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Case Series

Surgery Section

Multifaceted Role of the Acellular Dermal Matrix in Novel Wound Healing: A Case Series

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ABSTRACT

Acellular Dermal Matrix, Matriderm®, a collagen and elastin matrix, has emerged as a versatile tool in wound coverage, promoting healing and reducing scarring, thus offering numerous advantages in various clinical scenarios. The varied uses demonstrated here include concomitant application of the acellular dermal matrix while grafting with a full-thickness skin, application over bare bone in Split-Thickness Skin Grafting (STSG) and in the treatment of mucocutaneous fistulae in the oral cavity. The outcome with the use of Matriderm® in all these cases was satisfactory. Hereby, the authors present a case series of four patients that provide an understanding of Matriderm®'s efficacy in promoting healing and regeneration in complex wounds. Matriderm®, an acellular dermal matrix composed of collagen and elastin, supports tissue regeneration and reduces scarring, making it a valuable tool in complex wound management. The present case series highlights its versatility and potential in advancing wound care.

Keywords: Acellular dermal matrix, Bare bone, Full thickness wounds, Matriderm®, Mucocutaneous fistula, Orocutaneous fistula, Radiotherapy, Skin substitute

INTRODUCTION

Wound healing is a complex process involving various cellular and molecular mechanisms. Matriderm®, an acellular dermal matrix composed of bovine collagen and elastin, has been designed to mimic the human dermal structure, facilitating wound healing and reducing scar formation [1]. It is a three-dimensional matrix dermal substitute consisting of bovine collagen types I, III, and V, and elastin hydrolysate. This composition mimics the human dermal Extracellular Matrix (ECM), providing a scaffold for cellular ingrowth and neovascularisation [1]. The matrix is biocompatible, biodegradable, and non-immunogenic, making it an ideal substrate for wound healing [2]. Unlike other commercially available products similar to Matriderm®, the latter differs being composed of native bovine collagen (Types I, III, V) with 3% elastin, no cross-linking, advantage of one step grafting, rapid vascularisation, and yielding superior scar quality [1].

The mechanism of action involves several stages [2]:

i. Cellular infiltration: Its porous structure allows for the infiltration of fibroblasts, keratinocytes, and endothelial cells.

ii. Neovascularisation: The matrix supports the ingrowth of blood vessels, ensuring adequate nutrient supply for tissue regeneration.

iii Matrix remodelling: The temporary matrix is gradually degraded and replaced by the body's own ECM proteins, leading to tissue regeneration and reduced scarring.

Matriderm® is used in various clinical situations:

A. Burn wounds- It has been extensively used in the management of partial and full-thickness burns. When used in combination with STSG, either concomitantly or in subsequent sittings, it improves graft take, reduces scar formation and contractures, and enhances functional and aesthetic outcomes [3]. The matrix provides a dermal scaffold, allowing for better integration of the graft and improved long-term results.

B. Chronic wounds- Chronic wounds, such as Diabetic Foot Ulcers (DFUs) and Venous Leg Ulcers (VLUs), pose significant clinical challenges. It has shown promising results in these wounds by promoting granulation tissue formation and epithelialisation [4]. The matrix supports cellular ingrowth and revascularisation, addressing the underlying pathophysiology of chronic wounds has been used to promote granulation tissue formation and prepare the wound bed for STSG [5].

C. Surgical wounds- In reconstructive surgery, it has been used to correct soft-tissue defects and improve aesthetic outcomes. It is particularly useful in single-stage procedures, where it can be applied concurrently with STSG, reducing the need for multiple surgeries [6].

D. Paediatric wounds- It has also been successfully used in paediatric patients, demonstrating good safety and efficacy profiles [7,8].

E. Reconstructive surgery- It is also valuable in reconstructive surgery, particularly in cases where tissue loss is significant. It can be used to cover exposed structures, such as tendons or bone, reducing the need for complex flap procedures [9].

F. Trauma: In cases of open fractures or avulsion injuries. It has been used to cover fracture sites, promoting healing and reducing the risk of infection [10]. Its application in combination with negative pressure wound therapy has shown promising results in complex trauma cases [11].

G. Orthopaedic surgery: In patients undergoing bone tumour resection or corrective surgery for bone deformities. It has facilitated wound closure and healing [2].

Matriderm® offers several advantages, including:

i. Biocompatibility: Its bovine collagen-elastin composition is well-tolerated by the human body, with minimal risk of adverse reactions [12].

ii. Flexibility: It can be easily cut and shaped to fit various wound sizes and shapes [12]. After wet with saline, it conforms to the wound contour.

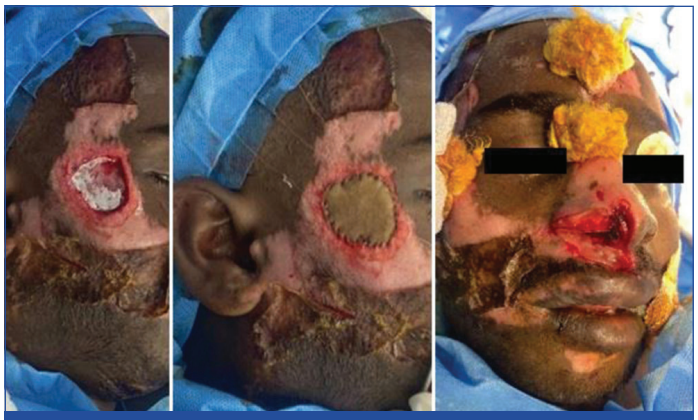
CASE SERIES

Case 1

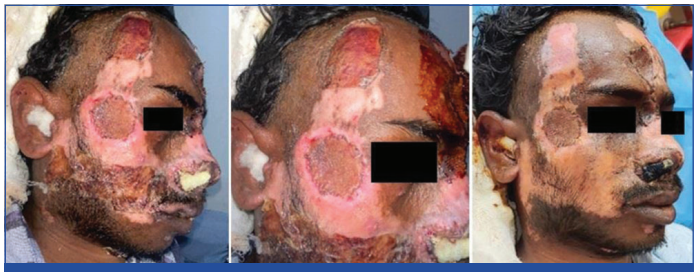
A 26-year-old male patient sustained facial injuries in a road traffic accident and presented with a contaminated wound within a few hours of the incident in a conscious state. Facial bone fractures

were conservatively managed with multiple facial wounds and abrasions, thoroughly debrided. In view of contamination, definitive wound closure was deferred and a meshed collagen sheet was applied [Table/Fig-1]. After two weeks patient was taken up for surgery. A 2 mm fenestrated Matriderm® along with simultaneous Full Thickness Skin Graft (FTSG) from groin (in view of large FTSG required and patient's reluctance for graft to be taken from head and neck areas/supraclavicular) was used to cover the full thickness skin loss over forehead, dorsum of nose, right cheek area, right nasal ala and upper lip on right-side. Tie over/bolster dressing was done to secure the FTSG and underneath Matriderm® in place [Table/Fig-2]. Uptake of all the FTSG was 100% [Table/Fig-3]. At the 6th month follow-up, the grafted areas were pliable, comparable to near normal skin tone. However, the grafts retained most of the groin skin colour and contrasted with the surrounding hypopigmented healed abrasions, though it was less dark than the original groin area colour [Table/Fig-4].

[Table/Fig-1]: Multiple full thickness skin loss over face and full thickness Cut Lacerated Wound (CLW) of upper lip (Left); Wound thoroughly debrided and skin suturing wherever possible was done (Middle); Collagen sheet applied (Right).



[Table/Fig-2]: A 2 mm fenestrated Matriderm® applied over the temporal defect (Left); Full Thickness Skin Graft (FTSG) harvested from the groin secured over the Matriderm® with continuous running suture (Middle); Bolster dressings applied (Right).



[Table/Fig-3]: Appearance of the Full Thickness Skin Graft (FTSG) at 3 weeks (Left); Note the FTSG taken up fully (Middle); Appearance of FTSG at 4 weeks (Right).

Case 2

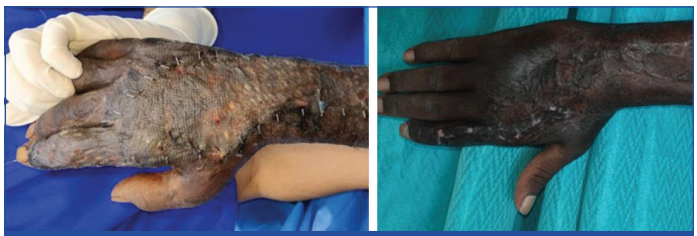
A 37-year-old male presented with post-debrided raw area (2 weeks before presentation to us) over the right upper limb due to necrotising fasciitis as a consequence of a snake bite (2 days before debridement surgery). At presentation, the patient had a large raw area extending from the dorsum of right index finger to the elbow over the dorsal aspect. The right index finger's proximal interphalangeal joint was exposed along with bare bone of the proximal phalanx without

[Table/Fig-4]: Appearance at 6 months. All the FTSGs grafted over the 5 areas of the face – forehead, right temporal, right lateral of nose, nasal flare on right-side and upper lip - all taken up well and appear pleasing with minimal graft contracture.

periosteum. The affected area was thoroughly debrided and irrigated [Table/Fig-5]. A 2 mm Matriderm® was applied over the open joint and bare bone of right index finger and the exposed tendons over the dorsum of wrist. STSG was harvested from the thigh and the meshed graft was secured over the raw area and Matriderm® concomitantly, in the same sitting [Table/Fig-6]. The STSG uptake was near complete with small islands of raw areas over the forearm which healed secondarily. The resultant grafted area where Matriderm® was applied, was supple and visibly more pleasing, at four months follow-up [Table/Fig-7].

[Table/Fig-5]: Full thickness skin loss post debridement of necrotising fasciitis of the right hand and forearm due to snake bite (Left); exposed bare bone (proximal phalanx) with open proximal interphalangeal joint (Right).

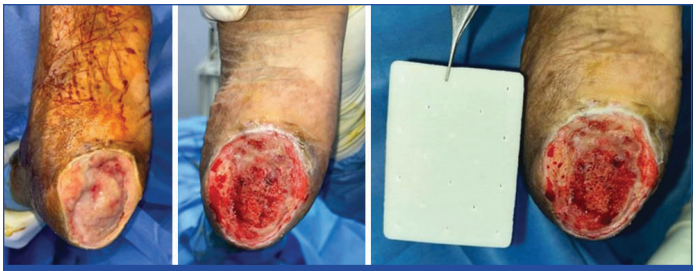
[Table/Fig-6]: A 2 mm Matriderm® applied over bare bone, joint and tendons (Left); Matriderm® wet with saline (Middle); Split Thickness Skin Graft (STSG) applied over the hand and forearm (Right).



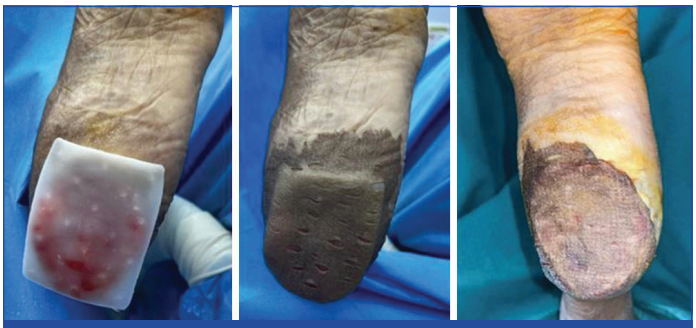
[Table/Fig-7]: Healthy STSG with intact staples noted at first dressing on 5th postoperative day (Left); STSG settled well at the end of 3 months (Right).

Case 3

A 67-year-old female patient presented with a Diabetic Foot Ulcer (DFU) over the right heel region for two months, measuring 7*8 centimetres with slough and islands of pale granulation tissue with minimal pain and tenderness. On debridement, the calcaneum was exposed. The osteomyelitis part was debrided till there was active bleeding. Since the elderly patient with multiple co-morbidities couldn't withstand major flap surgery, a 3 mm fenestrated Matriderm® was applied [Table/Fig-8], and split thickness skin grafting was done at the same time. Negative pressure wound therapy was applied. On the 7th postoperative day, the healthy skin graft was noted. The patient was followed-up for a week. At the time of the last follow-up (2 weeks after skin grafting), 100% of the skin graft was found to be healthy [Table/Fig-9].



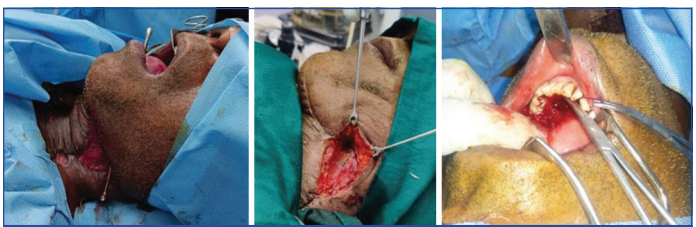
[Table/Fig-8]: Diabetic Foot Ulcer (DFU) over the volar surface of the left foot (Left); Appearance of the heel ulcer after debridement with the bare calcaneum exposed having the osteomyelitis bone been debrided (Middle); A 3 mm fenestrated Matriderm® before application (Right).



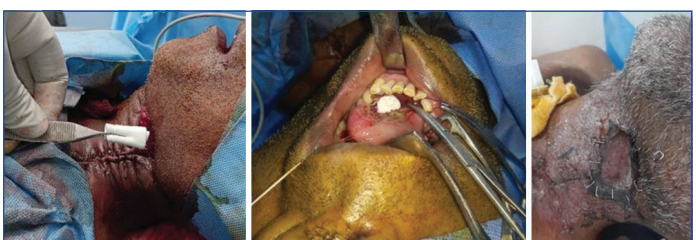
[Table/Fig-9]: The 3 mm fenestrated Matriderm® applied over the bare calcaneum (Left); STSG applied over the Matriderm® in the same setting over which negative pressure wound therapy was applied (Middle); STSG appearance after removal of the Negative Pressure Wound Therapy (NPWT) on 7th postoperative day (Right).

Case 4

A 48-year-old male patient was diagnosed with squamous cell carcinoma of the floor of the mouth upon biopsy of the ulcero-proliferative growth on the left-side. Patient was operated, a week after the diagnosis, with wide local excision and neck lymph node dissection. For the ensuing defect, free anterolateral thigh flap was planned and executed. Partial flap loss was noticed on 8th day and was debrided. After two weeks, an orocutaneous fistula was noticed communicating to the left-side of neck with continuous drooling of saliva [Table/Fig-10]. For this, we determined to use acellular dermal matrix for treatment instead of surgical intervention using flaps. A 3 mm Matriderm® was rolled and inserted into the curetted tract with the openings closed with Matriderm® pieces [Table/Fig-11]. The neck woundwas closed with STSG while the mucosal opening was closed with Matriderm® only. Bolster dressing was applied. The fistula healed, STSG uptake was 100% and the oral opening closed with mucosalisation. Patient later underwent radiotherapy. Patient was followed-up to six months with no recurrence or wound breakdown [Table/Fig-12].



[Table/Fig-10]: Communicating orocutaneous fistula shown with the scoop being placed in the fistula (Left); cutaneous fistula opening after thorough debridement (Middle); oral opening after debridement (Right).



[Table/Fig-11]: Rolled 3 mm Matriderm® being inserted into the fistula (Left); A piece of the Matriderm® placed in the floor of the mouth (Middle); STSG applied in the neck over Matriderm® (Right).

[Table/Fig-12]: The site of oral opening of the fistula completely healed (Left); STSG in the neck completely taken up well and having withstood radiotherapy (Right).

DISCUSSION

Numerous clinical studies have demonstrated the efficacy of Matriderm® in improving wound healing and reducing scar formation. A study by Cervelli V et al., concluded that Matriderm® when used with STSG, improves scar quality and superior patient-reported outcomes compared to STSG alone [6].

A study by Haslik W et al., demonstrated that this skin substitute, when used with STSG, led to significantly better Vancouver Scar Scale (VSS) scores compared to STSG alone [13]. Similarly, a study by Mantelakis A et al., concluded that it improves scar quality and elasticity in burn wounds [14].

A randomised controlled trial by Bloemen MCT et al., found that Matriderm®, in combination with STSG, led to faster healing and reduced recurrence rates in DFUs compared to STSG alone [7]. Moreover, a case series by Chew BMH et al., reported successful use of Matriderm® in the treatment of refractory VLUs [15].

A study by Ryssel H et al., reported successful use of Matriderm® in reconstructing full-thickness defects of the hand [9]. Similarly, a case report by Orabona DAG et al., described the use of Matriderm® in covering exposed skull bone, highlighting its versatility in reconstructive surgery [16].

In the patient, who underwent reconstruction of multiple facial wounds with simultaneous Matriderm® application and FTSG, Matriderm® improved graft uptake by providing a scaffold for cellular ingrowth and promoting vascularisation, which can be attributed to Matriderm®'s porous structure, which facilitates the migration of fibroblasts and endothelial cells, leading to faster revascularisation [17]. By incorporating Matriderm® application simultaneously with FTSG, patient discomfort of undergoing multiple surgical interventions can be avoided. In our patient, the FTSG was more supple and pliable than expected of FTSG alone. Also, it was noticed that gradually, the grafted areas were getting lighter compared to the original donor site colour, the groin. It also reduces the overall treatment time and benefits both the patient and the healthcare system, and reduces hospital stay length, morbidity, and cost of treatment [18]. This versatility makes Matriderm® a valuable tool in reconstructive surgery.

MedSkin Solutions on their website, while providing Matriderm® product information, states that Matriderm® is not suitable for infected wounds or those with exposed bone, tendon, or nerve [19]. Matriderm® in preparation for STSG over bare bone, in our case scenario, was observed to enhance the take of STSG over bare bone devoid of periosteum, by providing a well-vascularised bed for the graft. Bare bone is an absolute contraindication for STSG, and always dictates a flap cover. The Matriderm® matrix promotes angiogenesis and fibroblast proliferation, creating a favourable environment for graft take and subsequent survival [5]. The use of Matriderm®, in our study, is observed to allow for thinner STSGs, thus reducing donor site morbidity and pain.

Oral cutaneous fistula or mucocutaneous fistulae in the oral cavity present significant clinical challenges, often resulting from surgery, trauma, or infection. Matriderm®, can emerge as a promising tool

in the treatment of these fistulae due to its ability to promote tissue regeneration and healing, as shown in our patient. Its application promotes rapid granulation and closure of fistulae, reducing patient morbidity and hospital stay [20,21].

A study by van Zuijlen PP et al., demonstrated that the use of Matriderm® in full-thickness skin loss followed-up with STSG resulted in scars that were more elastic and less contracted compared to controls [22]. This is likely due to the elastin component of Matriderm®, which contributes to the elasticity and resilience of the neo-dermis. In a study by Nakhi MB et al., Matriderm® was used for defects on the nose, temple, and hand, with excellent aesthetic and functional results after skin grafting [18]. A prospective study by Min JH et al., found that patients treated with Matriderm® and a STSG reported better scar quality and overall satisfaction compared to those treated with skin graft alone [23].

While Matriderm® offers several advantages- including single-stage grafting, reduced scarring, and enhanced tissue regeneration - some limitations and risks merit discussion. One significant consideration is cost, as Matriderm® can be more expensive than some alternative collagen-based products available commercially, potentially limiting its accessibility in resource-constrained settings [10]. Additionally, while the product is generally well-tolerated, there remains a risk of infection, particularly if used in contaminated wounds or in immunocompromised patients [6,8]. Although Matriderm® is non cross-linked and bovine-derived, minimising immune reactions, this also raises concerns regarding disease transmission or allergic responses, especially in individuals with bovine protein sensitivities [13]. A nuanced understanding of these trade-offs is essential to optimising patient outcomes and selecting the most appropriate dermal substitute in diverse clinical scenarios.

While Matriderm® has shown promising results, further research is needed to optimise its use and understand its long-term effects. Larger, randomised controlled trials are required to compare Matriderm® with other dermal substitutes and standard treatments. Future research should focus on optimising Matriderm®'s use, potentially in combination with other therapies such as growth factors or stem cells. Also, research on use of Cultured Epidermal Autografts (CEA) in wound coverage along with Matriderm®, would be a game changer in medical field. Long-term follow-up studies are also needed to assess the durability of Matriderm®'s effects and its impact on patient quality of life.

CONCLUSION(S)

Matriderm® is a versatile and effective tool in wound coverage, with numerous applications in burns, chronic wounds. To fully establish its role in clinical practice, further comparative studies are warranted - particularly those assessing long-term outcomes and patient-centred metrics such as quality of life, graft durability, and functional recovery. Future research should also explore specific patient populations, including paediatric and immunocompromised individuals, to better delineate its indications and limitations. Large-scale, randomised controlled trials and long-term follow-up studies will be essential in validating its efficacy and safety relative to other established dermal matrices.

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