Ovine Forestomach Matrix in the Surgical Management of Complex Lower-Extremity Soft-Tissue Defects

A Retrospective Multicenter Case Series

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Background: Chronic lower-extremity defects may lead to major amputations and have severe consequences on patient quality of life and mortality. Dermal matrices have become part of the reconstructive ladder and are often deployed in these scenarios to quickly build neodermis, especially in volumetric defects over exposed bone and tendon initially, to allow for subsequent closure by means of split-thickness skin grafting (STSG) or secondary intention. Ovine forestomach matrix (OFM) is a decellularized extracellular matrix (ECM) bioscaffold available in both sheet and particulate forms that can be used as a dermal matrix in various soft-tissue reconstruction procedures.

Methods: This retrospective case series evaluated the use of OFM products in the surgical reconstruction of 50 cases (n = 50) comprised of challenging lower-extremity defects from seven healthcare centers. Patient records were reviewed to identify comorbidities, defect cause, defect size, presence of exposed structures, Centers for Disease Control and Prevention contamination score, Wagner grade, OFM graft use, time to 100% granulation tissue, STSG use, overall time to heal, and postoperative complications. The primary study outcomes were time (days) to 100% granulation tissue formation, with secondary outcomes including overall time to wound closure (weeks), STSG take at 1 week, and complications.

Results: The results of this case series demonstrate OFM as a clinically effective treatment in the surgical management of complex lower-extremity soft-tissue defects with exposed structures in patients with multiple comorbidities. One application of OFM products was effective in regenerating well-vascularized neodermis, often in the presence of exposed structures, with a mean time to 100% granulation of 26.0 $\pm$ 22.2 days.

Conclusions: These data support the use of OFM as a safe, cost-effective, and clinically effective treatment option for coverage in complex soft-tissue wounds, including exposed vital structures, and to shorten the time to definitive wound closure in complicated patient populations. (J Am Podiatr Med Assoc 113(3), 2023)

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Standard wound care, often along with adjunctive therapies (eg, negative-pressure wound therapy [NPWT], cellular tissue products) is the first-line intervention for lower-extremity soft-tissue defects. However, many cases may be complicated by additional factors, such as the presence of a deep infection that warrants immediate surgical intervention to reconstruct the defect and provide closure.[1] Lower-extremity defects can be challenging to manage effectively regardless of underlying cause and, when not adequately addressed, can lead to lower-limb amputation and an increased mortality rate. For example, lower-limb necrotizing soft-tissue infections (NSTIs) have a mortality rate of 25% to 35%.[2] These defects are complex when volumetric tissue loss is involved, resulting in complex soft-tissue wounds that often result in revealing denuded vital structures such as bone, tendon, nerve, and/or vasculature. Exposure of vital structures can lead to desiccation, necrosis, progressing infection, and severe long-term functional consequences.[3]

Lower-extremity defects present a reconstructive challenge to surgeons in terms of closure, preservation of function, and cosmetic outcomes.[2] Denuded and devitalized critical structures often lack sufficient vascularization and sof-tissue extracellular matrix (ECM) to support immediate coverage with a split-thickness skin graft (STSG) and therefore require surgical techniques that facilitate coverage and closure. Traditionally, this has been achieved through the use of local or free flap procedures to provide immediate coverage to the exposed vital structures once any infection has been addressed.[4] However, flap-based reconstructions can lead to lengthy operating times, introduce the risk of donor-site morbidity, and have the potential for flap failure.[5] Dermal matrices, among other surgical procedures, have filled a need in lower-limb reconstruction where traditional local or free flap procedures are not possible.[6] The use of a dermal matrix negates the risks associated with morbidity of the donor/harvest site and may decrease surgical complexity associated with local or free flap procedures. There are now a wide range of dermal matrices that are commercially available and include synthetic and tissue-derived technologies.[6] Tissue-derived products are typically manufactured from a suitable mammalian tissue source that is processed to isolate and decellularize the tissue ECM.[7] Unlike purely synthetic dermal matrices, decellularized ECM (dECM) products (sometimes referred to as "biologics") when processed properly, retain many of the biological components of tissue ECM that are known to aid tissue regeneration.[8,9] These types of products are now an integral part of the reconstructive ladder, and are especially useful where the soft-tissue defect is further complicated by microbial contamination, poor vascularity, or local chronic inflammation.[6] Like synthetic dermal matrices, dECM products provide a scaffold for cell infiltration, proliferation, and neovascularization, leading to neodermis formation and integration of the naturally occurring and preserved scaffold inherent in the source from which it was derived. Once the neodermis has been formed, definitive closure can be accomplished with a STSG, or closure by means of secondary intention. One common barrier to the adoption of dECM products tends to be limited accessibility because of relatively high product costs. However, relative to flap-based procedures, the overall surgical costs may be reduced using dECM products because of decreased surgical time and length of patient hospitalization.[5]

Various dECM grafts are clinically available that differ in the source tissue (eg, human, porcine, bovine, equine) and processing technique to decellularize the tissue.[10] Ovine forestomach matrix (OFM) is a dECM isolated from juvenile (<12 months) sheep forestomach and comprises the propria-submucosa tissue layer that has undergone decellularization, lyophilization, and terminal sterilization.[11] Ovine forestomach matrix–based products have been shown to be effective in chronic wounds,[12-15] plastic and reconstructive procedures,[16-19] and general surgery procedures.[20-23] Ovine forestomach matrix–based products have found a particular niche in the regeneration of soft tissues in patients who would otherwise experience compromised healing or are at risk for postoperative complications because of the presence of bacterial contamination, local chronic tissue inflammation, or patient comorbidities. Healing in these challenging environments may be aided by the inherent preserved biological components of OFM,[24] which have been shown to be anti-inflammatory,[25,26] stimulate angiogenesis,[27] and recruit mesenchymal stem cells.[28]

For reconstructive surgical procedures, OFM is available as a 2-, 3-, or 5-layer graft (Myriad Matrix; Aroa Biosurgery Limited, Aukland, New Zealand). The multilayer OFM graft is fabricated using a novel manufacturing process that retains the structure and biology of the dECM material, without introducing any additional components (eg, synthetic materials or crosslinked collagen).[29] The resultant OFM graft enables rapid cell infiltration by means of the porous architecture of OFM, but also by means of engineered pores and remnant vascular channels

that allow for vertical and transverse cell migration into the graft. Previous in vivo studies and histologic assessments have demonstrated the rapid cell infiltration, and neovascularization of multilayered OFM grafts.[30] More recently, a particulate format of OFM has been commercially available for applications in soft-tissue repair (Myriad Morcells; Aroa Biosurgery Limited). The particulate, or "morselized," format was designed to provide rapid biology to the wound bed and enables intimate contact with irregular wound surfaces compared to the sheet form. Given the previously reported performance of OFM in a range of inflammatory soft-tissue defects (eg, pilonidal sinus, hidradenitis suppurativa, chronic wounds), the following retrospective multicenter case series was undertaken to evaluate the performance of OFM graft, particulate products, or both in complex lower-extremity reconstructions that would otherwise be at risk of complications, such as infection or limb amputation.

Methods

The study protocol was evaluated by the Advarra Institutional Review Board (Columbia, Maryland) and ethical oversight of the retrospective study was waived. The study was conducted in accordance with institutional guidelines and the World Medical Association Declaration of Helsinki ethical guidelines. All patient information, including any patient images, were deidentified.

Data were collected from patients who met the inclusion and exclusion criteria (Table 1) and represented patients who had undergone inpatient lower-extremity reconstruction using OFM products between January of 2019 and December of 2021. Ovine forestomach matrix–graft (Myriad Soft Tissue Matrix) and OFM particulate (Myriad Morcells) were used according to the instructions for use. The selection of either product was at the discretion of the attending surgeon at the time of the procedure and included cases that had used either OFM graft or OFM particulate, or both products in combination. Cases included patients who had received an STSG, or those who underwent closure by means of secondary intention at the discretion of the attending physician (Fig. 1). The primary study endpoint was median time to 100% granulation (days) of the graft (Fig. 1). Secondary endpoints included median time to closure (weeks); percentage STSG take at 1 week (if applicable); and adverse events (including hematoma/seroma, dehiscence, infection, and recurrence). All data were collated in Excel (Microsoft Corp, Redmond, Washington). Descriptive statistics (mean, median, and standard error) were computed using GraphPad Prism (Version 9.0.0; GraphPad Software, LLC, San Diego, California).

Table 1. Inclusion and Exclusion Criteria

Inclusion
Male or female patients aged 18 years or older
Patients with a lower-extremity soft-tissue defect treated with OFM graft or OFM particulate as part of their surgical intervention
Exclusion
Patients still under active management
Patients who did not receive OFM graft or OFM particulate as part of their lower-extremity soft-tissue reconstruction

Abbreviation: OFM, ovine forestomach matrix.

Results

A total of 50 patients from seven sites were enrolled in the study having met the inclusion and exclusion criteria (Table 1). Median patient age was 63.0 years (mean, 60.6 ± 15.2 years; range, 28–87 years), with 54% of patients being male and 46% of patients being female (Table 2). Patient comorbidities included diabetes mellitus type 1 (2%), diabetes mellitus type 2 (66%), hypertension (34%), peripheral arterial disease (54%), peripheral veneous disease (80%), lymphedema (22%), atrial fibrillation/anticoagulant therapy (12%), and coronary artery disease (8%). Twenty-four percent of patients were previously diagnosed with four of the comorbidities captured in the study (Table 2). A significant proportion of all defects were classified as diabetic foot ulcers (DFUs) (48%) and of the DFUs, half were complicated by a necrotizing soft-tissue infection (50%) (Table 3). Of all defects included in the study, 34% had exposed bone, 10% had exposed tendon, 18% had both exposed tendon and bone, and 4% had exposed capsule (Table 3). Only 34% of the defects presented with no exposed structures. Where applicable, Wagner grades were recorded as grade 2 (8%), grade 3 (18%), and grade 4 (22%), and all defects had a Centers for Disease Control and Prevention contamination score of IV. Osteomyelitis was reported in 54% of cases. The median age of the defects was 5.5 weeks (mean, 60.0 ± 152.5 weeks; range, 0–780 weeks), and the median defect area was 40 cm^2 (mean, 84.2 ± 106 cm^2; range, 4–429 cm^2). The median wound depth was 0.3 cm (mean, 10.6 ± 0.9 cm; range, 0.1–5.0 cm).

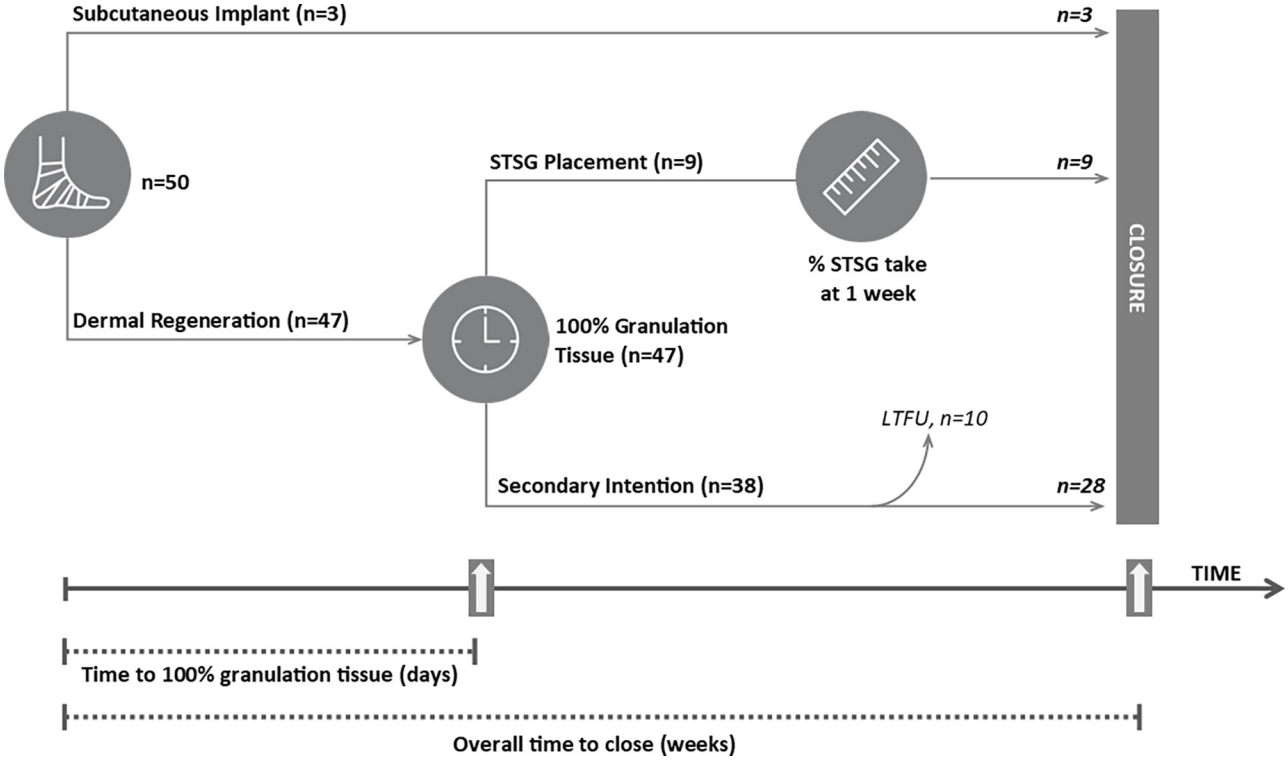

Figure 1. Retrospective study design and outcome measures. LTFU, loss to follow-up; STSG, split thickness skin graft; n, sample size.

Forty-one patients (82%) received OFM graft, whereas three patients (6%) received OFM particulate, and six patients (12%) received both (Table 4). The OFM graft was used as an implant to reinforce a flap in three patients. Median product use was 1.0 application (mean, 1.0 ± 0.1 application). Eighteen patients (36%) received postoperative NPWT, with a median NPWT treatment duration of 3.8 weeks (mean, 4.4 ± 2.5 weeks; range, 1–10 weeks).

Ten patients were lost to follow-up before complete closure of the defect, but after 100% granulation tissue had formed (Fig. 1). Where OFM products were used for dermal regeneration (n = 47), the median time to 100% granulation tissue was 17 days (mean, 26 ± 22.2 days; range, 7–120 days) (Table 5). Nine patients received an STSG as part of a two-stage reconstruction procedure. Of the patients who received an STSG, the median percentage STSG take at 1 week was 75% (mean, 74.6 ± 18%; range, 50–100%). Thirty-eight patients (76%) were closed by means of secondary intention, with an overall median time to close of 14 weeks (mean, 14.0 ± 5.9 weeks; range, 1–27 weeks) (Table 5 and Fig. 2). The overall time to closure (from the initial surgical procedure to closure) across defects (n = 40) was 13 weeks (mean, 13.7 ± 6.9 days; range, 2–29 weeks). A subgroup analysis based on surgical type (dermal regeneration, implant) and closure type (STSG or secondary intention) showed mean overall time to closure of 3.3 ± 2.3 weeks, 11.2 ± 6.4 weeks, and 15.6 ± 6.2 weeks for procedures using OFM graft as an implant, defects closed by means of STSG, and those closed through secondary intention, respectively (Table 5). No postoperative complications were reported across the cohort; specifically, no cases of infected OFM that required early graft removal or surgical-site infection (SSI) were reported (Table 5).

Case Reports

Case 1

A 28-year-old man with a significant medical history of diabetes mellitus type 1 presented with an NSTI of the left fifth digit and metatarsal (Fig. 3A). The patient was taken to the operating room for a resection of the fifth digit and metatarsal. The resulting soft-tissue defect was approximately 10 × 8 × 1 cm, with exposed extensor tendons and metatarsal bone (Fig. 3B). The defect was then dressed with a

Table 2. Patient Demographics

Characteristic	Value
No. of participants	50
Sex (No. [%])	
Male	27 (54)
Female	23 (46)
Participant age (years)	
Mean ± SD	60.6 ± 15.2
Median	63.0
Comorbidities (No. [%])	
DM1	1 (2)
DM2	33 (66)
HTN	17 (34)
PAD	27 (54)
PVD	40 (80)
Afib/anticoagulants	6 (12)
CAD	4 (8)
Cancer	3 (6)
Lymphedema	11 (22)
No. of comorbidities (No. [%])	
1	5 (10)
2	18 (36)
3	11 (22)
4	12 (24)
5	4 (8)

Abbreviations: Afib, atrial fibrillation; CAD, coronary artery disease; DM1, type 1 diabetes mellitus; DM2, type 2 diabetes mellitus; HTN, hypertension; PAD, peripheral arterial disease; PVD, peripheral vascular disease; SD, standard deviation of the mean.

nonadherent layer and NPWT at 125 mm Hg. The patient was then taken back to the operating room 72 hours later for reconstruction of the defect. A five-layer OFM graft was applied to the wound bed and secured to the wound perimeter with surgical staples (Fig. 3C). The wound was then dressed with a nonadherent contact layer and NPWT at 125 mm Hg. The patient was discharged to home with a 1-week postoperative follow-up. At the 1-week visit, the graft was 100% granulated with complete coverage of the exposed bone and tendons (Fig. 3D). The patient was taken back to the operating room the following week for application of an STSG. At 1 week after STSG application, there was 90% take of the graft with a small portion on the distal STSG lost (Fig. 3E). The STSG was epithelializing between the interstices and there were no complications. At the patient's 8-week follow-up, the wound was fully healed with pliable soft tissue (Fig. 3F). The patient was back to walking in an orthotic shoe with no recurrence to 6-month follow-up.

Case 2

A 52-year-old man with a significant medical history of diabetes mellitus type 1, peripheral vascular disease, and Charcot neuroarthropathy had previously undergone (4 weeks prior) a Charcot foot reconstruction consisting of a triple-joint arthrodesis and medial column fusion with internal and external fixation. Subsequently, the patient had a surgical dehiscence with exposed bone and joint of the right foot (Fig. 4A). The patient was treated with intravenous antibiotics and taken back to the operating room for surgical debridement of nonviable tissue. Ovine forestomach matrix particulate (1,000 mg) was hydrated with the patient's blood and packed into the defect over the exposed bone and joint space (Fig. 4B). A three-layer OFM graft was applied to the superficial defect overlying the OFM particulate and secured with nonabsorbable

Table 3. Baseline Defect Characteristics

Characteristic	Value
Defect age (weeks)	
Mean ± SD	60.0 ± 152.5
Median	5.5
Baseline defect area (cm^2)	
Mean ± SD	84.2 ± 106.0
Median	40.0
Baseline maximum defect depth (cm)	
Mean ± SD	0.6 ± 0.9
Median	0.3
Defect type (No. [%])	
Surgical dehiscence	5 (10)
Traumatic	5 (10)
Pyoderma gangrenosum	1 (2)
Burn	2 (4)
DFU	24 (48)
NSTI	12 (50)
Calciphylaxis	1 (2)
Mixed vascular ulcer	1 (2)
VLU	10 (20)
Arterial ulcer	1 (2)
Exposed structures (No. [%])	
None	17 (34)
Bone	17 (34)
Tendon	5 (19)
Bone and tendon	9 (18)
Capsule	2 (4)
Wagner grade (n = 24) (No. [%])	
1	—
2	4 (8)
3	9 (18)
4	11 (22)
CDC contamination score (No. [%])	
I	—
II	—
III	—
IV	50 (100)
Osteomyelitis (No. [%])	
Yes	27 (54)

Abbreviations: DFU, diabetic foot ulcer; NSTI, necrotizing soft-tissue infection; SD, standard deviation of the mean; VLU, venous leg ulcer.

Table 4. Use and Product Type

Characteristic	Value
Use type (No. [%])	
Implantation	3 (6)
Dermal regeneration	47 (94)
Product type (No. [%])	
OFM graft only	41 (82)
Three-layer	6 (15)
Five-layer	35 (85)
OFM particulate only	3 (6)
OFM graft and particulate	6 (12)
Three-layer	—
Five-layer	6 (100)
Product use	
Mean ± SD	1.0 ± 0.1
Median	1.0
NPWT duration (No. [%])	18 (36)
Mean ± SD (weeks)	4.4 ± 2.5
Median (weeks)	3.8

Abbreviations: NPWT, negative-pressure wound therapy; OFM, ovine forestomach matrix; SD, standard deviation of the mean.

sutures. The wound was treated with NPWT (125 mm Hg). The patient was discharged to a skilled nursing facility with weekly follow-up on an outpatient basis. At week 1, the OFM graft appeared viable, with no evidence of infection or other surgical complications (Fig. 4C). At week 2, the wound bed was 100% filled with viable granulation tissue, with no further exposed bone or joint. The patient was returned to the operating room for removal of the external fixator, and a second application of three-layer OFM graft was performed, as the patient was not deemed to be a good candidate for STSG. The hardware removal necessitated a return to the operating room regardless of the wound progress. Negative-pressure wound therapy (125 mm Hg) was continued. Two weeks after the second procedure, residual OFM was sharply debrided, revealing viable vascularized tissue filling the defect (Fig. 4D). The wound was closed by means of secondary intention with weekly application of one-layer OFM (Endoform; Aroa Biosurgery Limited). By 10 weeks after the index surgery, the wound bed was 80% epithelialized (Fig. 4E), and at the 12-week postoperative visit, the wound was fully healed (Fig. 4F). The patient suffered no complications from the procedure and was able to walk following healing and removal of the external fixator. There was no recurrence out to the last follow-up at 18 weeks.

Table 5. Study Outcomes

Characteristic	Value
Days to 100% granulation tissue	
No. (%)	47 (94)
Mean ± SD (days)	26.0 ± 22.2
Median (days)	17.0
% STSG take at 1 week	
No. (%)	9 (94)
Mean ± SD	74.6 ± 18.0
Median (%)	75.0
Time to close	
All participants	
No. (%)	40 (80)
Mean ± SD (weeks)	13.7 ± 6.9
Median (weeks)	13.0
Implant	
No. (%)	3 (6)
Mean ± SD (weeks)	3.3 ± 2.3
Median (weeks)	2.0
STSG	
No. (%)	9 (18)
Mean ± SD (weeks)	11.2 ± 6.4
Median (weeks)	9.0
Secondary intention	
No. (%)	28 (56)
Mean ± SD (weeks)	15.6 ± 6.2
Median (weeks)	16.0

Abbreviations: SD, standard deviation of the mean; STSG, split-thickness skin graft.

Case 3

A 70-year-old woman with a significant medical history of diabetes mellitus type 1, peripheral vascular disease, and gangrene resulting in multiple digital amputations of the left foot had recently undergone (4 weeks prior) a transmetatarsal amputation (TMA). The patient presented to the hospital with surgical dehiscence of the TMA site with a concomitant cellulitis infection. The patient was treated

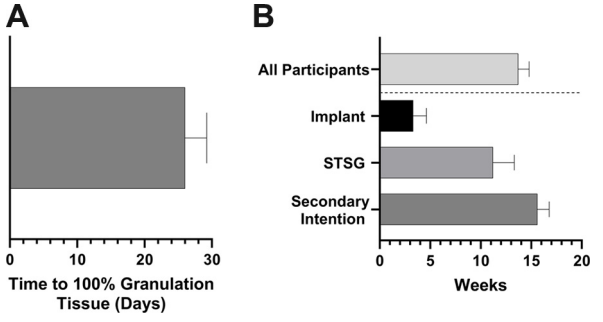

Figure 2. Study outcomes. A, Time to 100% granulation tissue. Error bars represent standard error of the mean (n = 47). B, Overall time to heal. Error bars represent standard error of the mean. All participants, n = 40; implant, n = 3; split-thickness skin graft (STSG), n = 9; secondary intention, n = 28.

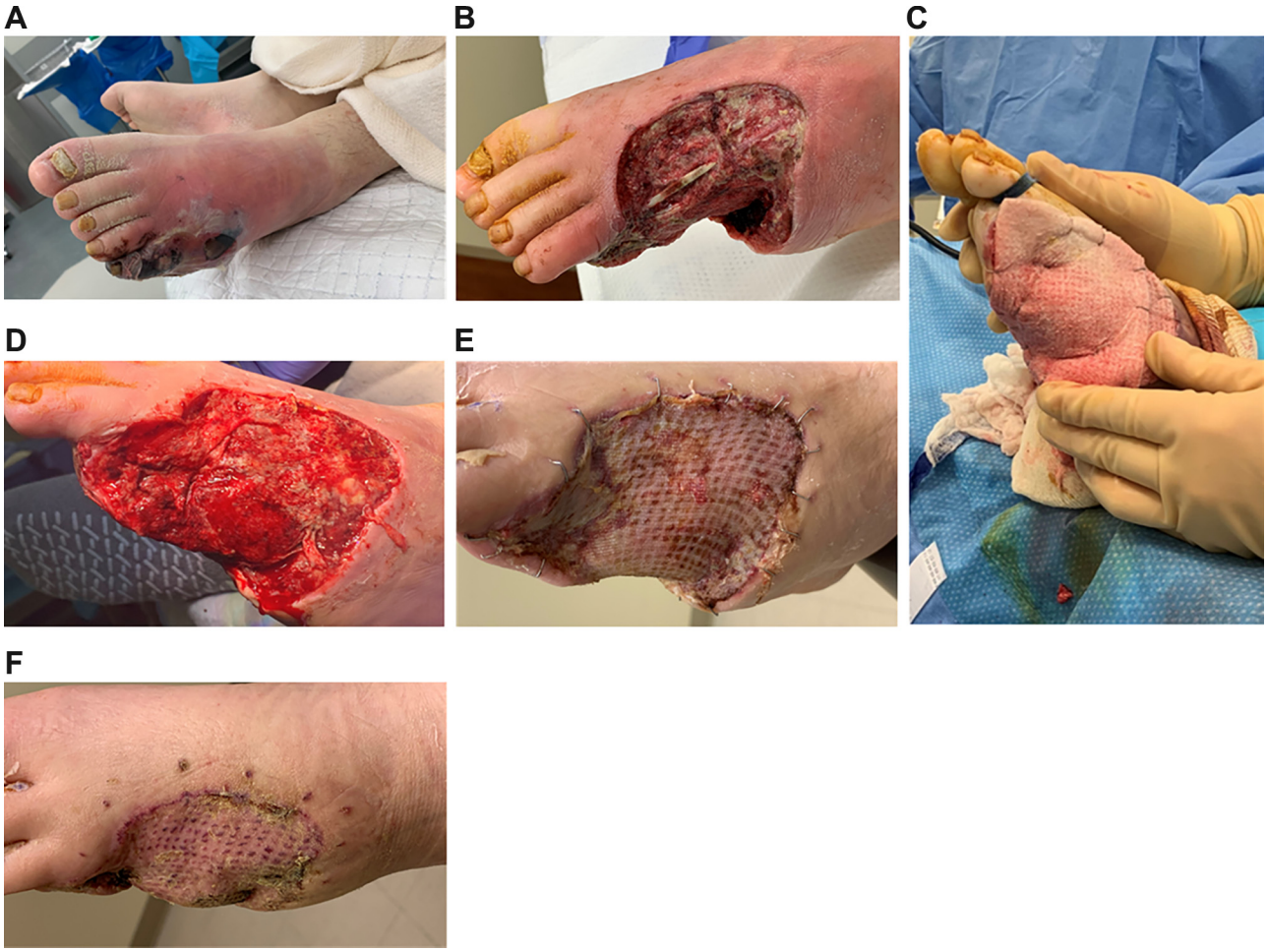

Figure 3. A, Necrotizing soft-tissue infection of the left fifth digit and metatarsal on presentation. B, After resection of necrotic tissue. C, Ovine forestomach matrix five-layer graft placement. D, One week postoperatively. E, One week after split-thickness skin graft placement. F, Eight-week postoperative follow-up.

with intravenous antibiotics and taken to the operating room for a revision TMA, resulting in further bone and soft-tissue resection at the site. A five-layer OFM graft was hydrated with sterile saline solution, applied over the exposed bone and soft tissue of the TMA site, and secured to the wound bed with absorbable sutures (Fig. 5A). A layered surgical closure was performed to implant the OFM graft, with a skin closure by means of nonabsorbable sutures (Fig. 5B). The wound was dressed with nonadherent and foam dressings. The patient was discharged to home with oral antibiotics and instructed to follow-up 1 week postoperatively. At 2 weeks, the flap was found to be viable, with the skin edges healing well. The wound was fully healed by week 3 and there was no evidence of infection or dehiscence noted at the 2-month follow-up.

Discussion

Patients included in this multicenter retrospective study presented with a typical range of lower-extremity defects requiring surgical intervention, and all patients had compromised healing potential and an elevated risk for amputation because of significant comorbidities (Table 2). Most cases (66%) were further complicated by exposed vital structures (ie, bone, tendon, capsule), that would otherwise have presented a challenge to immediate closure by means of STSG. Dermal matrices, whether synthetic or biologic, are typically used to regenerate neodermis in deep partial- or full-thickness defects before STGS placement or to accelerate closure by means of secondary intention. As such, the primary study endpoint was time to granulation of the OFM graft, rather than time to

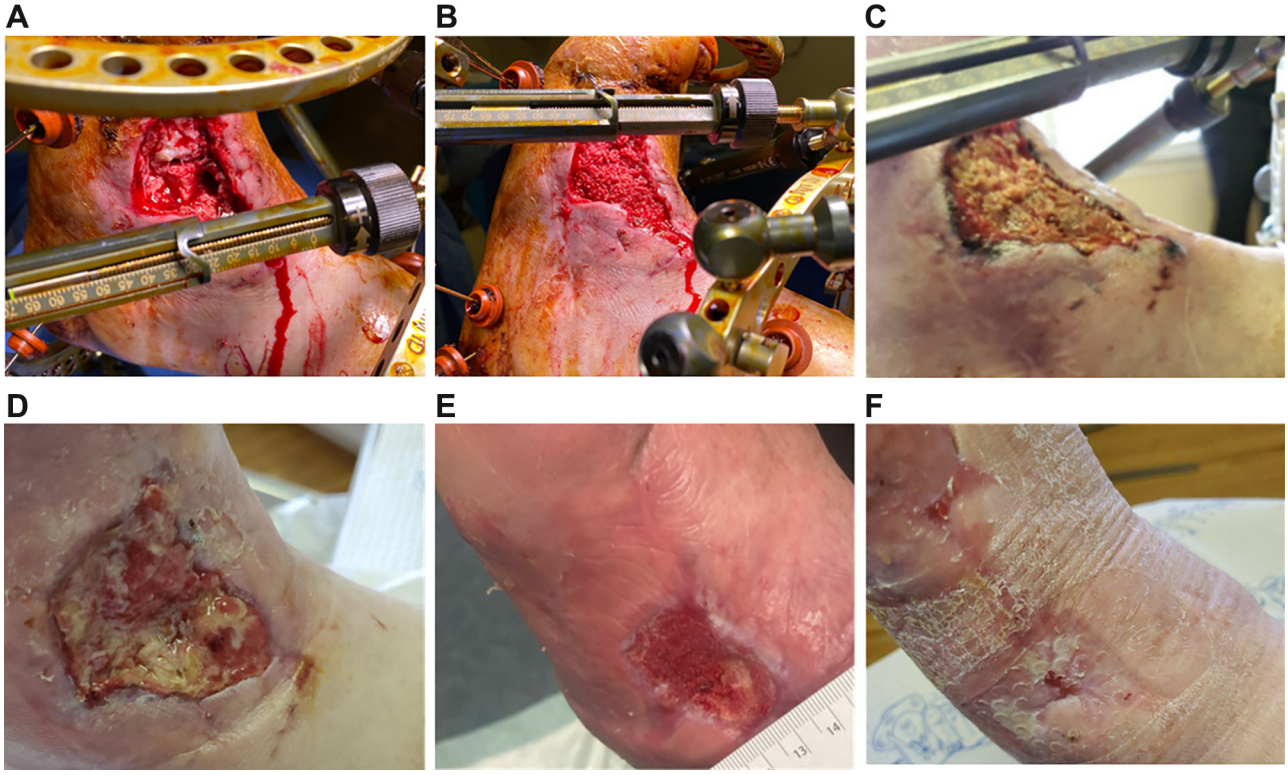

Figure 4. A, Initial wound after surgical dehiscence from Charcot reconstruction. B, Ovine forestomach matrix particulate placed directly over exposed bone and joint. C, One week postoperatively. D, Two weeks postoperatively from second ovine forestomach matrix graft placement. E, Ten weeks postoperatively, 80% epithelialized. F, Twelve weeks postoperatively, fully epithelialized.

complete wound closure. Across the 50 patients, the median time to 100% granular neodermis was 26 days. This is comparable to the median time to granulation tissue observed with use of other dermal matrices. Li et al[31] reported a median time to granulation of approximately 36 days (range, 15–81 days) in a retrospective case series of 35 complex wounds, including 14 lower-extremity wounds using a polyurethane biodegradable temporizing matrix. Studies using a bilayered dermal matrix in lower-limb reconstruction have reported times to graft integration of 14 to 28 days[32] and 21 days.[33]

As is commonly seen in these types of lower-extremity defects, bacterial contamination was a potential challenge across all patients, with Centers for Disease Control and Prevention contamination grades of IV, and 54% of patients having underlying osteomyelitis. Furthermore, 50% of DFUs required reconstruction because of an NSTI. Across the 12 cases that included an NSTI, there were no instances of SSI or graft loss because of infection. This finding is consistent with clinical studies using OFM-based devices for complex hernia repair of contaminated defects where the rates of SSI and other complications were low.[20,23] This is in contrast to synthetic dermal matrices where infection and infection-related complications (eg, graft loss) are often reported. In some instances, these synthetic dermal matrices result in containment of purulent exudate if the graft becomes infected, requiring "milking" or removal of the matrix.[34] One synthetic dermal matrix was cited by Solanki et al[34] to "avoid its use in the foot and ankle region in patients with peripheral vascular disease . . . as they are at high risk of [biodegradable temporizing matrix graft] failure." In a 2020 systematic review of over 3,500 articles, 26 articles were found to have reported infection rates when collagen-glycosaminoglycan biodegradable matrix grafts (Integra Bilayer Wound Matrix [IBWM]; Integra LifeSciences Corp, Plainsboro, New Jersey) were used. The meta-analysis of those 26 articles revealed infections in 212 of the 1,254 wounds treated with IBWM (16.9%).[35] Furthermore, one retrospective case series of nonhealing soft-tissue defects of the lower extremity that were treated with IBWM found a 17.6% infection rate.[36] These infections have been reported to be

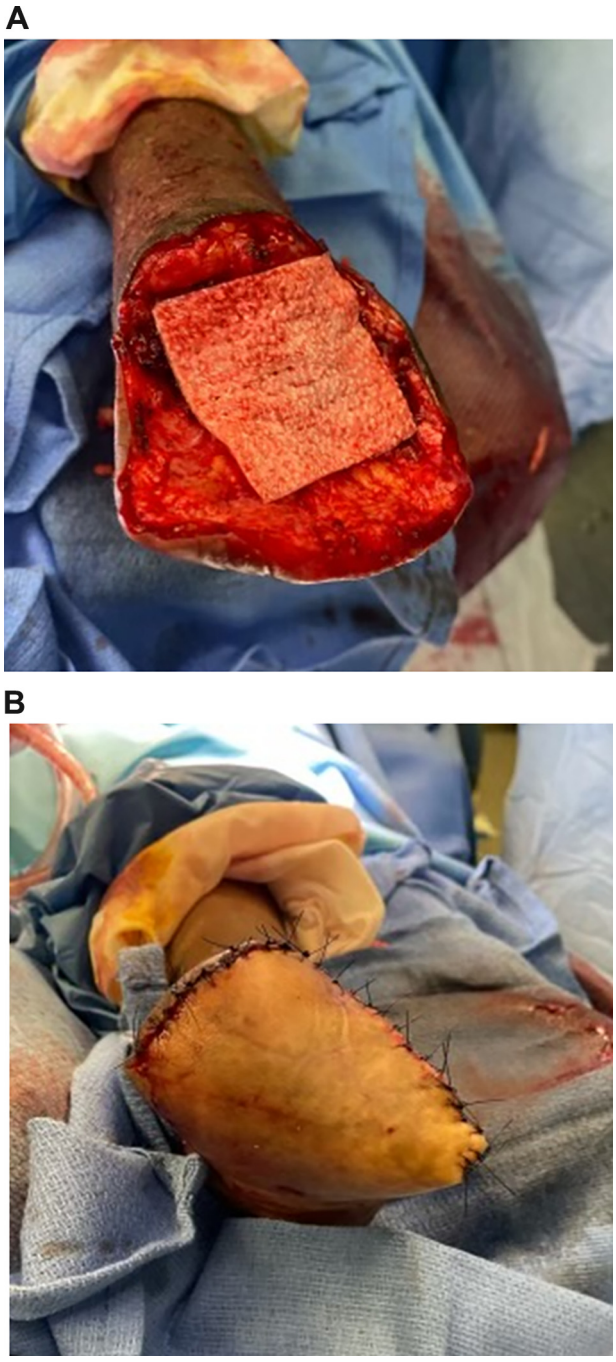

Figure 5. A, Intraoperative photographs after resection with placement of ovine forestomach matrix five-layer graft. B, Skin surgical closure with nonabsorbable sutures.

associated with higher graft failure[35] and highlights the established fact that IBWM requires an uncontaminated wound bed for success.[37] The differences between synthetic grafts mentioned above compared to OFM graft may be attributed to the beneficial biological components found in OFM.[24] Previous studies have described antibacterial properties of dECM scaffolds, acting to quench matrix metalloproteinases and inflammation,[38,39] and OFM is known to include a number of ECM proteins that have antibacterial properties in human tissue.[24] There are also additional ECM components that aid in neovascularization, which is critical for the effective delivery of protective immune components to the site of repair.[27]

The authors found the OFM graft and particulate easy to use and provided flexibility to augment the required surgical approach. For example, the OFM particulate enabled ready packing or filling of tunneled and undermined areas of the defects, and both products could be used with NPWT, as desired. The graft was found to be more robust compared to amnion-based grafts that may not be appropriate for these types of deep volumetric wounds of the lower extremity involving exposed structures. Compared to synthetic dermal matrices, OFM has a unique appearance in the wound bed as the dECM integrates. Partially degraded dECM components were typically visible on the surface of the newly formed vascularized tissue as the OFM integrated (eg, Fig. 4 C and D). This appears as a creamy golden-yellow substance and should not be mistaken for nonviable slough (or infection), and can, at the surgeon's discretion, be removed. In contrast, synthetic dermal matrices remain colored gray before cell infiltration and neovascularization.[34]

A comparable dECM technology that is used for inpatient soft-tissue reconstruction is porcine urinary bladder matrix (UBM). Urinary bladder matrix is supplied in a variety of sheet formulations in addition to a particulate. One distinguishing difference in how OFM and UBM behave clinically is the necessity for frequent repeated applications of UBM.[6,40,41] A noteworthy finding of this study was that the median number of OFM applications to achieve 100% granulation over exposed vital structure was one (a single) application. In comparison, synthetic dermal matrices may require repeated application because of graft loss or failure to integrate.[31,33,34,42,43]

Traditionally, the standard for soft-tissue reconstruction in large defects is accomplished by flap-based procedures. Although OFM grafts are not a replacement for these types of interventions, they offer an important alternative on the reconstructive ladder. Given the promising clinical outcomes in this retrospective, multicenter, real-world data set

of OFM graft and particulate use, these biological dECM options provide a viable solution for the successful management of complex lower-extremity soft-tissue reconstruction, even in contaminated wounds.

Limitations

This retrospective case series is not without its limitations that deserve further consideration. This was a single-arm retrospective case series that did not have a direct comparative arm. Considering that this was a multicenter study, there was no standardization regarding the secondary dressings used, follow-up timeline, or intraoperative techniques.

Conclusions

Ovine forestomach matrix graft and particulate are safe, cost-effective, and accessible treatment options, separately or in combined use, in volumetric lower-limb soft-tissue defects. When compared with similar dermal matrices, OFM graft and particulate may shorten the time to cover exposed vital structures and thereby decrease the overall time to attain definitive closure.

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