Outcome of Skin Graft versus Flap Surgery in the Salvage of the Exposed Achilles Tendon in Diabetics versus Nondiabetics

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Background: Achilles tendon wounds pose a reconstructive dilemma because of the tendon's functional importance and the paucity of soft tissue surrounding the ankle. The currently accepted treatment is to repair the wound with a flap (local, pedicled, or free). In this article, the authors examine whether skin graft coverage of the exposed Achilles tendon is a viable option for reconstruction and whether the comorbidity of diabetes affects the outcome.
Methods: Forty-five consecutive patients presenting with wounds involving the Achilles tendon in 49 limbs were retrospectively evaluated from the authors' limb salvage registry from 1990 to 1999.
Results: After initial debridement, the method of reconstruction consisted of closure by secondary intention ($n = 6$), skin grafting ($n = 27$), and reconstruction with a flap ($n = 10$) or free flaps ($n = 6$). The primary success rate of each procedure was not significantly different: secondary intention, 83 percent; skin graft, 83 percent; local flap, 80 percent; and free flap, 83 percent. The overall wound-healing rate was 96 percent and the limb salvage rate was 98 percent. Six wounds eventually recurred in patients who had undergone skin grafting. All but one went on to heal with conservative therapy. There was no difference in any of the result parameters between diabetics and nondiabetics.
Conclusions: This study demonstrates that, with a properly prepared wound bed, skin grafting can be as effective as local or free flaps in successfully healing Achilles tendon wounds. Diabetes should not be used as a contraindication to limb salvage in patients who present with Achilles tendon ulceration or gangrene. (*Plast. Reconstr. Surg.* 117: 2460, 2006.)

Over the past 20 years, ulceration over the Achilles tendon has typically been treated with local and pedicled flaps[1–8] or free flaps.[9–13] There is a great reluctance in using skin grafts on the Achilles tendon, as is evident by the lack of plastic, podiatric, and orthopedic literature on this topic. This may in part be attributable to the inhospitable recipient bed of a freshly debrided Achilles tendon. However, it may also be attributable to a concern that a skin graft may tether the Achilles tendon and/or be too fragile to hold up to the normal daily wear and tear that is exerted on this tissue.

The Achilles tendon enjoys an excellent arterial supply from the sural, peroneal, and posterior tibial arteries.[14] If good wound care is applied and the tendon is kept physiologically moist, granulation tissue will form over the tendon. Adjuncts such as the vacuum-assisted closure device, skin substitutes, hyperbaric oxygen, and/or growth factor can help stimulate the formation of granulation tissue, leading to a wound bed that can then be skin grafted.

Because of the wide variation in physicians' approaches to diabetic limb salvage, diabetics presenting with a large ulcer or gangrene of the foot and/or ankle area face a 23 percent chance of undergoing immediate amputation.[15] The variability of a physician's approach to diabetic limb salvage versus amputation in the United States is 8.6-fold. This pessimism in approaching diabetic foot ulcers has been shown to be unjustified.[16,17] The question is whether it is also

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unjustified in dealing with Achilles tendon ulcers.

This study was undertaken to retrospectively examine all of the Achilles tendon wounds from the Georgetown University Hospital limb registry and evaluate whether the poor reputation of applying skin grafts was justified and whether the comorbidity of diabetes affected the outcome.

PATIENTS AND METHODS

Forty-five consecutive patients presenting with wounds involving the Achilles tendon, in 49 limbs, were identified from our limb salvage registry from 1990 to 1999. All office and hospital medical records were reviewed and patients were contacted for an interview. Information was obtained pertaining to patient demographics, diabetes status, comorbidities, wound cause, procedures performed, and complications. The healing time for each procedure was analyzed from the time of presentation until the wound was completely healed. It was calculated using the nonparametric Mann-Whitney test and reported with standard deviations. The patient survival, limb salvage rate, healing success rate, and patient functional status, reported both in the text and in the tables, were analyzed using the Fisher's exact test.

All Achilles tendon wounds were treated according to our Limb Center protocol. If the limb was ischemic and the wound was chronic without cellulitis, the patient was initially referred to a vascular surgeon for leg revascularization. If the ischemic limb had wet gangrene with cellulitis, the limb was first debrided and then revascularized as soon as possible. Once the leg had adequate vascular supply, the ulcer or gangrene was debrided down to healthy, firm tendon. Care was taken to ensure that the tendon above and below the wound was also healthy. Cultures were taken during all debridements, and a broad-spectrum antibiotic was started until the culture results were available. Once culture sensitivities became available, the antibiotic regimen was tailored for the specific organisms.

All wounds were initially treated with silver sulfadiazine until they began to form granulation tissue and the edges for the wound showed no signs of inflammation. At that time, a decision was made to either let it heal by secondary intention or to reconstruct the soft-tissue defect with a skin graft, local flap, or free flap. The initial decision for wound management was made following evaluation of the patient's overall medical condition and the wound's ability to form good granulation tissue with local wound care. Patients who were felt to be too unstable to undergo skin grafting or flap surgery were treated with wound care until the wound healed by secondary intention. If the patient was medically stable and sufficient healthy granulation tissue had formed, skin grafting was undertaken. If the formation of granulation tissue was not progressing well, adjunct therapies were applied, which included serial xenografts, hyperbaric oxygen (topical hyperbaric before 1994 and systemic hyperbaric after 1994), and topical growth factor. When the tendon was covered with adequate granulation tissue, it was then skin grafted. If, despite aggressive adjunctive wound care, the wound failed to form healthy granulation tissue, a local or free flap was applied. Regardless of which mode of reconstruction was chosen, the ankle was immobilized for 6 weeks postoperatively with the ankle in the neutral position until the skin graft took or the flap healed.

Complications were carefully evaluated. They included anything that delayed primary healing after the reconstructive procedure was performed. This included cellulitis, dehiscence, partial skin graft loss, partial flap loss, limb loss, and medical complications.

RESULTS

There were a total of 45 patients identified with 49 Achilles tendon wounds. There were 14 diabetics, with an equal male-to-female ratio, and 31 nondiabetics, with an 18:13 male-to-female ratio. The mean age was 65.9 years (range, 47 to 85 years) for the diabetics and 60.4 (27 to 87) years for the nondiabetics. The 14 diabetic patients had 16 Achilles tendon wounds and the 31 nondiabetics had 33 Achilles tendon wounds. Risk factors of atherosclerosis (coronary artery disease, hypertension, peripheral vascular disease) were three times more prominent in the diabetics than in the nondiabetics (Table 1). The causes of the 16 diabetic Achilles tendon wounds were principally trauma (eight of 16) and infection (seven of 16). Among

Table 1. Patient Comorbidities in Diabetics versus Nondiabetics*

	Diabetics (n = 14)	Nondiabetics (n = 31)
Hypertension	7	4
Coronary heart disease	6	5
Status after myocardial infarction	4	2
Peripheral vascular disease	5	3
Smoker	3	10

*Risk factors for the diabetic versus nondiabetic patients. The diabetic patients had a threefold higher manifestation of the consequences of advanced atherosclerosis.

nondiabetics, the causes were more varied: trauma (11 of 33), infection (12 of 33), vasculitis (five of 33), pyoderma gangrenosum (two of 33), venous stasis (two of 33), and cancer (one of 33) (Table 2). Five of the 14 diabetic patients (36 percent) had peripheral vascular disease. However, only one patient required a lower extremity arterial bypass. Only three of the 31 nondiabetic patients (10 percent) had peripheral vascular disease and, again, only one patient required a lower extremity bypass. All wounds involved the Achilles tendon and presented either as chronic ulcers [30 of 49 (61 percent)] or frank gangrene [19 of 49 (39 percent)] and were equally divided within both groups.

All wounds were initially surgically debrided and then treated topically. Twenty-three debridements were performed for the 16 diabetic wounds and 33 were performed for the 33 nondiabetic wounds. When the normal wound dressings failed to promote the formation of healthy granulation tissue, wound-healing adjuncts were applied. Thirty of the debrided Achilles tendon wounds required additional wound-healing adjuncts. Theses included one or more of the following: xenograft ($n = 14$), Apligraf ($n = 2$) (Organogenesis, Inc., Canton, Ohio) AlloDerm ($n = 1$) (LifeCell, Inc., Branchburg, N.J.), topical hyperbaric oxygen ($n = 8$), systemic hyperbaric oxygen ($n = 10$), and/or growth factor ($n = 2$). The wounds then went on to heal by secondary intention ($n = 6$) or were skin grafted ($n = 27$). The remaining wounds were reconstructed with local flaps ($n = 10$) or free flaps ($n = 6$).

The overall primary healing success rate of surgical reconstructions was 86 percent (37 of 43). Of the wounds treated by wound care only, five of six (83 percent) healed by secondary intention. When each surgical procedure's success rate was compared, no statistical difference was detected between skin grafts [24 of 27 (83 percent)], local flaps [eight of 10 (80 percent)], and free flaps [five of six (83 percent)]. Seven wounds required additional procedures, including wound care ($n = 1$) skin graft ($n = 3$), local flaps ($n = 2$), free flap ($n = 1$), to heal, increasing the overall healing success rate to 96 percent. There was no statistical difference when reconstructions in diabetics were compared with those in nondiabetics (Table 3).

Table 2. Achilles Wound Cause in Diabetics versus Nondiabetics*

	Diabetics ($n = 16$)	Nondiabetics ($n = 33$)
Trauma	8	11
Infection	7	12
Vasculitis	1	5
Other		5

*Although most wounds start with some form of trauma, we arbitrarily assigned to each wound the most likely principal cause when the wound was initially evaluated. Included among the "other" diagnoses assigned to the nondiabetic group were ulcers caused by pyoderma gangrenosum, venous stasis, and cancer.

The overall complication rate was 35 percent, again with no statistical difference between the two groups (Table 4). Of the seven wounds that initially failed to heal, four were attributable to complications following local flaps, two after skin grafts, and one after free flap. The short-term limb salvage rate was 100 percent, and the long-term limb salvage rate was 98 percent (one of the patients developed a recurrent *Pseudomonas* infection and underwent an above-knee amputation). That patient was hemiplegic and a nonambulator with a flexion contraction at the knee who had initially been offered the amputation but had refused and therefore limb salvage was attempted.

The average time to heal from the time of initial presentation, 93 ± 21 days, was not statistically different between all three modes of therapy and between the diabetics and the nondiabetics. Six wounds eventually recurred [six of 49 (12 percent)]. These occurred in the patients who had undergone skin graft reconstructions, for a skin graft recurrence rate of 25 percent. All but one of these wounds healed with conservative wound care. The recurrent wound that did not heal was in the above-mentioned hemiparaplegic patient who had an ineradicable *Pseudomonas* infection and underwent an above-knee amputation.

The survival rate for patients with Achilles wounds at the mean follow-up of 46 ± 5.3 months was 65 percent in diabetics and 68 percent in nondiabetics. Three patients were lost to follow-up. The mean follow-up was 55.5 ± 6.6 months in the diabetics and 41 ± 4.4 months in the nondiabetics. Of the patients who were still alive at follow-up, 22 of the 30 were ambulating without assistance (Table 5). Five required a prosthetic or mechanical supporting device and three required the use of a wheelchair. Again, there was no significant difference between diabetics and nondiabetics.

DISCUSSION

In recent years, microsurgical flap coverage of the exposed Achilles tendon has been the most popular method of reconstruction. If the patient has a palpable posterior tibial pulse, the procedure is relatively straightforward and should, in experienced hands, carry no higher than a 4 per-

Table 3. Primary Mode of Repair and Initial Healing Success*

	Diabetics (%)	Nondiabetics (%)	Total (%)
Secondary intention	1/2 (50)	4/4 (100)	5/6 (83)
STSG	10/10 (100)	14/17 (82)	24/27 (89)
Local flap	0/1 (0)	8/9 (89)	8/10 (80)
Free flap	2/3 (67)	3/3 (100)	5/6 (83)
Success	13/16 (81)	29/33 (88)	42/49 (85)

STSG, split-thickness skin graft.
*The success of each reconstructive option is shown. This table counts success as those wounds that healed completely after the primary procedure without requiring additional procedures. There was no statistical difference between any of the procedures chosen or between wounds in diabetic and nondiabetic patients.

cent failure rate.[18] The type of flap used was shown not to be critical, as fasciocutaneous flaps,[9,10,12] musculocutaneous flaps,[13] and fascial flaps with skin graft[12] all proved successful. The disadvantages of free flaps, of course, are that they require a significant operative time (4 to 8 hours) and healthy recipient vessels at the ankle. In addition, there is the donor-site morbidity to consider and a prolonged hospital stay that usually requires one night in the intensive care unit for flap monitoring. The advantage of free flap reconstruction is that the Achilles tendon is covered with a healthy layer of viable tissue that decreases the risk of tethering and subsequent ulceration.

Local and pedicled flaps are also viable options. The problem is that most involve neighboring tissue, and the resultant defect can be problematic. For instance, if the defect extends too far laterally, the pedicle to the sural artery flap[3] may be sufficiently compromised so that the flap is no longer an option. In addition, the sural artery flap carries a significant complication rate,[19] the proximal sural nerve stump can develop a painful neuroma, and the skin-grafted midcalf donor site can prove to be problematic in the future if a below-knee amputation is eventually required. With the other pedicled fasciocutaneous flaps such as the lateral supramalleolar flap,[6] the dorsalis pedis flap, and the lateral malleolar flap,[7] the donor sites are difficult to close primarily and often need to be skin grafted. An alternative to these local fasciocutaneous flaps is the wraparound soleus flap[2] and skin graft. This flap is a good solution, provided that there is sufficient local soleus muscle underneath the ulcer. Unfortunately, this is rarely the case.

Table 4. Complications*

	Diabetics	Nondiabetics
STSG loss (partial)	1	6
Dehiscence	1	3
Flap loss (partial)	1	1
Infection	1	1
Donor-site morbidity		2
Medical compromise		2
Total (%)	4/16 (25)	15/39 (38)

STSG, split-thickness skin graft.
*There was no significant difference in complications from the primary procedures between the diabetic and nondiabetic patients.

Local rotation, advancement, or transposition flaps based either on posterior tibial or peroneal artery perforators are good alternatives because the donor site can usually be closed primarily.[5] However, the availability of adequate soft tissue around the ankle is limited. Consequently, there is typically a good deal of tension along the incision line and dehiscence can easily occur. In our experience, the highest complication and failure rates came from local flaps because of dehiscence or incision line necrosis. Therefore, local flaps should only be used if (1) the flap can be closed over the defect without tension, (2) strong Doppler signals can be detected from the appropriate perforators at the base of the flap, and (3) the patient can comply with the postoperative regimen. The key is to immobilize the ankle. Because patient compliance can be a real issue,[20] the use of a monopolar external fixator should be used whenever there is a question about the feasibility of keeping the ankle immobilized. Alternatives include casting or splinting. If the donor site cannot be closed without tension, one should not hesitate to apply a skin graft over the donor site.

Skin grafts over the Achilles tendon are not listed among the viable reconstructive options in the orthopedic and podiatric literature. The reason is most likely the fact that an immediately debrided Achilles tendon provides an unsuitable bed for successful skin graft take. Successful skin grafting requires a healthy bed of granulation tissue to form over the tendon. For the granulation tissue to form, it is necessary to apply good wound-healing techniques and to use wound-healing adjuncts such as negative-pressure dressings, skin substitutes, growth factor, and hyperbaric oxygen when required.

Table 5. Ambulatory Status

	Diabetics	Nondiabetics
Secondary intention	0	0
STSG	3	3
Local flaps	0	4
Free flaps	1	2
Combination	2	7
Total	6	16

STSG, split-thickness skin graft.
*Of the 30 remaining patients at follow-up, 22 were ambulating without assistance. The combination category consists of patients that healed following a combination of skin grafting, local flaps, and/or free flaps.

The first key is aggressive debridement[21,22] to get rid of all necrotic tissue and infection. For the debridement to be successful, there has to be good local blood flow. Any infection should be treated with appropriate oral and topical antibiotics. Once the tendon has been debrided, it has to be kept physiologically moist to promote healing and prevent desiccation. Progressive necrosis leads to further debridements that lead to the eventual loss of the tendon. Silver sulfadiazine is an excellent initial topical agent[23] that not only prevents desication but is also both bactericidal and bacteristatic. Once the wound is relatively sterile, the initiation of healing often has to be encouraged so that the tendon becomes covered with healthy granulation tissue. Skin graft substitutes such as xenograft,[24] Apligraf,[25,26] and Dermagraft[27] (Smith & Nephew, Inc., Largo, Fla.) are excellent in this regard. Not only do they act as a biological dressing that promotes wound healing, they also help indicate whether the underlying bed is free of infection so that it can successfully support a split-thickness skin graft.

Additional factors that can speed up the formation of granulation tissue include growth factor[28] (Ethicon, Inc. Somerville, N.J.), hyperbaric oxygen,[29] and subatmospheric pressure devices such as the V.A.C.[30,31] (Kinetic Concepts, Inc., San Antonio, Texas). Growth factor works best when applied to freshly debrided wounds free of metallic proteases that inactivate growth factors. Systemic hyperbaric oxygen treatments work only when there is good vascular inflow and the patient has passed a successful oxygen challenge test showing that the extra oxygen actually reaches the wound.[32] Topical hyperbaric oxygen can be beneficial by getting rid of the edema surrounding the wound and by ensuring twice-daily dressing changes. The actual benefit of the local increase in oxygen pressure has yet to be proven. Subatmospheric pressure devices work well to promote granulation on denuded beds such as bone or tendon, provided there is adequate blood supply. In addition, the subatmospheric device, when applied as a dressing on top of a skin graft, helps secure the graft to the underlying bed and can increase the skin graft take rate to 95 percent.[33] Because this retrospective study was performed before the commercial availability of the V.A.C. device, it did not play a prominent role in our practice. Today, however, we would use the V.A.C. device as our primary dressing after debridement with or without cultured skin.[34] We would then use the V.A.C. device as our initial dressing over the skin graft to ensure skin graft take (Fig. 1). Cultured skin or hyperbaric oxygen with or without growth factor would only be used if we saw little response with the V.A.C. device.

Because there is a higher risk of recurrent ulceration in skin-grafted Achilles tendon wounds, we would currently recommend limiting it to the less active elderly population. When dealing with young, healthy, athletic patients, a pedicled or free flap offers a more long-term, risk-free solution. However, skin grafting is still a viable option for this group because the recurrent breakdowns all went on to heal by secondary intention.

This study found that the average healing time from initial presentation to healing between the various treatment modalities was not statistically significant. The reason for this becomes clear when the vast number of variables is considered for each modality. For instance, patients who were allowed to heal by secondary intention were typically medically unstable and unable to undergo further surgery. Therefore, their ability to heal was also significantly reduced, leading to prolonged healing times. Patients who underwent flap surgery did so typically because granulation tissue failed to progress or progressed slowly. In general, patients who underwent skin grafting or flap surgery were given a significant period of time to allow for adequate granulation tissue formation before the decision to perform surgery was made. In addition, other factors such as the timing of vascular surgery, correction of comorbid medical issues, and the need for additional debridements all affected the time to heal. The actual time from the definitive reconstructive procedure to healing, for both skin graft and flap, was 3 weeks. The patient's ankle was immobilized for an additional 3 weeks to ensure that the repair could hold up to the normal wear and tear of ambulation.

Although patients with diabetes had significantly higher comorbidities, they experienced equally successful reconstruction of their Achilles tendon wounds when compared with the nondi-

Fig. 1. Photograph of diabetic patient who presented with gangrene of the Achilles tendon (*above*, *left*). The tendon was radically debrided (*above*, *right*) and treated with the V.A.C. device (*center*, *left*) to develop a granulating base (*center*, *right*). The wound was then skin grafted (*below*, *left*). The skin graft was covered with a V.A.C. device to ensure maximal take. He was placed in a cam walker to immobilize the ankle. The wound healed without incident (*below*, *right*) and remained healed for the subsequent 2 years until he died.

abetic cohort. There was no statistical difference between the primary healing rates, time to heal, complication rates, limb salvage rates, and survival rates. Indeed, diabetic Achilles tendon wounds had a 100 percent healing rate when skin grafts were applied. Diabetes, therefore, should not be used as a contraindication to salvaging infected Achilles tendon wounds.

CONCLUSIONS

This study demonstrates that skin grafts can be a successful alternative to flap surgery in healing Achilles tendon wounds. The benefit of applying skin grafts is that the wound can be taken care of in an outpatient setting. The wound can be debrided and the patient can be discharged on daily dressing changes with oral or intravenous antibiotic therapy until the wound is ready for skin grafting. Many adjunctive wound-healing therapies can be added in the outpatient setting if there is inadequate formation of healthy granulation tissue. After reconstruction, immobilization of the ankle in the neutral position until the flap has healed or the skin graft has taken is crucial to a successful outcome. Although we reported a wound recurrence rate of 25 percent following skin grafting, this is less disturbing when one realizes that most of the recurrences went on to heal by secondary intention with simple wound care techniques. The presence of diabetes as a comorbidity did not affect the success and long-term outcome of the reconstructive procedure. Skin grafting therefore should be considered a viable alternative to flap reconstruction whenever treating a complex Achilles tendon wound in both diabetic and nondiabetic patients.

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