

Reconstruction of Skin and Tendon Defects from Wound Complications After Achilles Tendon Rupture

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Four patients who developed combined tendon and overlying skin defects following operative repair of ruptured Achilles tendon were presented. Three patients had an infected wound. The average interval from the first operation for repairing the ruptured Achilles tendon and the reconstructive procedure was 46.2 days (range, 5–65 days). All patients were treated with a one-stage operation including radical debridement, reconstruction of the Achilles tendon defects using vascularized or nonvascularized tendon grafts, transfer of peroneus brevis for augmentation, and skin coverage with a free flap. The patients recovered uneventfully. The average follow-up period was 39.2 months (range, 18–79 months). In all patients, an evaluation of the clinical outcome, the performance of the calf muscles using a computerized dynamometer, and structural changes of the reconstructed Achilles tendon using magnetic resonance (MR) imaging were made. The clinical outcome was excellent in three patients and good in one. In isokinetic testing (Cybex-Norm), strength was found to be normal in one patient and abnormal in three patients. MR images revealed an intratendinous area of homogenous and normal intensity signal, and a significant increase in thickness and width in all levels of the reconstructed Achilles tendon. The authors conclude that it is possible to obtain satisfactory function in patients with complex wounds in the region of the Achilles tendon. (The Journal of Foot & Ankle Surgery 40(3):158–165, 2001)

Key words: Achilles tendon rupture, microvascular reconstruction

Many excellent reviews have documented the considerable experience of the evolving management of the ruptured Achilles tendon. Although high satisfaction rates have been reported concerning open operative repair of the Achilles tendon ruptures, the main disadvantage is a postsurgical complication rate ranging from 3% to 17% (1–5). Skin and tendon necrosis associated with wound infection in the Achilles tendon region may be catastrophic, and poses one of the greatest challenges to the foot and ankle surgeon.

Prevention of infection, reconstruction of the skin and tendon defects, and restoration of the function must all be accomplished in order to consider the result a success.

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Reconstructive procedures including turned-over fascio-aponeurotic flaps (6), pedicled local flaps (7), and various free flaps (8–15) with nonvascularized and vascularized fascial or tendon grafts have been proposed as potential treatment options. The long-term functional results following free transfers of compound tissues to the Achilles tendon region have been reported, but these series are heterogenous; they consist of cases who have incomplete and complete ruptures. They also do not include recovery of strength and a discussion of the morphologic changes of the reconstructed tendon as part of their objective evaluation (6–15).

The purpose of this retrospective study was to present our experience and functional results in four patients who had reconstruction of combined defect of overlying skin and Achilles tendon. Furthermore, the calf muscles performance using computerized dynamometer and structural changes of the reconstructed Achilles tendon using magnetic resonance (MR) imaging were examined in these patients.

Materials and Methods

Between 1993 and 1998, four patients who developed combined skin and tendon defects following operative

TABLE 1 Clinical data on four patients undergoing reconstruction

Case	Age & Sex	Occupation	Injury Mechanism	Interval from Repair to Reconstr. (days)	Infection	Defect after Debridement		Grafts for Tendon Repair		
						Tendon (cm)	Skin (cm)	Vasc.	Nonvasc.	Free Flap
1	24/M	Football Player	Sports	65	<i>S. aureus</i>	6	9 × 4.5	BR	PL	Radial forearm
2	30/M	Surgeon	Sports	60	<i>S. aureus</i>	9	10 × 5	—	Plantaris fascia lata	Lateral arm
3	47/M	Tailor	Sports	55	<i>S. aureus</i>	5	9 × 5	Triceps aponeurosis	FCR, PL	Lateral arm
4	39/F	Housewife	Motorcycle chain	5	None	8	10 × 5	—	FCR, PL	Lateral arm

BR, Brachioradialis; FCR, flexor carpi radialis; PL, palmaris longus; Vasc., vascularized; Nonvasc., nonvascularized.

repair of a ruptured Achilles tendon were treated in İzmir Hand and Microsurgery Hospital. Three of them were referred to us after the first operation because of wound complications.

There was one female and three males, ranging in age from 24 to 47 years (average, 35 years). The preinjury employment status and the mechanism of the injury of the patients are shown in Table 1. The average delay between the rupture and the primary operation was 2.3 days (range, 1–4 days). The method of tendon repair at the first operation was primary tenorrhaphy. In one patient (case 1), the method of tendon repair was reinforcement with proximally attached gastrocnemius aponeurosis flap. In two patients, a longer strip of tendon attached proximal to the rupture was turned distally and used like a suture material to bring the torn ends together (cases 2 and 3). Additionally, two of these patients had undergone unsuccessful reconstructive attempts with a rotational flap because of skin breakdown after the initial repair procedure (cases 1 and 2). The other patient (case 4) sustained an open injury involving disruption of the Achilles tendon and skin from a motorcycle accident. This was treated in our hospital by initial debridement and leaving the wound open.

The average interval from the first operative procedure and microvascular flap transfers for the reconstruction was 46.2 days (range, 5–65 days). Three patients had a necrotic wound that included the region of repaired tendon and clinical evidence of an active infection. Culture-directed intravenous antibiotics were begun preoperatively and continued postoperatively for 3 weeks. The other patient who had no infection was given 1 g of cephtriaxone intravenously for prophylaxis.

All patients were treated with a one-stage operation according to the following protocol:

1. Radical debridement, including excision of all necrotic and infected tissues (Fig. 1B)
2. Reconstruction of the defects of the Achilles tendon (Fig. 1C)

3. Transfer of the peroneus brevis tendon for augmentation, as described by Turco and Spinella (16)
4. Skin coverage with free flaps (Fig. 1D)

Achilles tendon defects were reconstructed using vascularized tendon grafts (brachioradialis and lateral one-third of triceps aponeurosis) in two patients, and nonvascularized tendon (flexor carpi radialis and palmaris longus) and fascia lata grafts in the remaining patients. The grafts were passed through the proximal and distal Achilles tendon stumps and then secured with interrupted sutures. The coverage of the skin defects was performed using lateral arm flaps in three patients and a radial forearm flap in one patient. All flaps were harvested associated with a larger fascial portion than the skin component. These fascial portions were used to construct a vascularized sheath that was placed circumferentially around the tendon repair site for separation from the peritendinous tissues.

Postoperatively, the extremity was immobilized with a long leg splint. The patients were discharged 7–10 days after the operation. After wound healing, a long leg cast was applied with the knee flexed 45° and the ankle fixed in 30° of equinus. After 4–6 weeks, a short leg cast with the ankle in neutral position was applied for 4 weeks. After this period, the cast was discontinued and the patients were allowed partial weightbearing, and a rehabilitation program was begun. Activities of daily living were initiated after 4 months, and sports activities were allowed after 6 months.

The subjective evaluation consisted of assessment of complaints during daily and sporting activities, problems with conventional shoe wear, and cosmesis. Objective assessment included measurements of range of motion of the ankle joint, ankle and calf circumferences, the ability to stand and to walk on tiptoes, the stability and sensation (with Semmes-Weinstein monofilaments) of the flaps, and the presence of adhesions. Clinical results were evaluated by the method of Percy and Conochie (17). Criteria for excellent results were full return to level of preinjury



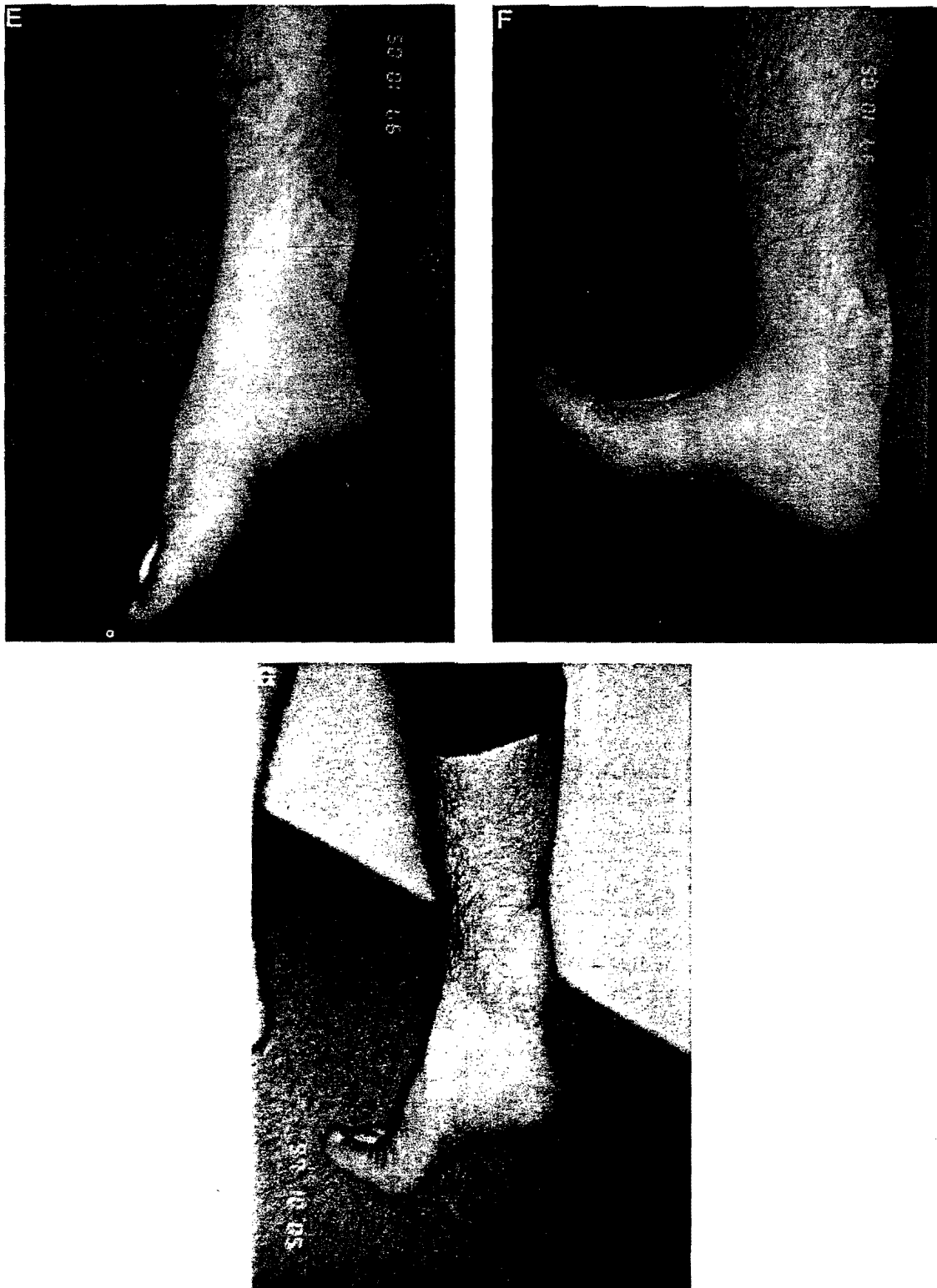


FIGURE 1 A 30-year-old surgeon (case 2) who sustained a complete rupture of the Achilles tendon during a sporting activity. Skin slough and deep infection had developed following primary tenorrhaphy and Bosworth procedure. Forty days postoperative, the unhealed wound had been debrided to control infection. *A*, He was referred to us 55 days after the first operation. *B*, A 9-cm tendon defect occurred after debridement of necrotic and infected tissues. *C*, The tendon reconstruction was performed with a nonvascularized fascia lata and plantaris tendon grafts, and the peroneus brevis was transferred to the distal stump of the Achilles tendon. *D*, Skin coverage was provided by a lateral arm flap, and fascial portion of the flap was wrapped circumferentially around the reconstructed tendon region. *E–G*, 30 months later, he has a fully functional ankle.

TABLE 2 Results of clinical evaluation

Case	Follow-up (months)	Return to Preinjury Activity (months)	Flap Sensation			Diameter Difference (cm)		Walk on tip-toe	Ankle Range of Motion (Affected/Unaffected)		
			Stability	(SW)	Cosmesis	Calf	Ankle		Plantar-flexion	Dorsi-flexion	Clinical Outcome
1	79	12	Good	3.84	Accept.	-1.5	3	Yes	47°/50°	12°/14°	Excellent
2	30	6	Good	4.17	Accept.	-1	4	Yes	45°/48°	12°/13°	Excellent
3	30	6	Good	4.31	Accept.	-2	3.5	Yes	42°/46°	10°/12°	Excellent
4	18	10	Good	4.08	Unaccept.	-1.5	5	Yes	40°/48°	10°/13°	Good *

SW, Semmes-Weinstein.

activity, no residual symptoms, and stable free flap. The result was characterized as good when the patient had slight stiffness and an adherent scar but experienced a full return to the preinjury activity level. A fair result was assigned if there was definite weakness, moderate pain, or some decrease in level of activity. A poor result was assigned when there was severe weakness, marked limp, an unstable microvascular graft, and no return to level of activity before the injury (17).

The Cybex-Norm dynamometer⁵ was used to measure the muscular performance. Isokinetic strength testing of the calf muscles was performed bilaterally using standardized protocol. The knee was maintained in approximately 10° of flexion, with the patients in supine position. Two submaximal and one maximal trials were done before each test session. A 30-second rest period was set between each test. Testing was performed with three maximal dorsiflexion and plantarflexion cycles for 30° per second and 120° per second. Maximal torque values of the plantar muscles were recorded, and calculated as a percentage of those of the unaffected side. These values were interpreted according to the guidelines of Sapega (18): in bilateral comparison, imbalances of strength less than 10% were considered normal, differences of 10%–20% were possibly abnormal, and those greater than 20% were probably abnormal.

Multiplanar imaging of the reconstructed Achilles tendon and the surrounding tissues was performed on a 1.5-T superconductive MR unit (Philips NT). TSE (Turbo spin echo) proton density-weighted and T2-weighted images in the axial and sagittal planes were obtained with the patient in supine position with the knee in full extension and the ankle in neutral position. The signal intensity changes of the reconstructed Achilles tendon and the appearance of the surrounding peritendinous tissues were evaluated. The width and the thickness of the Achilles tendon were measured on both planes, 5 cm above the calcaneal insertion of the tendon. All measurements were compared with those of the unaffected side.

Results

The average defect of the Achilles tendon after debridement was 7.5 cm (range, 5–9 cm). The cutaneous portion of the flaps measured an average of 9.5 by 5 cm (range, 9 × 4.5 cm to 10 × 5 cm). All of the flaps survived. Only one patient had a reoperation within 12 hours after the procedure for a postoperative arterial thrombosis.

The patients were followed for an average of 39.2 months (range, 18–79 months) after the reconstructive procedure. The results of the clinical evaluation are shown in Table 2. All of the patients returned to their former occupations within 1 year of reconstruction. One patient (case 1), a professional football player, was able to join his team 1 year after reconstruction and continued playing football for 4 years. Three patients noted occasional and mild pain during extreme activities. All of the flaps had good stability and protective sensibility. Three patients had an acceptable appearance of the affected ankle and were able to wear conventional shoes. One patient (case 4) had an unsatisfactory appearance of the ankle, and required specially fitted shoes to accommodate the contour of his leg. The patients had an average reduction of 1.5 cm (range, 1–2 cm) in calf circumference. The ankle circumference was on average 3.8 cm (range, 3–5 cm) greater than that of the unaffected side. All the patients were able to stand and walk on their tiptoes. The ankle joint arc of active motion as compared to that of the unaffected side in all patients was nearly normal, with dorsiflexion averaging 11° and plantarflexion averaging 43.5° (Table 2). According to the criteria of Percy and Conochie (17), the clinical results were excellent in three patients and good in one.

The peak torque values as a percentage of the unaffected side are listed in Table 3. The results of isokinetic muscle strength in our series, at 30° per second, was normal in one patient, probably abnormal in three patients, and, at 120° per second, was possibly abnormal in two patients, and probably abnormal in two patients.

TSE proton density-weighted and T2-weighted MR images showed homogenous and normal intensity signal at all levels of the reconstructed tendon in three patients. In one patient (case 3), on sagittal and axial T2-weighted

⁵ Henley Healthcare, New York.

TABLE 3 Results of isokinetic testing of calf muscles and MR imaging of the Achilles tendon

Case	Isokinetic Peak Torque ^a		Magnetic Resonance Imaging				Peritendinous Fibrosis in MRI
	30°/s	120°/s	Width (mm)		Thickness (mm)		
			Affected Side	Unaffected Side	Affected Side	Unaffected Side	
1	94	86	18.2	13.7	12.6	4.6	Less
2	78	82	17.4	12.7	12.4	5.3	None
3	75	72	14.1	13.6	9.5	6.9	None
4	70	74	16.7	14.9	13.6	5.4	None

^aThe values are given as a percentage of unaffected side.

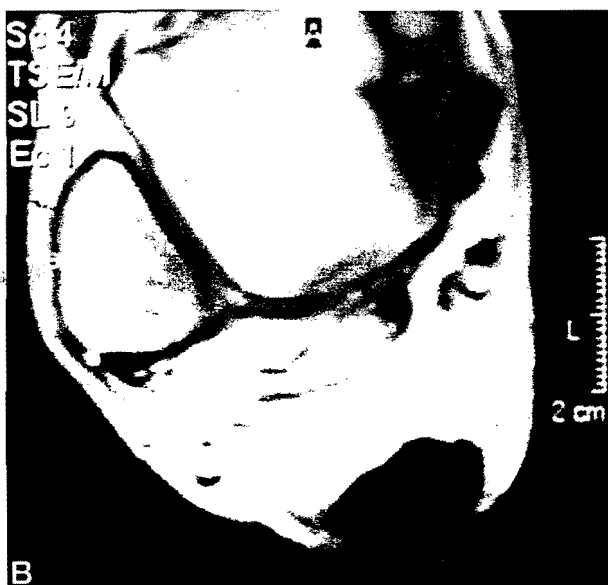


FIGURE 2 MR images of case 2, 30 months after reconstruction. *A*, Sagittal TSE T2-weighted image. The substance of the Achilles tendon has a normal intensity signal and a smooth contour. *B*, Axial view shows a marked thickening of healed tendon and an absence of peritendinous fibrosis.

TSE images, vertically oriented intermediate intensity signal stripes were observed within the tendon. Diffuse tendon thickening with well-defined margins along the entire length of the reconstructed tendon site was observed in all images of the axial and sagittal planes (Fig. 2). The measurements of the thickness and the width of the Achilles tendon are listed in Table 3. When the ratios of these measurements were calculated at the same level, the reconstructed tendons were 2.7, 2.3, 1.3, and 2.5 times thicker, and 1.3, 1.4, 1.0, and 1.1 times wider than the unaffected side, respectively. None of the MR images

in three patients revealed the findings of the surrounding peritendinous fibrosis. In one patient (case 1), axial plane images showed a low intensity signal between the reconstructed Achilles tendon and anterior soft tissues.

Discussion

Wound complications following Achilles tendon surgery may significantly diminish the capacity to preserve function of the muscle tendon unit. This catastrophic situation is complicated not only by the presence of an

open defect with a poorly vascularized and contaminated soft-tissue cover, but also by an exposed and necrotic tendon segment. In the present study, we report the functional results of microvascular reconstruction in four patients with a defect involving the skin and the Achilles tendon following the repair of a ruptured Achilles tendon.

A number of reports have described the successful use of microvascular free flaps with nonvascularized and vascularized tendon or fascial grafts to manage the complex wounds of the Achilles tendon region (6–15). Most of these series have included little information regarding objective quantification of the performance of the triceps surae and structural changes of the reconstructed Achilles tendon. Only the study by Leppilahti et al. (11) reported the detailed functional results of the four patients who developed skin breakdown after Achilles tendon surgery who were treated using free flaps. They reported good results in three patients and an excellent result in the other one.

Although the vascularized tendon grafts have some advantages such as rapid healing, preservation of the tendon structure, and fewer adhesions in a poorly vascularized bed, it is difficult to replace extensive defects and still attain optimal tension of the graft. Conventional free tendon grafts can also achieve satisfactory results in well-vascularized beds. We preferred to use a vascularized tendon graft to replace small defects (less than 5 cm), and nonvascularized tendon and fascia lata grafts to replace more extensive defects. To create a well-vascularized bed, fascial portions of the free flaps that were harvested as described above, were wrapped circumferentially around the reconstructed tendon region. This technique, to our knowledge, is original and offers the potential benefits of decreasing firm adhesions and improving tendon gliding. Accordingly, the clinical results and MR imaging findings obtained in this study support the positive effect of this procedure, despite the relatively small number of cases.

For the unique zone at the posterior aspect of the ankle, pliable and thin innervated tissue is required to allow the wearing of conventional footwear. Many authors have suggested that the lateral arm, the radial forearm, and the dorsalis pedis innervated flaps are the best selection of appropriate coverage for this region (7–11, 13). Good alternatives for reconstruction of the defects of the Achilles tendon and overlying skin include the groin flap with a vascularized fascio-aponeurotic segment, the tensor fascia lata flap, and a lateral thigh flap with vascularized fascia lata (12, 14, 15). The disadvantages are that they are too bulky and the harvesting technique is difficult. In our series, we preferred the lateral arm flap in three patients, and the radial forearm flap in the other one. All flaps offered good stability and protective sensibility. Three patients had an acceptable appearance and were able to wear normal shoes. The other one had unacceptable cosmesis and problems with conventional shoe

wear. In this patient, the wound was located just above the insertion of the Achilles tendon, and was rather wide. Although a debulking procedure was recommended, the patient refused it.

Augmentation with tendon transfers to increase the overall strength of the plantarflexion in the delayed treatment of previously ruptured Achilles tendons has been recommended by some authors (1, 16). We used the peroneus brevis tendon transfer for this purpose in all patients. We have considered that tendon transfer has contributed to the good clinical outcome of our patients. However, the results of isokinetic strength testing are not in accordance with the clinical results.

The MR images allowed quantitative assessment of the reconstructed Achilles tendon and the surrounding tissues. The consistent findings in comparison to the unaffected side were no changes in signal intensity (minimal changes in one patient) and a marked increase in the thickening and the width of the reconstructed Achilles tendon. The causes of these changes in tendon caliber can be explained by the abundance of tendon grafts, the presence of peroneus brevis tendon, and hypertrophy as a result of proliferative collagenous ingrowth.

In summary, this report demonstrates that microvascular reconstruction may result in satisfactory function in patients with combined defects of overlying skin and tendon following Achilles tendon surgery that are not otherwise treatable by conventional methods. Although the present study consists of a small number of cases, it provides useful guidance to manage these patients.

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