. Currently, medical providers and health care facilities worldwide are emphasizing the need for cost-efficient and accessible treatments; such treatments are particularly vital for vulnerable populations with limited access to advanced medical resources. The use of extracellular matrix (ECM) technologies has become widespread in the management of acute and chronic wounds, including burns. Ovine forestomach matrix (OFM) is an ECM bioscaffold isolated from sheep forestomach tissue and has been shown to be effective in soft tissue reconstruction procedures. **Case Report.** The use of OFM in the treatment of 2 facial thermal burn injuries, including in a pediatric patient, is described. Both patients fully recovered from their facial injuries with satisfactory cosmetic outcomes. **Conclusions.** Although OFM technology is widely used in the management of acute and chronic wounds, the authors believe this to be the first published report of its use to aid healing in burns. Ovine forestomach matrix may provide a valuable additional tool for the management of complex burns.

KEYWORDS

wound healing, burns, pediatrics, tissue engineering, biomaterials, ovine forestomach matrix, extracellular matrix, regenerative medicine

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Soft tissue defects secondary to burn injuries can be devastating and difficult to treat. The incidence of facial burns varies by country but has been reported to range between 27% and 60%.¹ These facial burn injuries are often extremely painful and prone to infection, and acceptable cosmetic outcomes are critical for the patient.² Even if a burn injury progresses to complete closure, concern remains for the longer-lasting sequelae, such as chronic nerve pain, disfigurement, painful fibrotic scar, loss of function, loss of sensation, and psychosocial implications for the patient.^{1,3,4} Although the skin of the face tends to be more vascularized than peripheral anatomy, facial burns pose a treatment challenge for multiple reasons. Skin contracture is common in areas of the face with

underlying mobile tissues, whereas the forehead is at increased risk of exposed bone and the associated challenges of achieving adequate coverage.⁵ Eyelids and lips are thinner tissues and thus are particularly prone to contracture.⁵ Facial burns are also difficult to manage due to airway management, the potential for respiratory compromise resulting from thermal inhalation injury, or postinjury edema.

Ovine forestomach matrix (OFM) is a decellularized extracellular matrix (ECM) bioscaffold that has been used extensively in the management of complex wounds and soft tissue reconstructions, including chronic lower extremity wounds and acute surgical wounds.⁶⁻¹² The process of tissue decellularization of the intact ovine tissues removes all cells and cellular

debris, leaving an intact, native, and biocompatible scaffold for use in soft tissue regeneration applications.¹³ Ovine forestomach matrix contains naturally occurring anti-inflammatory proteins¹⁴ and demonstrates anti-inflammatory properties in vitro and in vivo,^{15,16} stimulates blood vessel formation,¹⁷ and is remodeled into functional soft tissue over time.^{17,18} The structure of OFM is biomimetic of native soft tissue ECM and serves as a scaffold for fibroblast and keratinocyte migration and proliferation.¹³ A proteomic analysis of OFM identified more than 150 known ECM and ECM-associated proteins, including various growth factors (eg, epidermal growth factor, platelet-derived growth factor) and antibacterial proteins, including cathelicidin and β -defensin.¹⁴



Figure 1. Case 1: A 9-month-old male infant presented with facial burns and was managed with ovine forestomach matrix. (A) At approximately 4 days after initial injury, remote patient evaluation was conducted. (B) At the initial in-person clinical presentation (week 0, approximately 8 days after the initial injury), appearance predebridement showing a covering of more than 80% fibrotic slough (wound dimensions, 13.2x12.7cm). (C) Week 2 (predebridement), showing approximately 75% fibrotic tissue in the wound bed. (D) Week 3 (predebridement), showing 25% granular tissue and 75% fibrotic slough in the wound bed. (E) At week 3 (postdebridement), the wound measured 12.5x10.6cm in size. (F) At week 3.5 (postdebridement), the wound measured 8x6.2cm in size. (G) At week 7, the wound measured 4.3x3.8cm in size. (H) At week 8, the wound was fully epithelialized. Guardian consent was obtained for the publication of the patient's case and photos.

Although the use of OFM in managing chronic wounds has been widely published, few reports describe its use in the treatment of burns. This case report documents the successful use of OFM to treat 2 patients with challenging facial thermal burns. The authors obtained patient or guardian consent to publish the case photos and data.

CASE REPORTS

Case 1

A 9-month-old male infant sustained a thermal burn injury to the entire left side

of the face, with portions of full-thickness damage, resulting from an open fire. Because of sociopolitical factors, the patient and family were unable to seek immediate medical attention; thus, the initial evaluation was conducted remotely approximately 4 days postinjury (Figure 1A). The patient was evaluated in person approximately 8 days after the initial injury (Figure 1B). The skin defect equated to approximately 10% total body surface area (TBSA) for an infant under the age of 1 year. The patient could not be admitted

for surgical debridement under anesthesia because of sociopolitical factors.

The initial wound, which measured approximately 13.2 cm x 12.7 cm, presented with a covering of fibrotic slough (>80%), inflammation, and significant drainage, and it was suspicious for infection (Figure 1B). Hair follicles adjacent to the left side of the face had been entirely lost, and the patient was experiencing significant discomfort.

The patient had no known comorbidities or other underlying health conditions at the time of treatment. During the initial evaluation, he was treated for a suspected local infection with antibiotic therapy and underwent mechanical debridement of nonviable tissue to the limits of his pain tolerance. Postdebridement (not shown), treatment was initiated with 2 layers of OFM plus 0.3% ionic silver (Endoform Antimicrobial; Aroa Biosurgery Limited) for suspected local infection. After the initial 2-layered OFM application, an additional layer of OFM was applied weekly for 7 weeks. The OFM bioscaffold integrates into the regenerating tissue over time; thus, there is no need to remove the dressing from the wound bed.

Physical examination 2 weeks after the initial in-person consultation revealed resolving soft tissue inflammation, no further clinical signs of infection, and a reduction in nonviable tissue in the wound bed to approximately 75% (Figure 1C). By week 3, the patient's discomfort had dramatically reduced (pain score, 0 of 10). This allowed the clinician to perform more aggressive debridement (Figure 1D), which revealed a well-granulated wound bed (Figure 1E). At 3.5 weeks, approximately 40% of the original skin defect had epithelialized (wound dimensions, 8 cm x 6.2 cm) (Figure 1F), and by week 7, the original skin defect had decreased to 4.3 cm x 3.8 cm in size (Figure 1G). At week 8, the burn was fully epithelialized (Figure 1H), and approximately 10% skin contracture was noted. The neoepithelialized skin was pliable, elastic, and grossly comparable to the patient's normal skin



Figure 2. Case 2: A 38-year-old male presented with a facial burn injury. (A) At approximately 2 days after initial injury (postdebridement), the patient initially presented. (B) Four days after initial evaluation (predebridement), showing more than 10%–20% fibronectic covering the injury (wound area, 27.9×15.2cm). (C) At 6 days after initial presentation (predebridement), showing minimal desiccated slough. (D) Week 2, after completion of treatment with ovine forestomach matrix. (E) Week 3 follow-up, showing 100% epithelialization. Patient consent was obtained for the publication of the case and photos.

pigmentation. Of note, the hair follicles that had been damaged by the thermal burn had begun to show signs of viability and formation of new hair. The patient had no residual pain, maintained sensation of the damaged area of his face, and resumed normal activities.

Case 2

A 38-year-old male with no significant past medical history sustained a partial-thickness thermal burn injury to most of the forehead and both cheeks secondary to a gas explosion. Initial evaluation was conducted remotely, followed by an in-person examination approximately 2 days postinjury. The skin defect covered approximately

4.5% TBSA. Initially, the wound measured approximately 27.9 cm × 15.2 cm; presented with a covering of fibrotic slough (>50%–60%), inflammation, and notable drainage; and was suspicious for infection. As a result, the patient was admitted to the hospital and an initial debridement was performed (**Figure 2A**). The patient was experiencing significant discomfort, with a pain score of 8 on a 10-point scale. Two days later (4 days postinjury), approximately 10% to 20% of the patient's face was covered by devitalized tissue (**Figure 2B**). After sharp debridement was performed, OFM (Endoform Natural; Aroa Biosurgery Limited) was placed over the injury site, in addition to a layer of hydrogel and

secondary gauze dressing. Wound dressings were changed every 48 hours. By 6 days postinjury, the patient's pain score had decreased to 3. Light mechanical debridement was performed to manage a small amount of slough (**Figure 2C**); this was followed by a repeat application of OFM and hydrogel with gauze secondary dressing. At 9 days postinjury, the patient was reevaluated before discharge. The wound area had decreased to 2 cm × 7 cm in size (**Figure 2D**), and wound management transitioned to the application of 2.5% hyaluronic acid cream and sun protection factor 15 sunscreen 3 times daily. By the final follow-up visit, 20 days postinjury, complete epithelialization of the skin had occurred. The neoepithelialized skin was pliable, elastic, and grossly comparable to the patient's normal skin pigmentation (**Figure 2E**).

DISCUSSION

The use of ECM bioscaffold technologies in the management of burn injuries has become widespread.¹⁹ These products are used either as part of a 2-stage reconstructive procedure to build granulation tissue before definitive closure with a split-thickness skin graft (STSG) or in instances in which STSG is not available or is inappropriate. These same technologies can be used to aid closure via secondary intention.²⁰ Even with the growing clinical evidence to support widespread adoption of ECM technology for advanced burn and wound care, its use may be limited by lack of availability, mostly because of the cost of such treatment.²¹

Extracellular matrix technologies differ significantly from synthetic and semisynthetic bioscaffolds because ECM technologies include naturally occurring ECM proteins that have important biologic roles in soft tissue regeneration following burn injury.²² As in all wounds, soft tissue regeneration following burn injury typically proceeds via the orderly phases of wound healing, with the inflammatory phase initiated after the initial injury and hemostasis.²³ A prolonged inflammatory phase in

burn healing can lead to hypertrophic scarring, exacerbation of pain, and overall impaired healing.²⁴ Biologically active molecules present in OFM are known to have anti-inflammatory properties.²⁵ For example, tissue inhibitors of metalloproteinases (eg, TIMP-4) and serpins are naturally occurring protease inhibitors and are present in OFM.²⁵ This finding may explain the broad-spectrum inhibitory effect of OFM on matrix metalloproteinases, which are a known contributor to wound chronicity.¹⁵ Ovine forestomach matrix has a native matrix structure composed of proteins to aid cell repopulation, migration, and proliferation¹⁷; promote angiogenesis¹⁷; and recruit mesenchymal stromal cells (MSCs).²⁵ In thermal burn injuries, MSCs have been shown to play a substantial role in regeneration by accelerating epithelialization,²⁶ differentiating and regenerating the stratified epidermis,²⁷ and modulating inflammation.²⁸

Although many ECM technologies have been commercialized for soft tissue repair, OFM is a commercially available product for which the barriers to access, namely cost, have been significantly reduced.¹² Both patients in this case series had limited access to advanced burn care technologies due to sociopolitical factors, including refugee status. Data from the World Health Organization suggest that more than 95% of burn deaths occur in low- to middle-income countries.²⁹ Burns are among the most common and devastating medical conditions encountered in refugee camps.³⁰ Therefore, access to cost-effective advanced ECM technology for the early treatment of thermal burns can have a significant effect on patient outcomes. In a multicenter study, Pham et al³¹ found burns that epithelialized in less than 21 days to be at much lower risk of hypertrophic scarring compared with slower-to-heal burn injuries. Shortening the time to wound closure and minimizing contractures can facilitate earlier return to work^{32,33} and improve the long-term psychosocial status of survivors of burn injury.³⁴

The application of OFM in the patients with significant facial burns in this case report helped to provide immediate coverage and facilitate epithelialization in 20 days (partial-thickness burn) and 56 days (deep partial-thickness burn). Both patients experienced a notable reduction in pain and discomfort. These initial positive outcomes using OFM in the management of challenging partial-thickness and deep partial-thickness facial burns and the accessibility of the products have prompted the authors of this case report to adopt OFM as part of the standard of care for patients with burns. Although no large-scale prospective efficacy studies of OFM in the management of burns have been conducted, the authors' experiences of managing burns reflect outcomes of previously published studies in acute and chronic wounds treated with OFM.

LIMITATIONS

This case report is limited by the sociopolitical factors that may have prevented the current standard of care treatment of acute facial burns. Although the details and management of facial burns vary from patient to patient, to the knowledge of the authors of this case report, this article is the first publication in which OFM was used in the management of burn wounds. Additional studies with larger sample sizes are needed to substantiate the outcomes of the 2 cases reported herein.

CONCLUSIONS

Thermal burns are painful soft tissue defects that are challenging to manage. Such injuries can benefit from the use of advanced technologies to accelerate wound closure and reduce the risk of complications. This case report suggests that OFM is a cost-effective treatment for partial-thickness and deep partial-thickness facial thermal burns that provides immediate coverage, builds granulation tissue, and aids epithelialization at the site of burn injury. 

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