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Technical Tips

Free adipose tissue (FAT) graft pooling for severe dead space management: a technical trick

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Abstract

Complex lower extremity trauma with large soft tissue defects requires early wound coverage to reduce the risk of complications. In particular circumstances, however, local or free flaps may be contraindicated due to local or systemic issues. This study presents a helpful and effective salvage procedure for soft tissue reconstruction that uses autologous fat grafting combined with negative pressure wound therapy.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

Keywords: Surgical flaps; Adipose tissue/transplantation; Bone exposure; Hyperbaric oxygenation; Negative pressure wound therapy.

Introduction

Early soft tissue coverage plays a critical role in minimizing complications in the setting of complex lower extremity trauma. For smaller defects, local rotational muscle flaps can help to provide an adequate local blood supply, which is essential for fracture healing. For larger defects, fasciocutaneous (ie, anterolateral thigh) or muscle (ie, rectus abdominis, latissimus dorsi) free flaps can also achieve similar goals, with recent data suggesting that fasciocutaneous flaps may be associated with delayed union compared to muscle flaps[(1)].

In certain clinical situations, however, the use of local flaps may not be possible due to soft tissue trauma/damage, and even free flaps may be contraindicated due to the lack of suitable vessels for anastomosis or due to systemic issues. In these settings, options for dead space management are limited and amputation may seem inevitable. Another option, however, can be implemented. Here, we present a novel technique for the management of dead space not amenable to free flap coverage. The free adipose tissue (FAT) graft pooling technique combines the angiogenic and reparative properties of adipose-derived stem cells with negative pressure wound therapy (NPWT) to manage these complex clinical situations.

The successful use of adipose-derived stromal/stem cells has been reported in aesthetic, cardiac, and reconstructive posttraumatic procedures[(2)]. Potential advantages of autologous fat grafting include abundant fat, easy harvesting via liposuction, and cost-effectiveness compared to commercially available artificial skin[(3)].

Regenerative properties of adipose-derived stem cells

Adipose-derived stem cells have paracrine activity and secrete antiapoptotic and angiogenic factors, thereby promoting tissue repair. Mature adipocytes are the main part of the aspirated fat content. Fat tissue is very sensitive to ischemia and apoptosis and has a lower concentration of growth factors and mesenchymal cells than manipulated concentrates of adipose-derived mesenchymal cells, but it does act com-

Study performed at the Felício Rocho Hospital, Belo Horizonte, MG, Brazil.

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petently in wound healing, without any extra additive[4-7]. Adipocytes interact with the local environment through their microconnections (cellular niche), exerting endocrine effects on the surrounding tissues. These observations have drawn attention to the importance of the integrity of intercellular connections in the extracellular matrix, which is still present in the adipose tissue *in natura*[8].

Hamada et al.[3], comparing artificial dermis with adipose-derived stem cells in wounds with exposed bone in a rat model, reported that adipose-derived stem cells showed significantly higher expression of basic fibroblast growth factor (bFGF) and vascular endothelial growth factor (VEGF), thereby exhibiting potential for differentiation into fibroblasts and blood vessel endothelial cells.

NPWT is an extremely useful adjuvant to coverage of complex wounds due to its angiogenesis-stimulating properties and ability to reduce exudate, edema, and bacterial proliferation[9].

Methods

FAT graft pooling technique: a case example

A 28-year-old man was involved in a motorcycle accident and sustained closed subtrochanteric and distal right femur fractures associated with a Gustilo-Anderson type IIIB distal tibia fracture, precisely at the level of a preexisting ankle arthrodesis. The patient had hematogenous osteomyelitis during childhood requiring multiple surgical procedures, including debridement, tibial lengthening with the Ilizarov external fixator, and ankle arthrodesis. As a result, the patient had limb shortening and gross tibial and femoral deformities (Figure 1).

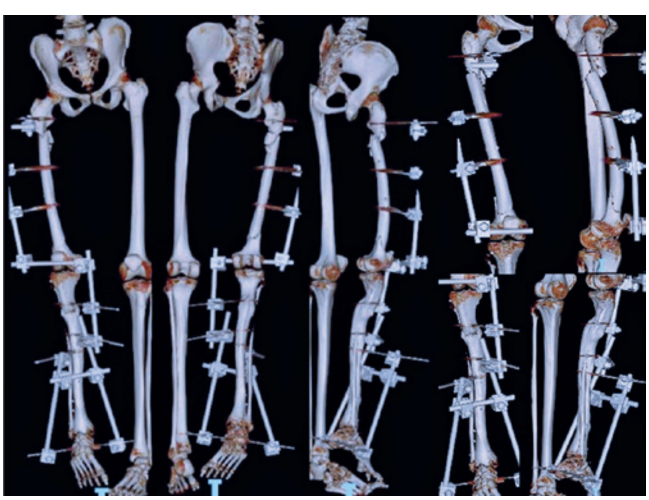

Figure 1. Computed tomography with 3D reconstruction showing subtrochanteric and distal femur fractures. Note the severity of the anterior bowing of the femur. The 3D reconstruction of the tibia also shows multiple tibial deformities and fracture at the level of the ankle arthrodesis.

No signs of active infection were observed at the time of the current trauma. Initial treatment was debridement, external fixation of the entire extremity, and intravenous antibiotics. Two additional debridements were performed at 3 and 5 days after trauma, but NPWT was not available at this time. After 9 days, the femur fracture was fixed by a combination of retrograde nailing and placement of a cephalomedullary nail, in a "kissing nail technique". The choice of 2 independent nails was based on the severity of the anterior bowing of the femur, which precluded the use of a single long nail. The choice of a short retrograde nail instead of a lateral locking plate was also based on the distal femoral deformity, which hindered adequate plate placement. After fracture fixation, another debridement was performed and NPWT was applied. Due to poor soft tissue conditions at the distal third of the leg as a consequence of previous osteomyelitis and multiple surgical procedures, local and free flaps were not indicated. After 16 days, autologous fat grafting with the pooling technique was performed using both thighs as donor sites, followed by a second NPWT application. Nine days later, the same procedure was repeated but now using the abdominal panniculus as the donor site. NPWT was repeated twice with a 7-day interval between applications, and the patient remained hospitalized because he lived in a distant city, with limited resources. Finally, 30 days after the first fat grafting session, skin grafting was performed. Because after the second debridement the wound culture was positive for multidrug-resistant Gram-negative bacteria, intravenous antibiotic was maintained until skin grafting and the transarticular external fixator was kept as a definitive treatment. Length of hospital stay was 50 days. The skin graft was fully incorporated (Figure 2). The external fixator was removed after complete ankle arthrodesis healing (77 days). After 4 months, both femur fractures were also healed (Figure 3). Eight months later, no signs of infection or systemic or local complications were detected. Written informed consent was obtained from the patient to publication of this case example and images.

Technique

Potential donor sites for fat grafting include the inner aspects of the thighs, lower anterior and lateral aspects of the abdomen, and waist. The instruments required for the FAT graft pooling technique are summarized in table 1.

Fat was harvested from de medial aspect of both thighs (first session) and from the abdominal panniculus (second session). The donor sites were infiltrated with 0.9% saline with 1:500,000 epinephrine (tumescent technique) without lidocaine, and a 4 mm x 25 cm liposuction cannula was then used for fat harvesting. The fat was processed by decantation before grafting, and a total amount of 80 cc of fat tissue was obtained per session (Figure 2C). Fat grafting was performed in 2 different ways. First, retrograde subcutaneous injection of fat was performed in multiple tunnels (lipofilling or structural fat grafting) with a 1.8-mm cannula through skin counterincisions (one proximal incision and one distal incision 3 cm away from the wound edge) to fill the wound edges. Second, fat was

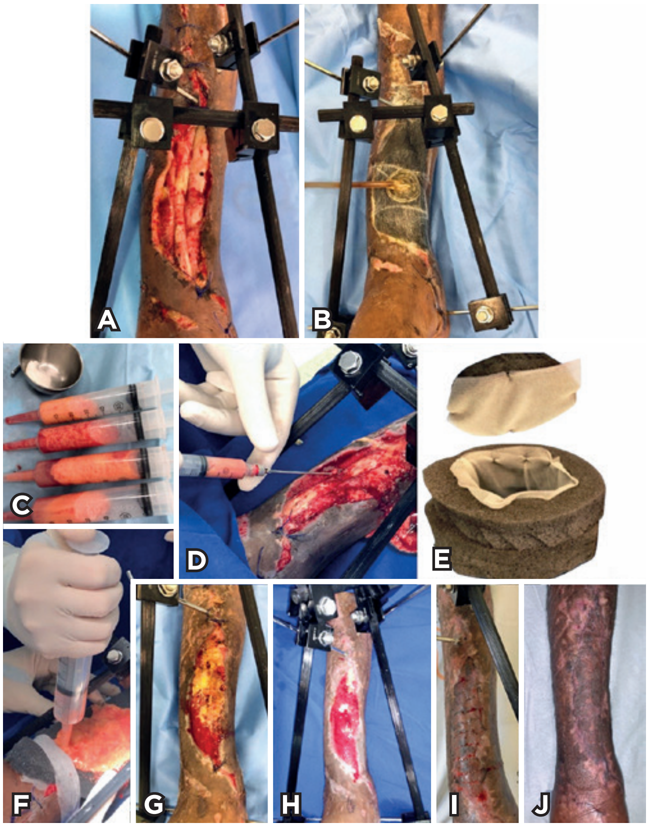

Figure 2. (A) Intraoperative photograph showing the anterior soft tissue defect at the level of the distal third of the tibia. Note the extensive exposure of the bone and anterior tibial tendon. (B) First negative pressure wound therapy (NPWT) application. (C) Approximately 80 cc of fat graft was harvested. (D) Retrograde subcutaneous injection in multiple tunnels (lipofilling or structural fat grafting) with a 1.8-mm cannula through skin counterincisions to fill the wound edges. (E) Intraoperative photograph showing the pool prepared by customizing the NPWT foam. (F) Customization of a "pool" by using the NPWT foam for containment of the grafted material. (G) Intraoperative photograph showing wound appearance 7 days after the first fat grafting procedure. (H) Note the granulation tissue covering the entire exposed bone surface and tendon after the fourth NPWT application. (I) Anterior view of the leg showing skin graft integration without necrosis 7 days after the procedure. (J) Note complete wound healing 2 months after skin grafting.

Figure 3. (A) Panoramic radiograph of the lower limbs in the anteroposterior view showing fracture fixation. Note right limb shortening and deformity. (B and C) Radiographs of the right femur in the anteroposterior and lateral views showing fracture healing 4 months after fixation. (D) Radiographs of the right ankle in the anteroposterior and lateral views showing arthrodesis healing 4 months after external fixation.

Table 1. Instruments required for the free adipose tissue graft pooling technique

Saline solution (0.9%)
Epinephrine (dilution 1:500,000)
Liposuction cannula (4 mm) for fat grafting
Lipofilling cannula (1.8 or 2.0 mm) to fill the wound edges through skin counterincisions
60 cc syringe (vacuum syringe) or conventional liposuction probe
Vaseline gauze (Adaptic®)
Negative pressure wound therapy kit

further injected subcutaneously through the wound edges, so that fat would reach the wound center from underneath and from the sides, until it filled and overflowed the wound surface (topical fat grafting) (Figure 2D).

To prevent loss of harvested fat, a "pool" was prepared and held around the wound limits by using the NPWT foam to support and keep the grafted material on the wound surface overflowed with fat tissue (Figure 2E). The foam was "carved" or "sculpted" in a customized design to keep the fat over the wound. After all fat tissue had been injected, another piece of foam was applied over the grafted fat as a "pool" (Figure 2F). The NPWT dressing was completed with progressive application of plastic film, wrapping it around all parts until perfect sealing was achieved, thus keeping the pool made of foam full of grafted fat over the wound. After sealing and stabilization of the fat over the wound, negative pressure was set to -125mmHg in a continuous mode of administration. The skin around the wound and the fat were previously protected with a Vaseline gauze (Adaptic®) as a wound contact layer.

Discussion

Subcutaneous lipofilling for augmentation and correction of soft tissue defects remains the major indication for autologous fat grafting in clinical practice. With the processing and differentiation of adipose-derived mesenchymal cells and observation of their trophic and regenerative effects, a wide range of new indications has emerged for fat and its products, with great potential for many benefits[10-12].

Lin et al.[13] reported a case of plate and screw exposure due to skin necrosis at the medial aspect of the ankle that was successfully treated with fat grafting. Purified, emulsified fat was used with a micro-autologous fat transplantation gun. The wound healed 18 weeks after surgery. Souza et al.[14] also reported the successful combination of autologous fat grafting with NPWT in a case of chronic osteomyelitis with 10 cm of distal tibial exposure after a failed fasciocutaneous flap. Three weeks after fat grafting and NPWT, granulation tissue covered the entire exposed bone surface, thus allowing skin grafting.

Potential advantages of the FAT graft pooling technique include low morbidity at the donor site (usually the thigh), abundant fat, and no need for a long learning curve, such as that usually required for microvascular surgery. Furthermore, the graft functions as a matrix, thereby allowing for more effective cell connections and promoting anti-inflammatory and paracrine activities, which are beneficial for wound healing.

Although the technique presented here often requires prolonged hospital stay and multiple NPWT applications, which cannot be disregarded in terms of cost-effectiveness, we believe that the procedure is an extremely helpful salvage technique for complex wounds where standard techniques are contraindicated or have failed. Our preliminary results are promising, but a large case series is needed to fully validate this novel salvage procedure. Our group is currently working on this direction.

Conclusion

The FAT graft pooling technique combines the angiogenic and regenerative properties of adipose tissue with NPWT to manage complex clinical situations. We advocate this technique in certain circumstances where the use of local flaps is not possible due to soft tissue trauma/damage, or when free flaps are contraindicated due to the lack of suitable vessels for anastomosis or due to systemic issues.

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