Iran J Burn Wound Res
ISSN: 3060-8414
2025, Volume 1, Number 4
Case Report

Bone burn reconstruction using fish skin xenograft: A case series report

Mostafa Dahmardehei[1], Ali Dahmardehei[2*], Zahra Dahmardehei[3], Seyedeh Somayeh Mousavi[4], Mahmoud Amini[5], Maryam Milanifard[6,7], Hamidreza Atashhoosh[8]

1. *Burn and Stem Cell Regenerative Medicine Research Center, Iran University of Medical Sciences, Tehran, Iran*
2. *Department of General Surgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran*
3. *Department of General Surgery, Shahriar Hospital, Iran University of Medical Sciences, Tehran, Iran*
4. *Department of Burn and Wound Care, Motahari Burn Hospital, College of Medicine, Iran University of Medical Sciences, Tehran, Iran*
5. *Burn Department, Shahid Motahari Hospital, Tehran, Iran*
6. *Trauma and Injury Research Center, Iran University of Medical Sciences, Tehran, Iran*
7. *Student Research Committee, Iran University of Medical Sciences, Tehran, Iran*
8. *Vise President of Sales and Commercial Affairs, Tehran, Iran*

ABSTRACT

Article info:
Received: 30 Aug 2025
Accepted: 15 Oct 2025

Keywords:
Burns
Fourth-degree
Xenografts
Fish skin
Skin transplantation
Bone exposure

Fourth-degree burns with bone exposure present a major reconstructive challenge due to periosteal loss, infection risk, and limited vascularity. Traditional flap procedures are complex, invasive, and costly, with prolonged hospitalization and pain. Acellular fish skin (AFS) xenograft has emerged as a biologically active, omega-3–rich matrix that supports granulation and epithelialization in complex wounds. This case series reports outcomes of a two-stage reconstruction using AFS followed by split-thickness skin grafting (STSG) in four patients with bone-exposed burns (three tibial, one cranial). After surgical debridement and irrigation, AFS (Kerecis®, Ísafjörður, Iceland) was rehydrated in sterile saline and applied to the wound as a periosteal substitute. Seven days after the AFS application, a thin-meshed STSG (mesh ratio 1:1.5–1:3) was placed over the wound. This dressing strategy reduced the frequency of dressing changes and was associated with decreased patient-reported pain and lower resource use; however, these observations require confirmation in larger studies. All patients achieved complete epithelial coverage within 3–4 weeks, and after six months of follow-up, tissue repair was flexible, of high quality, and demonstrated favorable aesthetic outcomes. No infections, graft losses, or major complications were observed. The two-stage AFS + STSG technique appears to promote rapid epithelialization and durable wound coverage with minimal morbidity, representing a simple and less invasive alternative for bone-exposed burn reconstruction when flap surgery is not feasible.

***Corresponding Author(s):**
Ali Dahmardehei, MD
Address: *Department of General Surgery, Tehran University of Medical Sciences, Tehran, Iran*
Tel: +98 912 6191730
E-mail: Ali.phoenix1373@gmail.com

https://doi.org/10.61882/ijbwr.1.4.38

1. Introduction

Burns are among the most common skin injuries worldwide, ranging from superficial to deep and complex full-thickness lesions [1]. Superficial burns can be managed with conventional dressings, whereas deep and extensive burns require advanced reconstructive interventions for optimal recovery [2]. In fourth-degree burns, the skin and subcutaneous tissues are destroyed and the injury extends to underlying structures, including bone, often exposing the periosteum, cortex or tendon. Such injuries pose a high risk of infection, bone necrosis, and severe functional impairment, while also causing significant psychological distress and reduced quality of life [3,4].

Traditional reconstruction with local or free flaps remains the standard for coverage of deep and fourth-degree burns involving bone or tendon. However, several authors have reported that these procedures are technically demanding, time-consuming, and associated with high complication rates, donor-site morbidity, and increased costs [5–7]. In recent years, the use of acellular fish skin (AFS) xenografts has emerged as a promising alternative for complex burn wounds [2,3]. These xenografts provide a three-dimensional collagen matrix enriched with bioactive lipids and growth factors, supporting rapid epithelialization and tissue regeneration while modulating inflammation [1,4,8,9]. Compared with traditional methods, AFS xenografts are easier to apply, less invasive, and more cost-effective [10–12]. Given the complex healing process of deep and fourth-degree burns and the need for reliable wound coverage to prevent infection and preserve function, this study presents our clinical experience using AFS xenografts for the reconstruction of bone-exposed burn wounds through a two-stage approach.

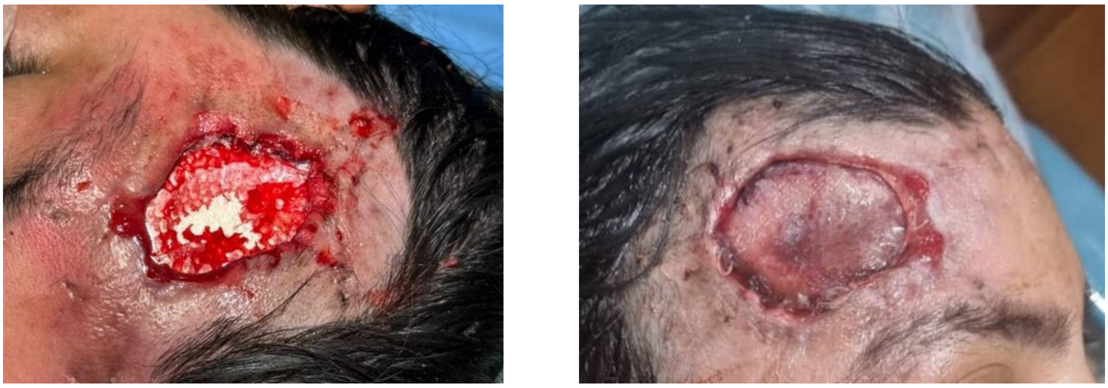
2. Case Presentation

Four patients were included in this case series, comprising three men aged 28, 45, and 54 years, and one woman aged 39 years. All patients were referred from other hospitals to Motahari Burn Hospital in Tehran in 2025 with severe fourth-degree burns involving bone exposure. The three male patients presented with tibial bone burns of the lower leg, while the female patient had a scalp burn with exposure of the cranial bone. Each case was evaluated clinically and radiologically to determine burn depth, bone viability, and the extent of soft-tissue loss before reconstruction. All patients were hemodynamically stable and free of systemic infection before intervention. The management strategy included meticulous debridement of necrotic bone and tissue, followed by staged wound reconstruction using AFS xenograft and subsequent split-thickness skin graft (STSG). Perioperative parameters such as hospital stay, number of dressing changes, complications, and follow-up duration were documented for each patient to allow direct comparison of outcomes. Representative pre- and post-treatment images of the scalp burn are shown in Figure 1. A summary of individual patient data is presented in Table 1.

Table 1. Summary of patient characteristics and outcomes

Case	Age/Sex	Burn Site	Degree	TBSA (%)	STSG Timing (day)	Hospital Stay (days)	Complications	Follow-up (months)	Outcome
1	28 /M	Lower leg (tibia)	4th	15	7	14	None	6	Excellent
2	45 /M	Lower leg (tibia)	4th	12	7	16	None	6	Excellent
3	54 /M	Lower leg (tibia)	4th	10	7	15	None	6	Excellent
4	39 /F	Scalp	4th	8	7	13	Minor discharge (resolved)	6	Excellent

TBSA: Total Body Surface Area; STSG: Split-Thickness Skin Graft. All patients achieved complete epithelial coverage within 3–4 weeks.



(a) (b)

Figure 1. Fourth-degree scalp burn (Case 4) before treatment (a) and at six-month follow-up (b) showing complete epithelial coverage and restored contour after two-stage AFS + STSG treatment.

3. Methods

This case series was conducted at Motahari Burn Hospital (Tehran, Iran) in 2025. Inclusion criteria were fourth-degree thermal burns with exposed bone and the absence of systemic infection. Patients with chronic comorbidities (e.g., uncontrolled diabetes, vascular disease) or poor general condition precluding surgery were excluded. Four patients met the eligibility criteria: three men with tibial bone exposure in the lower leg and one woman with a scalp burn and cranial bone exposure. In all patients, the periosteal layer had been destroyed, making conventional reconstruction challenging. Given the high morbidity, longer hospital stay, and increased costs associated with free or local flap procedures, a two-stage approach with AFS xenograft followed by split-thickness skin grafting (STSG) was used. To our knowledge, this is among the first reported case series from Iran describing the use of a two-stage AFS approach for reconstruction of wounds with bone exposure. In this study, acellular fish skin xenograft (AFS; Kerecis®, Ísafjörður, Iceland) was used as the primary scaffold for the treatment of burn wounds. Before surgery, all patients underwent hemodynamic stabilization, nutritional optimization, correction of anemia, and blood glucose control. All patients received standard perioperative antibiotic prophylaxis (intravenous cefazolin 1 g every eight hours for 5 days) and daily wound inspection for infection monitoring. Surgical management consisted of aggressive debridement of necrotic bone until punctate bleeding was visible, followed by copious irrigation with sterile normal saline. Then, for preparation, the fish skin was rehydrated in sterile normal saline according to the manufacturer's instructions and trimmed to the wound dimensions. The graft was placed directly on the bone with a 2–3 mm overlap at the wound edges to ensure complete contact with the wound bed. A non-adherent layer, moistened gauze, and a light pressure dressing were applied.

The timing of STSG application (day 7) was determined based on the presence of healthy granulation tissue and absence of exudate or infection. At this stage, a thin meshed or unmeshed STSG (mesh ratio 1:1.5–1:3) was harvested and applied over the wound. The graft was secured with sutures and a bolster dressing. Postoperative care included limb elevation, gentle mobilization, and daily sterile dressing changes after removal of the bolster. This protocol aimed to reduce the number of dressing changes, minimize patient discomfort, and shorten the length of hospital stay while achieving stable wound coverage.

4. Results

Four patients with fourth-degree burns and bone exposure were treated using the two-stage AFS + STSG technique. The cohort included three men (aged 28, 45, and 54 years) with tibial bone burns of the lower leg and one woman (aged 39 years) with a scalp burn involving cranial bone exposure. All patients were hemodynamically stable and free of systemic infection at the time of intervention. Sequential healing progress of tibial cases is demonstrated in Figure 2 and 3. In all tibial cases, early adherence of the graft and progressive wound coverage were observed within the first two weeks. The mean time to complete epithelialization was 21 days for the tibial wounds, while the scalp burn patient achieved complete epithelialization after 25 days. No cases required reapplication of AFS or additional surgical procedures.

Figure 2. Tibial bone exposure in the lower leg (Case 1) before AFS application (a) and after two-stage AFS + STSG (b), demonstrating granulation and epithelialization by day 14.

Figure 3. Fourth-degree tibial burn (Case 2) before (a) and after (b) two-stage AFS + STSG showing rapid epithelialization and wound closure by day 21.

In all patients, seven days after applying the AFS onto the bone, it functioned as a periosteal substitute, showing firm adherence and early granulation. This provided stable coverage and protected the bone from infection or further necrosis. No instances of graft failure, bone infection, or wound dehiscence were observed. This approach was associated with fewer dressing changes and reduced treatment costs compared with conventional flap techniques. One patient (female, scalp burn) developed a minor controlled discharge during the early post-grafting period, which resolved with standard wound care. Hospitalization ranged from 13 to 16 days (mean 14.5 days). Patients reported minimal postoperative pain, particularly those with tibial burns, and none required opioid analgesia beyond the early postoperative period. Functional recovery was satisfactory in all cases, and no significant complications were recorded during the six-month follow-up. Final aesthetic outcomes with stable skin coverage are presented in Figure 4. All patients achieved durable, pliable skin with minimal scar contracture and acceptable cosmetic appearance. Table 1 summarizes individual patient characteristics and clinical outcomes.

Figure 4. Outcomes at six months in tibial cases showed stable coverage, pliable skin, and good cosmetic results. Panels (a, b) represent Cases 1 and 2.

5. Discussion

In recent years, the two-stage use of AFS xenografts for the reconstruction of complex wounds, including third- and fourth-degree burns, has gained increasing clinical interest. Several studies have demonstrated that AFS promotes faster wound healing, reduces infection risk, and provides a less invasive alternative to conventional flap surgery [13–16]. The results of our case series are consistent with these findings, showing rapid granulation, successful graft take, and stable wound coverage with minimal complications. For instance, a recent international randomized controlled trial by Dardari et al. demonstrated that the application of intact fish skin grafts in the treatment of deep diabetic foot ulcers significantly accelerated wound healing. By week 16, 44% of ulcers in the fish skin group achieved complete closure versus 26% in the standard care group, and the mean healing time was 17.3 weeks versus 19.4 weeks in controls [14]. This highlights the ability of AFS to support tissue regeneration even in complex wounds. Additionally, the case series by Benedict et al. described a sandwich single-stage technique using intact fish skin laminated with a simultaneous STSG and reported favorable healing and a reduced number of procedures [4]. Similarly, Castellani et al. [10] and Stone et al. [9] observed faster wound improvement in patients treated with fish skin grafts compared with standard dressings. Staubach et al. also confirmed accelerated epithelialization in pediatric burn patients treated with AFS [15]. Moreover, Wallner et al. reported reduced pain and itching in patients treated with fish skin grafts [17]. In contrast, flap and free flap procedures are often associated with noticeable scarring and poor cosmetic results, which may lead to psychological distress in patients [18]. AFS provides a biologically active collagen matrix enriched with omega-3 fatty acids that enhances granulation and epithelialization while maintaining a moist wound environment. This environment may also contribute to lower infection rates. In the trial by Dardari et al. [14], the rate of primary wound infection was comparable between groups (30.2% in the fish skin group vs. 24.6% in controls), indicating that fish skin grafting did not increase infection risk despite its biologic origin. AFS treatment has also been linked to decreased postoperative burden. Dardari et al. [14] found that patients treated with fish skin grafts demonstrated faster healing and required fewer clinical visits, indirectly reducing overall hospitalization time and treatment burden. Likewise, Benedict et al. [4] and Castellani et al. [10] reported reduced dressing frequency with this method. Moreover, patients experienced lower pain scores, which may be attributed to the protective moist interface of the graft. In addition, Dardari et al. [14] reported that patients treated with fish skin grafts experienced lower pain intensity during the healing process, likely due to the graft's protective moist environment and reduced dressing frequency. Overall, our findings support AFS as a practical, effective, and less invasive alternative for wound reconstruction in selected burn patients, particularly in settings where flap or free flap procedures are not feasible. Its favorable healing profile, low infection risk, and reduced patient burden make it a promising adjunct to burn care.

This study has several limitations. The small sample size and single-center case series design limit the generalizability of the findings. The absence of a control group prevents direct comparison with standard flap or grafting techniques. Additionally, the relatively short follow-up period restricts long-term outcome assessment. Future controlled studies with larger patient populations are needed to validate these results and establish standardized protocols. The two-stage reconstruction technique using AFS xenograft followed by STSG demonstrated effective and reliable wound coverage in patients with fourth-degree burns and bone exposure. This approach facilitated rapid granulation, reduced infection risk, minimized pain, and decreased the frequency of dressing changes and hospital stay compared with conventional flap procedures. The outcomes in this case series indicate that AFS can serve as a biologically active and less invasive alternative for bone-exposed burn reconstruction, particularly when flap or free-flap options are limited or contraindicated. Further large-scale controlled studies are recommended to confirm these findings and to define standardized clinical protocols for optimal use of AFS in complex burn management.

Acknowledgment

We hereby express our sincere gratitude to all the professors and colleagues who assisted us in the implementation and writing of this study.

Authors' contributions

Conceptualization and Study Design: M D and A D; Data Collection and Curation: A D and Z D; Clinical Management and Documentation: S S M; Clinical Interpretation and Literature Review: M M; Supervision: M D and M A; Writing – Original Draft: A D; Writing – Review & Editing: M M and H A. All authors have read and approved the final version of the manuscript for publication.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

This study was conducted in accordance with the ethical standards of national research committees and the Declaration of Helsinki. As Kerecis® fish skin graft is an approved medical product in Iran, formal IRB approval was not required. The protocol was reviewed and approved by the Burn Department of Motahari Hospital, and written informed consent was obtained from all patients for treatment and publication of anonymized data.

Financial support

Self-funded.

References

[1] Ibrahim M, Ayyoubi HS, Alkhairi LA, Tabbaa H, Elkins I, Narvel R. Fish Skin Grafts Versus Alternative Wound Dressings in Wound Care: A Systematic Review of the Literature. Cureus. 2023;15(3):e36348. DOI: 10.7759/cureus.36348 PMID: 37082504

[2] El Araby MM, Marcaccini G, Susini P, Giardino FR, Pozzi M, Pizzo V, et al. From the Ocean to the Operating Room: The Role of Fish Skin Grafts in Burn Management-A Systematic Review. J Clin Med. 2025;14(16):5750. DOI: 10.3390/jcm14165750 PMID: 40869579

[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;58(7):912. DOI: 10.3390/medicina58070912 PMID: 35888631

[4] Benedict KC, Sullivan JM, Galarza LI, Walker ME. Single-Stage Coverage of Exposed Critical Structures With Intact Decellularized Fish Skin and Simultaneous Epidermal Autograft Application: The "Sandwich" Technique. J Hand Surg Glob Online. 2024;7(1):109-113. DOI: 10.1016/j.jhsg.2024.09.008 PMID: 39991607

[5] Kasmirski JA, Alessandri-Bonetti M, Liu H, Corcos AC, Ziembicki JA, Stofman GM, et al. Free Flap Failure and Complications in Acute Burns: A Systematic Review and Meta-analysis. Plast Reconstr Surg Glob Open. 2023;11(10):e5311. DOI: 10.1097/GOX.0000000000005311 PMID: 37817922

[6] Ziegler B, Hundeshagen G, Warszawski J, Gazyakan E, Kneser U, Hirche C. Implementation and Validation of Free Flaps in Acute and Reconstructive Burn Care. Medicina (Kaunas). 2021;57(7):718. DOI: 10.3390/medicina57070718 PMID: 34356999

[7] Gorecka ZM, Laczyk M, Majewski M, Antonov S, Surowiecka A, Korzeniowski T, et al. The role of microsurgical flaps in the treatment of burn patients – a single center experience. Current Issues in Pharmacy and Medical Sciences. 2025;38(3):180-186. DOI: 10.12923/cipms-2025-0029

[8] Rajabimashhadi Z, Gallo N, Salvatore L, Lionetto F. Collagen Derived from Fish Industry Waste: Progresses and Challenges. Polymers (Basel). 2023;15(3):544. DOI: 10.3390/polym15030544 PMID: 36771844

[9] Stone R 2nd, Saathoff EC, Larson DA, Wall JT, Wienandt NA, Magnusson S, et al. Comparison of Intact Fish Skin Graft and Allograft as Temporary Coverage for Full-Thickness Burns: A Non-Inferiority Study. Biomedicines. 2024;12(3):680. DOI: 10.3390/biomedicines12030680 PMID: 38540293

[10] Castellani L, Arruda S. Hooked on Healing - Fish Skin Grafts for Diabetic Foot Ulcers. NEJM Evid. 2024;3(12):EVIDe2400373. DOI: 10.1056/EVIDe2400373 PMID: 39589198

[11] Veitinger AB, Lippert BM, Fiedler LS. Resolution of a chronic occipital wound with exposed skull bone with a fish skin graft: a successful treatment approach. BMJ Case Rep. 2024;17(8):e261172. DOI: 10.1136/bcr-2024-261172 PMID: 39097322

[12] Dueppers P, Bozalka R, Kopp R, Menges AL, Reutersberg B, Schrimpf C, et al. The Use of Intact Fish Skin Grafts in the Treatment of Necrotizing Fasciitis of the Leg: Early Clinical Experience and Literature Review on Indications for Intact Fish Skin Grafts. J Clin Med. 2023;12(18):6001. DOI: 10.3390/jcm12186001 PMID: 37762941

[13] Ziegler B, Hundeshagen G, Will PA, Bickert B, Kneser U, Hirche C. Role, Management, and Outcome of Free Flap Reconstruction for Acute Full-Thickness Burns in Hands. Ann Plast Surg. 2020;85(2):115-121. DOI: 10.1097/SAP.0000000000002412 PMID: 32472799

[14] Dardari D, Piaggesi A, Potier L, Sultan A, Diener H, Francois M, et al. Intact Fish Skin Graft to Treat Deep Diabetic Foot Ulcers. NEJM Evid. 2025;4(3):EVIDx2500032. DOI: 10.1056/EVIDx2500032 PMID: 39365895

[15] Staubach R, Glosse H, Loff S. The Use of Fish Skin Grafts in Children as a New Treatment of Deep Dermal Burns-Case Series with Follow-Up after 2 Years and Measurement of Elasticity as an Objective Scar Evaluation. J Clin Med. 2024;13(8):2389. DOI: 10.3390/jcm13082389 PMID: 38673661

[16] Bonetti MA, Jeong T, Liu HY, Arellano JA, Pandya S, Stofman GM, et al. Pedicled and Free Flap Lower Extremity Reconstruction in Acute Burn Injuries. Ann Plast Surg. 2025;95(1):46-50. DOI: 10.1097/SAP.0000000000004344 PMID: 40209804

[17] Wallner C, Holtermann J, Drysch M, Schmidt S, Reinkemeier F, Wagner JM, et al. The Use of Intact Fish Skin as a Novel Treatment Method for Deep Dermal Burns Following Enzymatic Debridement: A Retrospective Case-Control Study. Eur Burn J. 2022;3(1):43-55. DOI: 10.3390/ebj3010006 PMID: 39604176

[18] Alessandri Bonetti M, Jeong T, Stofman GM, Egro FM. A 10-Year Single-Burn Center Review of Free Tissue Transfer for Burn-Related Injuries. J Burn Care Res. 2024;45(1):130-135. DOI: 10.1093/jbcr/irad132 PMID: 37703393