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Case Report

One-stage transplantation of artificial dermis and autologous split-thickness skin graft for the repair of severe foot trauma: a case report

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Abstract: For the repair of complex wounds involving bone and joint infections resulting from severe trauma, the conventional approach typically involves a two-stage procedure: initial implantation of an artificial dermis (AD), followed by autologous split-thickness skin grafting (STSG) after 2-3 weeks. This report presents an innovative one-stage technique in which AD and autologous STSG were transplanted simultaneously onto a wound bed prepared with antibiotic-loaded bone cement (ALBC). The patient had sustained multiple open fractures, dislocations, bone defects, and bone and joint infections following a traffic accident. After two initial surgical procedures that included thorough debridement, fracture fixation, and ALBC placement for infection control, a one-stage skin graft was performed to co-implant AD and autologous STSG (0.15-0.25 mm thick) for wound closure. At the 18-month follow-up, the graft flap exhibits no contraction, and its color, texture, softness, and elasticity closely resemble those of the surrounding normal skin. This ALBC-assisted one-stage transplantation of AD combined with autologous STSG offers a feasible and efficient method for repairing complex wounds involving bone and joint injuries with concomitant skin and soft tissue defects. Moreover, it may reduce treatment duration and simplify the clinical pathway compared with traditional two-stage skin grafting protocols.

Keywords: Artificial dermis, autologous split-thickness skin graft, wound repair, trauma

Introduction

Severe foot injuries often involve extensive skin and soft tissue loss, along with exposed tendons, bones, and neurovascular structures, presenting significant treatment challenges. The primary therapeutic strategies include thorough debridement, fracture reduction, and wound reconstruction through skin grafting. Although autologous flap transplantation is widely used for such repairs, it can be limited by donor site morbidity, suboptimal aesthetic outcomes, and complex surgical procedures [1, 2].

The combination of artificial dermis (AD) and autologous split-thickness skin grafting (STSG) offers a novel strategy for repairing complex skin defects. However, some key factors such as significant wound contamination, instability of bones or joints, and persistent fluid leakage from joint spaces can compromise the success of AD grafting. Therefore, thorough debridement, negative pressure drainage, and regular dressing changes are prerequisites for successful AD grafting. After wound infection is adequately controlled, a two-stage skin grafting approach is commonly adopted in clinical practice - first transplanting AD, followed by coverage with autologous STSG after 2-3 weeks of vascularization [3]. In contrast, a one-stage transplantation technique involves the simultaneous application of AD and autologous STSG. This method requires more favorable wound bed conditions compared to the two-stage procedure and is therefore more commonly used in sterile, well-vascularized wounds - such as those resulting from scar excision or elective plastic surgery. Its application remains rare in complex, contaminated wounds involving bone or joint injuries.

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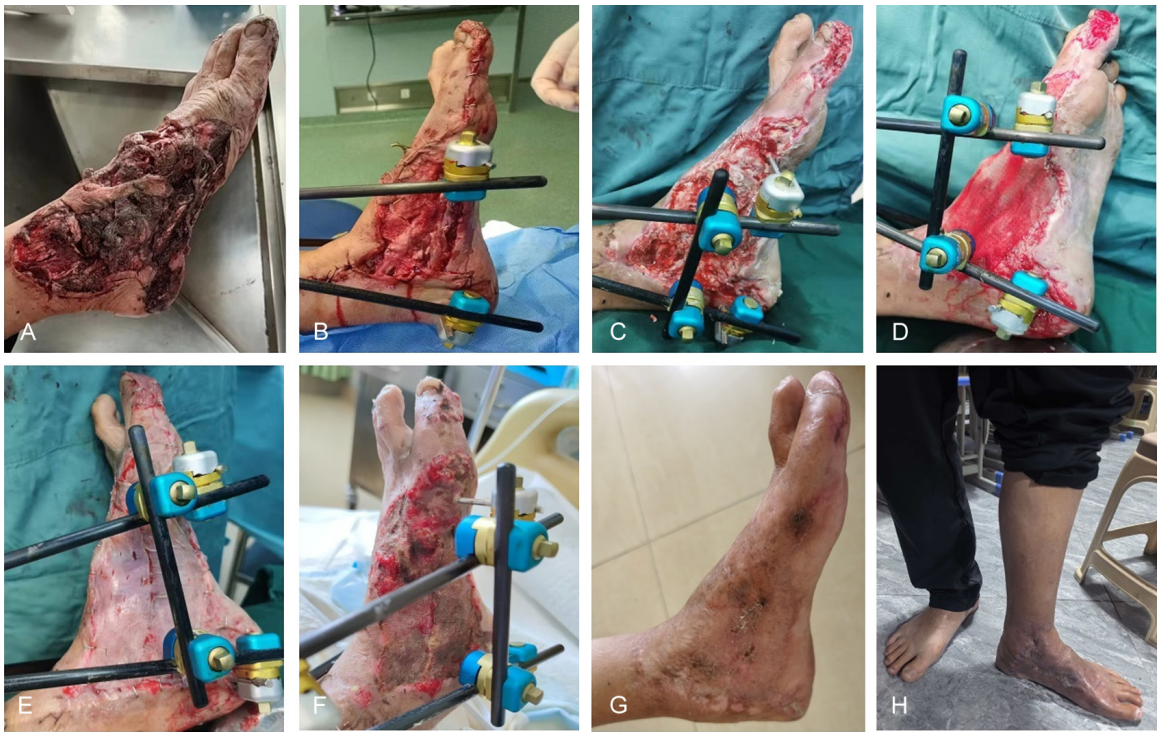

Figure 1. Representative images of the patient at different treatment stages. A. On the day of injury, the patient presented with a severe laceration of left foot, accompanied by multiple fractures and bone defects. B. Following initial debridement, an external fixation frame was applied. C. Prior to wound repair, granulation tissue had developed adequately, with scattered small areas of necrotic tissue and focal bone exposure. D. After debridement, an artificial dermis (AD) collagen layer was placed over the wound bed. E. An autologous split-thickness skin graft (STSG) was placed over the AD layer and secured with skin staples. F. Ten days after the one-stage transplantation of AD and autologous STSG, the skin graft adhered firmly to the wound bed, displayed a rosy color, and showed complete survival. G. One year after the one-stage transplantation, the skin graft showed no contracture, with color, texture, pliability, and elasticity comparable to the surrounding normal skin. H. At 18 months postoperatively, the left foot maintained a normal contour without deformity, and the ankle joint retained a normal range of motion, allowing for full weight-bearing walking.

In January 2024, we performed comprehensive debridement and antibiotic-loaded bone cement (ALBC) application in a patient with severe foot trauma and infectious bone and joint injury resulting from a motor vehicle accident. Subsequently, a one-stage transplantation of AD combined with autologous STSG was performed, yielding satisfactory outcomes. No similar cases have been reported to date. This study was approved by the ethics committee of the 909th Hospital, and informed consent was obtained from the patient.

Case presentation

A 52-year-old male presented with severe skin and soft tissue avulsion injuries on the posterior aspect of his left foot following a traffic accident. The wound measured approximately 15 cm × 10 cm and was severely contaminated. Multiple open fractures, dislocations, and bone defects were evident in the metatarsals, tarsals, left distal tibia, and left ankle, with several joint cavities exposed (**Figure 1A**).

The patient underwent three surgical procedures: (1) Emergency debridement was performed, after which the fractures and dislocated joints were reduced and stabilized using Kirschner wires and an external fixator. The bone defect was filled with ALBC (**Figure 1B**), and negative pressure wound therapy with a vacuum sealing drain (VSD) was applied. (2) Eleven days after the initial debridement, expanded debridement was performed due to necrosis and exudation in portions of the marginally viable tissue, followed by re-application of ALBC and VSD therapy. (3) At one month post-injury, the patient was transferred to the Burn and Plastic Surgery Department for wo-

und repair. Preoperative bacterial culture of wound exudate was negative. Intraoperatively, after removal of the ALBC, the wound bed showed fresh, bleeding granulation tissue along with scattered necrotic tissue and punctate bone exposure (**Figure 1C**). Following debridement until minimal wound bleeding was achieved, a one-stage transplantation was performed: the collagen layer of an AD (Lando®) was applied to the prepared wound bed (**Figure 1D**), followed by placement of a 0.15-0.25 mm autologous STSG harvested from the scalp. The graft was secured with skin staples (**Figure 1E**) and covered with an outer VSD dressing.

On postoperative day 10, the skin graft was well-adhered to the wound bed and exhibited a ruddy color, indicating good viability (**Figure 1F**). With routine dressing changes, the graft gradually expanded, ultimately achieving complete wound closure. One year after surgery, the graft flap exhibits no contraction, and its color, texture, softness, and elasticity closely resemble those of the surrounding normal skin (**Figure 1G**). At 18 months postoperatively, the patient exhibited no deformities in the left foot, demonstrated a preserved normal range of motion in the ankle joint, and was able to walk with full weight-bearing (**Figure 1H**).

Discussion

In the management of this patient's condition, we rigorously followed the established clinical protocol for staged reconstruction of complex wounds. During the initial surgery, after achieving fracture fixation, ALBC was used to fill and cover the wound. The ALBC fulfilled several key roles: delivered a high local concentration of antibiotics for effective infection control, occupied the osseous defect while providing structural support to the surrounding soft tissues, and stimulated the development of a well-vascularized, bioactive "induced membrane" around the cement spacer [4]. This membrane contributed to shielding exposed tendons and bone, thereby establishing a favorable wound bed for subsequent wound repair.

Current consensus suggests that during primary debridement, the marginally viable tissue with uncertain perfusion should be preserved whenever feasible to avoid excessive tissue sacrifice, which could compromise healing and functional recovery. However, such a conservative strategy may elevate the risk of subsequent infection and frequently necessitates additional debridement procedures. Accordingly, the patient underwent a secondary debridement, augmented with ALBC and VSD, to further optimize the wound micro-environment. By the time of the third surgery, the wound infection had been adequately controlled and the blood supply to local tissues had improved. Although sporadic necrosis and scattered bone exposure remained, the residual small necrotic tissues were thoroughly excised, after which AD and autologous STSG were applied concurrently with VSD in a one-stage procedure. While the two-stage approach is often regarded as a more cautious strategy, in this case the resolution of wound infection and the marked improvement in local blood supply had eliminated the primary adverse factors affecting skin graft survival [5]. Therefore, a one-stage transplantation was considered a reasonable and advantageous exploratory option. The patient was monitored over an 18-month follow-up period, during which the skin grafts demonstrated excellent take and foot function recovered favorably. Compared with the conventional two-stage method, this one-stage transplantation of AD and STSG significantly shortens the treatment duration and simplifies the clinical management pathway.

The successful outcome of this case was contingent upon the early-stage application of ALBC to fill and cover the bone defect. This approach effectively transformed the contaminated wound - which was unsuitable for a one-stage skin grafting procedure - into a clean-like wound bed with optimal conditions for skin grafting. Moreover, the cross-linked porous architecture of the AD scaffold plays a crucial role in scaffold vascularization [6]. The specific macro- to micro-scale interconnected network of the Lando® AD collagen sponge utilized in this case enabled early plasma infiltration and rapid vascularization, which are essential for the survival of the STSG [7]. Furthermore, the use of VSD not only ensures thorough wound drainage prior to grafting, reduces the risk of infection, and stimulates the formation of granulation tissue, but also improves the adhesion between the AD matrix and the wound bed, accelerates AD vascularization, and further facilitates wound healing [8].

Conclusion

For the repair of complex wounds involving bone and joint infections resulting from severe trauma, we propose that in addition to thorough debridement and routine dressing changes, the combined use of ALBC and VSD can further control infection, optimize wound bed conditions, and establish a foundation for successful subsequent skin grafting. Once infection is fully controlled and adequate blood supply is confirmed, a one-stage transplantation of AD and autologous STSG may be considered. This method can promote early wound closure and functional recovery of the affected foot, while also achieving favorable aesthetic outcomes. Compared with the traditional two-stage method, the one-stage transplantation of AD and STSG represents a relatively straightforward, satisfactory, and safe strategy for wound repair in selected cases of severe and complex trauma.

Disclosure of conflict of interest

None.

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