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Single-stage Flexor Hallucis Longus transfer and Gracilis free flap cover for failed Achilles tendon repair with soft tissue defect

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Abstract *Introduction:* Reconstruction of failed Achilles tendon repair, with infection and loss of overlying skin, is a surgical challenge. This paper aims to deal with the technical considerations and study the outcome of reconstructing such defects by radical debridement and reconstruction with combined Flexor hallucis longus (FHL) transfer and free Gracilis flap cover.
Materials and methods: A retrospective study of six patients with failed Achilles tendon repair with overlying skin and soft tissue loss reconstructed by FHL transfer and free Gracilis flap cover performed between January 2017 and August 2020 was conducted. Postoperatively, they were assessed with the Mean Functional Gait Assessment score(MFGA), the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, the Achilles tendon Total Rupture Score (ATRS), and Modified Vancouver scar scale score (mVSS).
Results: All six patients reported a good gait at nine months of follow-up. The MFGA score at six months was 24.8. The mean ankle plantar flexion at nine months follow up was 39.1° . The mean nine-month postoperative AOFAS and ATRS scores were 86.33 $\pm$ 2.654 and 88.5 $\pm$ 5.54, respectively. At nine months, all the patients could perform a single-leg heel raise on the operated foot. The overall mean mVSS score was 1.41. In about 12 months, the peak forefoot to hindfoot ratio matched the uninjured opposite foot.

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Conclusion: Simultaneous reconstruction of the Achilles tendon with FHL transfer with free Gracilis flap for the coverage of overlying soft tissue loss is a good management option for failed Achilles tendon repair with overlying skin loss.

Introduction

The Achilles tendon is one of the most commonly injured tendons of the lower extremity.[1] Surgical treatment remains the mainstay in managing complex injuries of the Achilles tendon.[2] Failure of Achilles tendon repair with loss of skin cover is a devastating complication. The overall wound complication rates following surgical repair of the Achilles tendon are between 7% to 13% in the reported literature.[3,4] Management of such cases aims to eradicate the infection, restore Achilles tendon function, and provide durable soft tissue cover.[5] Though there are multiple treatment protocols, there is limited data on the simultaneous reconstruction of Achilles tendon and skin and soft tissue defect and their long-term outcomes.[6–9] The treatment options for the reconstruction of Achilles tendon defect involving the enthesis is limited and challenging.[6] This study aims to look at the results of the reconstruction of Achilles tendon defects involving the enthesis with overlying skin loss using a combined Flexor hallucis longus (FHL) transfer and free Gracilis flap cover.

Materials and methods

We conducted a retrospective study of six patients with failed Achilles tendon repair with Achilles tendon defects involving the enthesis with overlying skin and soft tissue loss operated between January 2017 and August 2020. There were five male patients and one female patient (Table 1). The mean age of all patients was 48 years (24 to 60 years). Trauma was the etiology of the primary injury in all patients. The average (or mean) length of follow-up was 26.5months (12–40 months). Three patients had diabetes mellitus, and one patient had hypertension. All these patients had undergone primary repair of the injured Achilles tendon elsewhere, which subsequently failed with overlying skin necrosis. The mean duration from injury to repair was one day (0 to 4 days). Subsequently, the patients had necrosis of the overlying skin and soft tissue loss with exposure of the repaired tendon at presentation. The mean duration from injury to presentation was 8.1 weeks (6 to 10 weeks). Five patients had an active infection at the wound site on arrival.

All patients underwent a two-stage procedure. A single initial radical debridement was performed under regional anesthesia and tourniquet control to excise all unhealthy and infected tissue. The Achilles tendon was resected to the gross healthy tendon proximally. All patients had a loss of the distal enthesis after debridement requiring the reconstruction of a neoenthesis subsequently. Broad-spectrum antibiotics were started initially and later changed according to the culture reports. Once the infection was under control and the inflammation resolved in the surrounding skin, Achilles tendon reconstruction was performe using Flexor hallucis longus(FHL) tendon transfer along with a simultaneous soft tissue reconstruction using a free microvascular Gracilis muscle flap (Figures 1–3). The interval between the two stages was 7–13 days with a mean of 8.5 days.

The patient was positioned supine considering the need to harvest the Gracilis muscle from the opposite thigh. The FHL tendon was divided from the base of the great toe. The distal end of the tendon was retrieved at the midfoot, where the knot of Henry was divided to free it from its attachment to the flexor digitorum longus tendon. The proximal part of FHL at the musculotendinous level is identified at the ankle level by longitudinally incising the deep fascia over the deep posterior compartment. The FHL was retrieved in the wound for Achilles tendon reconstruction. A new enthesis was created by making a mediolateral transosseous tunnel in the calcaneum and passing the FHL

Table 1 Preoperative case details.

Patient no.	Sex	Age (years)	Injury mechanism	Injured side	Time since rupture (weeks)
1	M	55	Sharp machine cut	Right	10
2	M	60	Sharp tool	Right	8
3	M	50	Forced dorsiflexion (rabbit hole)	Left	9
4	M	60	Workplace trauma	Left	6
5	F	24	Indian toilet closet	Left	10
6	M	39	Road traffic accident	Left	6

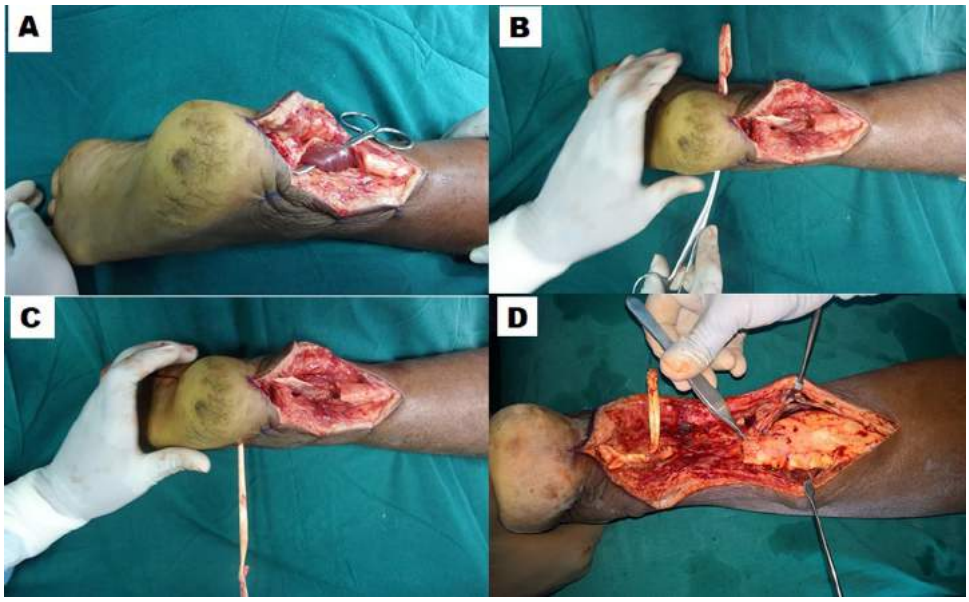

Figure 1 Technique. A. Isolation of Flexor hallucis longus at the lower leg level. B. Flexor hallucis longus tendon ready to be tunneled through the calcaneum. C. Flexor hallucis longus after being tunneled through the calcaneum. D. Flexor hallucis longus sutured on itself after being looped through the calcaneal tunnel.

Figure 2 Patient 1. A. Ten-week-old right Achilles tendon injury showing skin loss and exposed necrotic Achilles tendon. B. Flexor hallucis longus tendon isolated in the great toe and midfoot. The debrided wound shown in the background. C. Harvested Flexor hallucis longus tendon retrieved at the Achilles tendon region. D. Intraoperative picture showing the completed tendon transfer. E. Tendon transfer covered with microvascular gracillis muscle flap. F. Well-settled flap and healed wounds at 1-year follow-up.

Figure 3 Patient 6. A. Six-week-old Achilles tendon injury post road traffic accident showing the skin necrosis and slough. B. Post debridement picture showing the 7 cm defect in Achilles tendon. C,D. Intraoperative picture showing the retrieved Flexor hallucis longus tendon in the Achilles tendon region and the completed tendon transfer respectively. E) Tendon transfer covered with microvascular gracillis muscle flap. F) Well-settled flap and healed wounds at 1-year follow-up.

tendon subcutaneously from the posterior ankle to the medial end of the calcaneal tunnel. It was then passed through the transosseous tunnel and retrieved laterally and rerouted subcutaneously to the posterior ankle wound to complete the loop. The tendon was tensioned with the ankle in the maximum plantar flexion and then sutured onto itself using a Pulvertaft weave technique (Figure 1). The residual free distal end of the FHL tendon was then used to bridge the gap in the Achilles tendon by weaving it into the proximal end of the Achilles tendon. Once the transfer was completed, the residual skin wound was covered with a free Gracilis muscle flap cover anastomosed to the posterior tibial vessels in an end-to-end or end-to-side fashion. The free Gracilis muscle flap was resurfaced with a split-thickness skin graft. The foot was dressed, and the ankle was immobilized in an anterior below knee slab. The patient was closely and periodically monitored for postoperative complications.

The repair was protected in a below-knee slab with the ankle in the equinus position for two weeks. Once the flap edema settled down sutures were removed. Between the second and fourth weeks, the position of the ankle was gradually corrected to neutral by serial plaster of Paris slab changes. The leg was kept elevated for the first four weeks, and later dependency was allowed. Protected full weight-bearing was allowed by 8–10 weeks after surgery with a below-knee cast on the operated foot. Unprotected full weight-bearing was allowed at 12–14 weeks post-surgery. Footwear with a heel raise was provided. The patients were advised not to attempt isolated forefoot weight-bearing, particularly when climbing up the stairs. Ankle plantarflexion strengthening exercises were started, and the patient was reviewed once in 2 months. They had an AOFAS (American Orthopaedic Foot and Ankle Society) score, ATRS (Achilles tendon Total Rupture Score), and

Table 2 Outcome assessment criteria described by Percy and Conochie.[2]

Excellent	Full function with no residual disability
Good	Slight weakness, an adherent scar, and a minor disability, but no real limitation of activities and full return to function as in the prerupture period.
Fair	Definite disability and some limitation of activities and a slight limp
Poor	*Re*-rupture or failure with severe weakness and a marked limp.

Functional Gait Assessment scoring and overall outcome assessment as described by Percy and Conochie[2] (Table 2) at the nine-month follow up.

Results

The mean gap in the Achilles tendon post debridement was 6.3 cm (5–8 cm). All Gracilis flaps survived completely. Two patients had minimal graft loss; one patient had a superficial infection that settled with regular dressings and antibiotics. One patient had neuritic pain along the sural nerve territory, which was managed with medications. The mean hospital stay was 19 days. All the patients reported a good gait at nine months of follow-up. The Mean Functional Gait Assessment score at nine months was 24.8 (Range 21–29). The mean ankle plantar flexion on follow-up was 39.1° (Range - 35–45). The mean 9-month postoperative AOFAS and ATRS scores were 86.33 ± 2.654 and 88.5 ± 5.54, respectively (Table 3). At the end of nine months, all the patients could perform a single-leg heel raise on the operated foot. Two patients reported difficulty in running and walking fast. All the patients had acceptable esthetic outcomes on a mean follow-up of 26 months. The overall mean modified Vancouver Scar Scale (mVSS) score was 1.41 (Table 4). Four patients reported excellent outcomes, and two reported good outcomes at the end of 6 months follow-up. On serial pedobarogram assessments, it took about 12 months for the peak forefoot to hindfoot ratio to match the uninjured opposite foot (Figures 4,5).

Discussion

The Achilles tendon is the thickest tendon in the human body and is essential for normal ankle movement and efficient loading of the entire surface area of the foot.[10] Loss of its function strongly impairs daily activities such as walking, climbing stairs, standing for an extended period, or running.[11] Achilles tendon rupture leads to weakness in plantar flexion of the ankle. There is an abnormal increase in hindfoot pressure with a concomitant reduction in forefoot pressures during the stance phase.[12] A calcaneal gait with little or no third rocker period is seen with reduced duration of single-limb support on the affected leg, and exaggerated compensatory movements of the knee and hip joints. In effect, the patient develops a calcaneal gait with little or no forefoot loading, causing a significant reduction

Table 3 Postoperative case details.

Patient no.	Tendoachilles gap (cm)	Zone of injury	Soft tissue defect (cm2)	Immobilization (weeks)	Post op Ankle ROM (Degrees) Affected side		ROM Unaffected side (Degrees)		Complication	Follow up (Months)	Functional Gait Assessment	AOFAS score	ATRS score
					Plantar Flexion	Dorsi Flexion	Plantar Flexion	Dorsi Flexion				Post OP (9 months)	Post OP (9 months)
1	8	1	18	8	35	8	40	10	Nil	40	26	84	83
2	7	1	35	9	35	5	35	9	Partial SSG loss	37	21	78	92
3	5	2	20	8	40	8	40	12	Nil	24	24	86	88
4	5	1	40	8	35	8	35	10	Pain	30	21	82	81
5	6	1	24	9	45	12	50	12	Local infection	16	29	94	95
6	7	2	28	9	45	12	45	12	Partial SSG loss	12	28	94	92
											Mean value	86.33 ± 2.654	88.5±5.54

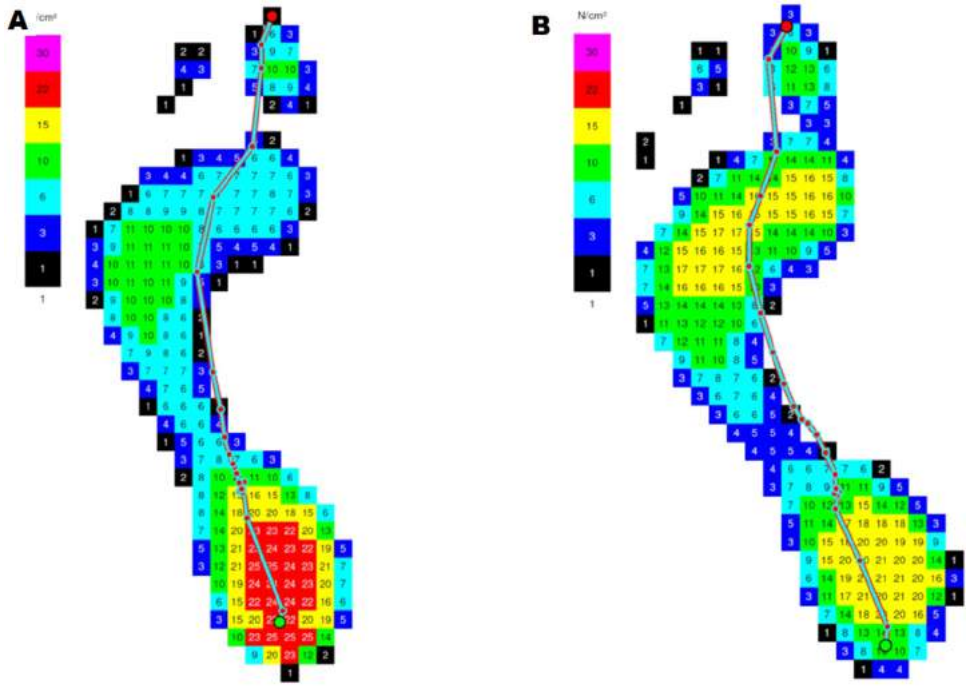

Figure 4 Pedobarogram. A. Preoperative pedobarogram showing calcaneal loading with high hind foot pressure and peak forefoot to hind foot pressure ratio of 1:3.5. B. Postoperative pedobarogram showing good loading of forefoot and reduction in calcaneal loading with normalization of peak forefoot to hind foot pressure ratio of 1:1.3.

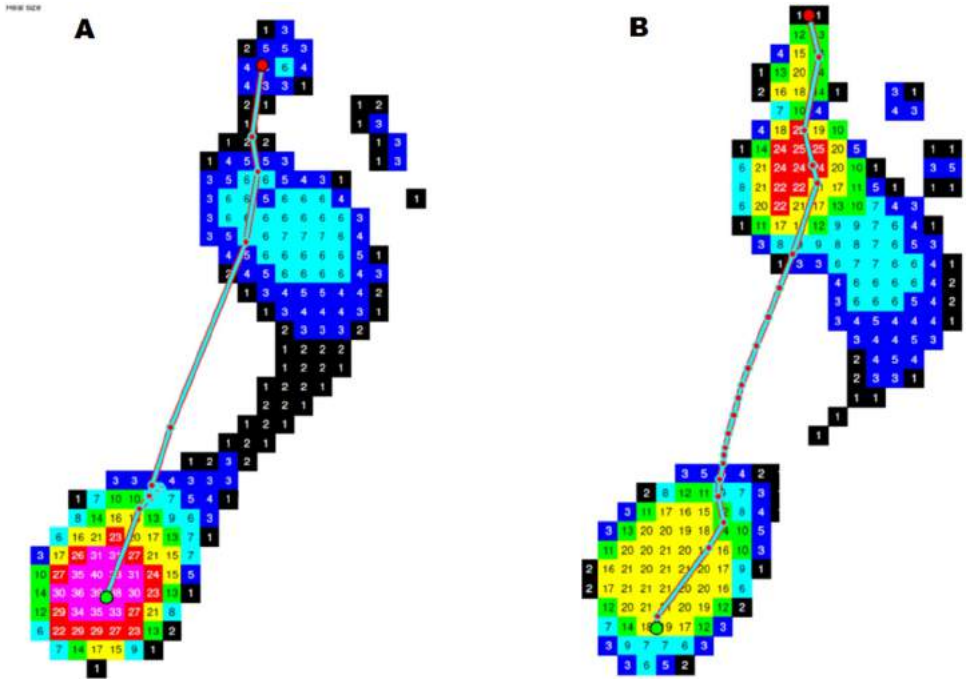

Figure 5 Pedobarogram. A. Preoperative pedobarogram showing calcaneal loading with high hind foot pressure and peak forefoot to hind foot pressure ratio of 1:5.7. B. Postoperative pedobarogram showing good loading of forefoot and reduction in calcaneal loading with peak forefoot to hind foot pressure ratio of 1:0.8.

Table 4 Modified Vancouver scar scale score (mVSS).

S.No	Parameter	Score (Mean ± SD)
1	Pigmentation	1.62 ± 0.76
2	Vascularity	1.23 ± 0.54
3	Thickness	1.72 ± 0.66
4	Pliability	1.10 ± 0.83

in the functional weight-bearing surface area of the foot. The patient also loses propulsive gait, causing a secondary decrease in the stride length, and as a result, is forced to take an increased number of steps to cover a given distance. This leads to repetitive injury, causing heel pain in the sensate foot and ultimately leading to fatigue failure of the plantar skin, further contributing to plantar ulcer formation in the insensate foot.[13-16]

Direct approximation of healthy ends of the Achilles tendon with good skin and soft tissue cover gives the best outcomes when treating Achilles tendon injuries. Gaps of more than 2 cm preclude direct approximation without additional surgical techniques.[17] Defects larger than 5 cm require a tendon transfer or some form of autologous grafting, depending on the integrity of the enthesis. Achilles tendon repairs are prone to complications.[18] Being a superficial tendon with relatively reduced vascularity of both the tendon and the overlying skin, infection of the repair, suture line dehiscence, and necrosis of overlying skin are not uncommon. Infection rates of around 2% to 4% are reported in published literature following primary Achilles tendon repair.[19,20] In addition, infection of the repaired tendon can lead to necrosis of the overlying skin and soft tissue.[20] Such complications place additional surgical demands to achieve a durable reconstruction with treatment options for skin cover varying from local flaps to microvascular free flaps.[7,18,21]

Microvascular free flaps can bring in well-vascularized tissue, providing the best quality cover when a tendon is transferred in a suboptimal bed. Microvascular flaps described for the cover of the Achilles tendon reconstruction site include anterolateral thigh flap, radial forearm flap, lateral arm flap, tensor fascia lata flap, latissimus dorsi flap, superficial circumflex iliac artery perforator (SCIP) flap, and parascapular flap.[21,22] We prefer the Gracilis muscle flap as it fills up the dead space, wraps around the transferred tendon, and the epimysium provides a good gliding surface for tendon movements. In addition, the contour of the ankle on long-term is excellent. It does not produce unaesthetic bulk around the ankle.

The FHL tendon is our choice of reconstruction. It is a strong, synchronous plantar flexor, and the axis of the FHL tendon is similar to that of the Achilles tendon and is available in the same operating field. The FHL is also long enough to be tunneled through the calcaneum and bridge small gaps in the Achilles tendon. The FHL muscle and tendon have proven to hypertrophy with time, resulting in increased plantarflexion strength.[23-25]

Reports on the combined use of an FHL transfer with simultaneous free flap cover is rare in literature and is mostly limited to single case reports. Simon et al., in their single case report, had described the use of FHL for reconstructing the Achilles tendon and simultaneously using free Gracilis flap and reported a good outcome with the patient walking on toes at four months post-op.[10] Nazerali et al. described a single case of a simultaneous transfer of the FHL tendon with a free radial artery flap cover with the patient regaining normal gait at 26 weeks.[26]

Leppilahti et al. described in their series of 4 patients the use of free flaps (three -radial artery forearm and one - lateral arm) and tendon grafts for wound complications following Achilles tendon surgery.[20] They reported that all cases resumed pre-injury activity levels within a year. In our series, patients returned to work at 7–12 months (mean 8.5 months), and force-plate studies results showed that the time taken for the peak forefoot to hindfoot ratio to match the uninjured opposite foot was about one year. Ademoglu et al. reported combined free tissue transfer (one -radial artery forearm and three - lateral arm flaps) and tendon augmentation in two patients with vascularized lateral one-third of triceps aponeurosis and brachioradialis tendon and nonvascularized palmaris longus and flexor carpi radialis tendon in one patient and fascia lata graft in one patient.[21] Three patients obtained excellent clinical outcomes, and one patient showed a good outcome. Haas et al. had used a simultaneous combination of fascia lata graft and lateral arm free flap (five cases) with good results in three younger (23–33 year old) patients.[27] They strongly recommended simultaneous reconstruction of the Achilles tendon and free flap cover for the skin defect in active young patients.

Bowers et al. reported two cases of Achilles tendon reconstruction and coverage with free flaps (one anterolateral thigh flap and one Gracilis flap) with a satisfactory outcome.[5] Feibel et al., in their work, presented a case where the free Gracilis muscle and the tendon were used for soft tissue cover and Achilles tendon reconstruction.[28] They had reported outcomes comparable to primary repair in their case report. Sabapathy et al. reported a case where a free Gracilis muscle flap was used to reconstruct the soft-tissue defect and bridge the defect of the Achilles tendon with an intact distal end.[29] They had reported that the patient could stand tiptoe, indicating the functioning of the Achilles tendon. Huemer et al. presented a series of Gracilis flap cover for the Achilles tendon region in 21 cases with simultaneous reconstruction of the Achilles tendon in three cases using semitendinosus graft. They had good to excellent functional and esthetic outcomes during their follow-up. They reported one flap loss, calcaneal osteomyelitis in two instances, hypertrophic scar, and Achilles tendon re-rupture in one case each.[1] Our series of six patients had excellent to good functional and cosmetic outcomes in our follow-up. We had encountered two instances of partial graft loss: one case of local infection and another of neuritic pain; these cases were treated with conservative management. There was no incidence of re-rupture of the reconstructed tendon in our series. All patients could do a single leg heel raise on the reconstructed foot when tested for the integrity of the repair at nine months of follow up.

Conclusion

The simultaneous reconstruction of the Achilles tendon with FHL transfer and free Gracilis flap cover is a good manage-

ment option in situations of failed Achilles tendon repair with overlying skin loss, reconstruction with an initial radical debridement followed by simultaneous tendon reconstruction and soft tissue cover gives consistent excellent to good outcomes.

Ethical approval

Ethical approval was not required as this was a retrospective study.

Conflict of interest

Nil.

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