Hybrid Reconstruction of UT Grade 2 and 3 Diabetic Ulcers with External Fixation and Piscine Xenograft

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Daniel Sanchez, DPM; Alexandria A. Armstrong, DPM; Kimberly Barron, DPM, FACFAS; Collin Pehde, DPM, FASPS; Ian Barron, DPM, FACFAS
University of Texas Health Science Center at San Antonio, TX, Department of Orthopaedics

Introduction:

Chronic diabetic foot ulcers (DFUs) remain a major cause of morbidity, infection, and limb loss. Deep or irregularly contoured wounds with exposed tendon, capsule, or bone present particular reconstructive challenges and often require more than local wound care alone. Successful management frequently requires correction of mechanical deforming forces and durable offloading in addition to biologic wound reconstruction.

Acellular fish-skin matrices possess structural and biologic properties favorable for tissue regeneration, including preserved collagen architecture and naturally occurring omega-3 fatty acids that may support resolution of chronic inflammation.

This series evaluates a hybrid reconstruction approach performed within a tertiary academic limb salvage program utilizing circular external fixation to correct mechanical forces and provide sustained offloading, combined with application of piscine xenograft for biologic wound bed regeneration in UT Grade 2 and 3 diabetic foot ulcers.

Methods:

A retrospective review was conducted at an academic medical center evaluating patients with UT Grade 2 and 3 diabetic foot ulcers requiring correction of mechanical forces and/or advanced offloading.

Circular external fixation was utilized to achieve limb realignment and sustained offloading of the ulcerated region. Soft tissue balancing and osseous realignment was performed as indicated Following mechanical correction and surgical wound preparation, acellular fish-skin xenograft was applied directly to the ulcer bed to facilitate biologic soft tissue regeneration, particularly in irregular or deep wound geometries.

Patients were followed throughout the postoperative period until clinical wound closure.

Results:

The staged reconstruction protocol combining mechanical offloading with biologic wound therapy resulted in progressive granulation and successful wound closure in treated patients. Application of the piscine xenograft allowed effective integration within irregular wound beds and areas of exposed deep structures.

Superficial pin tract irritation occurred in a limited number of cases and was managed successfully with local care. No major fixation-related complications occurred.

At follow-up, patients demonstrated durable epithelialization with maintenance of a plantigrade foot and adequate soft tissue coverage. Patients transitioned to protected weightbearing in accommodative footwear and maintained ulcer closure without recurrence at the original site during the follow-up period.

Discussion:

Management of complex diabetic foot ulcers requires addressing both the biologic wound environment and the mechanical forces that contribute to ulcer formation and persistence. Traditional wound care strategies alone may be insufficient when deformity, abnormal pressure distribution, or structural instability are present.

In this series, a hybrid reconstruction strategy combining circular external fixation with piscine xenograft allowed simultaneous correction of mechanical forces and biologic wound bed optimization. Circular external fixation provided durable offloading and limb realignment, while the acellular fish-skin conformed to irregular wound geometries and exposed structures, facilitating granulation and epithelialization.

The biologic properties of acellular fish-skin matrices, including preserved collagen architecture and naturally occurring omega-3 fatty acids, may support tissue regeneration and resolution of chronic inflammation. The particulate formulation may be particularly advantageous in wounds with tunneling, depth, or irregular contours where traditional sheet grafts may be difficult to apply.

This combined approach demonstrated favorable wound healing and limb preservation outcomes with minimal fixation-related complications. The strategy may decrease reliance on more invasive reconstructive procedures such as flap coverage while maintaining durable wound closure.

Conclusion:

Hybrid reconstruction utilizing circular external fixation for mechanical correction and sustained offloading combined with piscine xenograft for biologic wound regeneration represents a promising limb-salvage strategy for complex UT Grade 2 and 3 diabetic foot ulcers.

This approach promotes durable wound closure, restores a plantigrade foot, and may reduce reulceration by addressing both mechanical and biologic factors contributing to chronic diabetic wounds. Further prospective studies with larger patient cohorts are warranted to better define long-term outcomes and comparative effectiveness within multidisciplinary limb preservation programs.

References:

1.Baldursson BT, Kjartansson H, Konrádsdóttir F, Gudnason P, Sigurjonsson GF, Lund SH. Healing rate and autoimmune safety of full-thickness wounds treated with fish skin acellular dermal matrix versus porcine small-intestine submucosa: a noninferiority study. Int J Low Extrem Wounds. 2015 Mar;14(1):37-43. doi: 10.1177/1534734615573661. Epub 2015 Mar 9. PMID: 25759413.

2.Michael S, Winters C, Khan M. Acellular Fish Skin Graft Use for Diabetic Lower Extremity Wound Healing: A Retrospective Study of 58 Ulcerations and a Literature Review. Wounds. 2019 Oct;31(10):262-268. Epub 2019 Aug 21. PMID: 31730505.

3.Luze H, Nischwitz SP, Smolle C, Zrim R, Kamolz LP. The Use of Acellular Fish Skin Grafts in Burn Wound Management-A Systematic Review. Medicina (Kaunas). 2022 Jul 9;58(7):912. doi: 10.3390/medicina58070912. PMID: 35888631; PMCID: PMC9323726.

4.Yang CK, Polanco TO, Lantis JC 2nd. A Prospective, Postmarket, Compassionate Clinical Evaluation of a Novel Acellular Fish-skin Graft Which Contains Omega-3 Fatty Acids for the Closure of Hard-to-heal Lower Extremity Chronic Ulcers. Wounds. 2016 Apr;28(4):112-8. PMID: 27071138.

5.Yoon J, Yoon D, Lee H, Lee J, Jo S, Kym D, Yim H, Hur J, Chun W, Kim G, Cho YS. Wound healing ability of acellular fish skin and bovine collagen grafts for split-thickness donor sites in burn patients: Characterization of acellular grafts and clinical application. Int J Biol Macromol. 2022 Apr 30;205:452-461. doi: 10.1016/j.ijbiomac.2022.02.055. Epub 2022 Feb 14. PMID: 35176324.

6.Alam K, Jeffery SLA. Acellular Fish Skin Grafts for Management of Split Thickness Donor Sites and Partial Thickness Burns: A Case Series. Mil Med. 2019 Mar 1;184(Suppl 1):16-20. doi: 10.1093/milmed/usy280. PMID: 30901429.

7.Kirsner RS, Margolis DJ, Baldursson BT, Petursdottir K, Davidsson OB, Weir D, Lantis JC 2nd. Fish skin grafts compared to human amnion/chorion membrane allografts: A double-blind, prospective, randomized clinical trial of acute wound healing. Wound Repair Regen. 2020 Jan;28(1):75-80. doi: 10.1111/wrr.12761. Epub 2019 Oct 25. PMID: 31509319; PMCID: PMC6972637.

8.Magnusson, S., Baldursson, B. T., Kjartansson, H., Rolfsson, O., & Sigurjonsson, G. F. (2017). Regenerative and antibacterial properties of acellular fish skin grafts and human amnion/chorion membrane: Implications for tissue preservation in combat casualty care. Military Medicine, 182(Suppl 1), 383–388. https://doi.org/10.7205/MILMED-D-16-00142

9.Gao J, Ge LX, Gao QY, Zhang AM, Hu LJ. Efficacy of acellular fish skin graft in the management of chronic ulcer: a systematic review and meta-analysis. Langenbecks Arch Surg. 2024 Feb 16;409(1):64. doi: 10.1007/s00423-024-03230-1. PMID: 38363369.

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