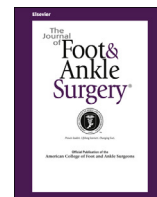




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A Perifascial Areolar Tissue Graft With Topical Administration of Basic Fibroblast Growth Factor for Treatment of Complex Wounds With Exposed Tendons and/or Bones

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ABSTRACT

The management of wounds with tendon and/or bone exposure is challenging because of the insufficient blood supply to the wound bed. We describe our experience with 19 patients using a perifascial areolar tissue (PAT) graft with topical administration of basic fibroblast growth factor (bFGF) in the treatment of complex wounds with exposed tendons and/or bones in the extremities. Using a PAT graft is minimally invasive and technically easy, and the donor site is relatively preserved. However, PAT grafts for the treatment of a complex wound with large areas of exposed tendons and/or bones have sometimes failed to survive because of insufficient vascularization of the wound bed. Therefore, topical administration of bFGF, which promotes angiogenesis, was added to the graft. All grafts showed good graft survival and successfully covered the tendons and bones. Topical administration of bFGF accelerated vascularization in the PAT graft and facilitated wound healing by increasing the blood supply to the wound bed and achieved success with the PAT graft. In conclusion, using a PAT graft with topical administration of bFGF is a suitable option for the treatment of complex wounds with a large proportion of exposed tendons and/or bones. With minimal damage to the tissues near the wound, the PAT graft can be a useful option for limb salvage and could become a valuable tool for reconstructive surgeons.

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The management of wounds with exposure of the tendons and/or bones is challenging because of the insufficient blood supply to the wound bed. The treatment of these types of wounds usually requires placement of various local flaps, distant arterial flaps, free flaps, or artificial dermis. However, in many cases, local flaps are unavailable because the surrounding tissue has been damaged, and the mobility of the flap is limited. Although distant arterial flaps and free flaps can be used for such complex wounds, their use has several shortcomings, including invasive time-consuming surgery and poor cosmetic outcomes at the donor site.

Peripheral artery disease has increased and become a global problem (1); thus, the need for minimally invasive treatment of wounds in the lower leg and foot has become significant. Koizumi et al (2,3) described a method for the reconstruction of a variety of tissue defects with poor blood circulation using a nonvascularized free perifascial areolar tissue (PAT) graft. The technique was easy and minimally invasive, and the scar at the donor site was minimal (2,3). They successfully treated defects with small areas of exposed tendons and/or bones, fistulas, and dead space after tumor resection. However, in cases with a large area of exposed tendons and/or bone defects, the graft sometimes failed to survive, because it was not sufficiently vascularized from the wound bed. Hayashi et al (4) reported that the use of a PAT graft might not be suitable for tendon exposures with widths >2 cm and that such cases might be beyond the scope of a PAT graft.

We report the use of a PAT graft with the topical administration of basic fibroblast growth factor (bFGF) for the minimally invasive treatment of complex wounds with exposed tendons and/or bones, including large areas (width >2 cm).

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Patients and Methods

Patients

We performed a review of data from the clinical databases of Kurobe City Hospital, Kouseiren Takaoka Hospital, and Kanazawa Medical University Hospital in Japan. A total of 19 patients with wounds involving exposed tendons and bones had received PAT grafts with the topical administration of bFGF from April 2010 to August 2016 (Table). During the review, the principles outlined in the Declaration of Helsinki were followed. Individuals with incomplete data were excluded. The institutional ethics board approved the present study. All the patients provided informed consent. Of the 19 patients, 18 were male and 1 was female (mean age 54.4, range 19 to 86 years). The wounds of the 19 patients included exposed tendons in 11, exposed bones in 4, and both tendon and bone exposure in 4. The etiology was a crush-avulsion injury caused by a traffic accident or machine in 6 patients, burn injury in 4, crush injury in 4, avulsion injury caused by a machine in 2, dermal and subcutaneous infection after internal fixation of an ankle fracture in 1, peripheral artery disease in 1, and diabetic foot ulcer in 1 patient. The regions of the wounds were in lower extremities in 11 patients (lower leg in 6, dorsal foot in 2, ankle in 2, and plantar foot in 1), in the upper extremities 7 (dorsal finger in 4 and dorsal hand in 3), and the face in 1 patient. Most of the lower legs and feet had been injured by trauma or an extensive burn, and in some, the development of ischemia was possible. All the upper extremity injuries were on the dorsal side of the hand or finger. The facial injury involved a mandibular bone with an extensive burn injury from the head to the lower legs, except for the back. The wounds were 2.2 to 25.6 cm long and 1.0 to 12.0 cm wide. The tendon and bone exposure was 1.0 to 8.4 cm long and 0.6 to 3.0 cm wide. One patient had used anticoagulation medicine (cilostazol, ticlopidine, warfarin), and 10 patients had a history of smoking. The comorbidities were hypertension in 8 patients, diabetes in 6, schizophrenia in 1, hepatitis in 1, cerebral hemorrhage in 1, and angina pectoris in 1 patient. All the patients underwent the same surgical procedure under general or local anesthesia and were followed up for a mean of 15.3 (range 5 to 36) months.

Perifascial Areolar Tissue

PAT is composed of loose connective tissue, collagen, and a rich microvascular network. PAT is found on the deep fascia of muscles overlaying deep fat located in the hypogastrium (Supplemental Fig. S1) or extremities. The PAT graft is usually obtained from the inguinal region because the scar can be covered by underwear.

Surgical Procedure

We present the data from a retrospective review. Under general or local anesthesia, the wound was prepared and draped in the usual sterile surgical fashion. First, the upper inguinal skin was incised at a slightly shorter length than that of the anticipated PAT graft. The subcutaneous fat tissue (superficial and deep fat) was then undermined widely from the thin connective tissue, which possesses an abundant vascular plexus and is located just above the fascia of the abdominal external oblique muscle. This thin connective tissue was the PAT graft (Supplemental Fig. S2). We obtained and elevated a free PAT graft that was larger than the area of exposure of the tendon and/or bone. The granulation or necrotic tissue surrounding the exposed tendon or bone was debrided until healthy bleeding was observed. The PAT graft was then applied to cover the defect, including the tendon and/or bone. The graft should be suitably larger than the exposed tendon and/or bone, and the contact area between the graft and the healthy tissue surrounding the exposed tendons and bone should be as wide as possible. A film dressing (Tegaderm™; 3M Medical, Maplewood, MN) or an artificial dermis (a bilayer with an outer silicone membrane and inner porcine tendon-derived collagen sponge; Pelnac®; Gunze Co., Kyoto, Japan) was placed over the graft. When the defect surrounding the tendon and/or bone exposure area was large, an artificial dermis was selected to promote healthy granulation and tissue formation.

Postoperative Management

Starting on postoperative day 1, multiple small daily injections of 0.1 mL of bFGF (Fiblast Spray®; Kaken Pharmaceutical Co. Ltd., Kyoto, Japan) were distributed and infiltrated evenly into the PAT graft under the film dressing or the silicone film of the artificial dermis by the surgeons (Supplemental Fig. S3). The film dressing or outer silicone membrane of the artificial dermis was removed 2 weeks after the surgery. All patients stayed in the hospital during this period because they could not walk or drive to the hospital daily for the injections. If patients are able to return to the hospital and rest the surgical region, postoperative management could be performed with the patients as outpatients.

Results

During the 5-year study period, 19 patients with complex wounds involving exposed tendons and/or bones underwent the surgical pro-

cedure. The PAT grafts were 2.2 to 9.4 cm long and 1.0 to 5.7 cm wide. The ratio of the graft area to the tendon and bone exposure area ranged from 1.6 to 5.5 (mean 2.95). In 18 cases, the donor site was the upper inguinal region, and in 1, it was the medial thigh region because the PAT in the inguinal region had been injured by a deep burn. Eighteen grafts survived completely and had successfully covered the tendons and bone by ~2 weeks after graft placement. One graft developed partial necrosis; however, the region of partial necrosis was so small that it had been covered by granulation tissue by 3 weeks after graft placement. Artificial dermis was used over the PAT graft for 14 patients and a film dressing for 5 patients. Sixteen patients received split-thickness skin grafts on the granulation tissue and the defects were completely closed. Three patients experienced epithelialization without any further surgical treatment within 4 weeks after placement of the PAT graft. All lesions healed without any postoperative complications, such as infection and hematomas, and all patients were satisfied with the surgical outcome.

Selected Case Reports

Patient 4

A 72-year-old male had presented with a crush-avulsion injury caused by a farm tractor while working. The wound showed a laceration of the gastrocnemius muscle and defects in the dermal and subcutaneous tissue. Although the gastrocnemius muscle was sutured, the long peroneal muscle tendon remained exposed because of the large skin defect. The skin defect was covered with an artificial dermis and treated with negative pressure wound therapy for 17 days. However, granulation tissue failed to form over the tendon (Fig. 1A), and a PAT graft with artificial dermis was placed 18 days after the injury (Fig. 1B). Starting on postoperative day 1, multiple small daily injections of 0.3 mL of bFGF were distributed evenly into the PAT graft under the artificial dermis. At 13 days after graft placement, granulation tissue had covered the tendon (Fig. 1C). A split-thickness skin graft was subsequently placed, and the wound was completely closed. No postoperative complications occurred.

Patient 11

A 79-year-old male had presented with a wound on his left distal lower limb. The wound had been noted 6 months previously and had been treated conservatively at a local hospital. However, no improvement had been observed. Lower limb arteriography showed occlusion of the origin of the left superficial femoral artery and all lower limb vessels. Therefore, a left superficial femoral–popliteal artery bypass was performed. However, the wound involving an exposed calcaneal tendon failed to heal (Fig. 2A). The skin perfusion pressure values of the inferior leg and dorsal and plantar skin were 29, 30, and 37 mm Hg, respectively. A PAT graft was placed 3 months after the bypass surgery, and the skin surrounding the wound was undermined to widen the attachment area of the PAT graft and ensure its adherence to well-vascularized tissue (Fig. 2B). An artificial dermis was placed over the graft (Fig. 2C). Starting on postoperative day 1, multiple small daily injections of 0.3 mL of bFGF were distributed evenly into the PAT graft under the artificial dermis. Thin granulation tissue had covered the tendon 2 weeks after graft placement. Subsequently, negative pressure therapy was performed for 2 weeks. Healthy granulation tissue had covered the tendon 4 weeks after graft placement (Fig. 2D). At that point, a split-thickness skin graft was placed, and the wound was completely closed. No postoperative complications occurred.

Patient 18

A 19-year-old male had presented with a crush injury caused by a traffic accident while driving. The wound showed ruptures of the extensor digitorum longus and hallucis longus and hallucis longus

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