Functional and Limb Salvage Outcomes after Excision of Infected Achilles Tendon in Diabetic Patients; a Comparative Prospective Study

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Background: Infected Achilles tendon is difficult to manage especially in diabetic patients. Total excision of the infected tendon may provide better option for limb salvage in these patients where altered walking pattern can minimize expected subsequent functional impairment.

Patients and methods: 35 diabetics with infected Achilles tendon were enrolled in this study. Nineteen patients underwent complete tendon excision (Group A) while in the remaining 16 patients, the tendon was partially excised (Group B). After wound approximation, negative pressure was applied to achieve healing by secondary intention. Initial immobilization and splinting were done followed by gradual weight bearing. Heel-rise test, activity limitation, walking difficulty on different surfaces and gait abnormalities were used to assess functional outcome.

Results: Group A had significantly larger ulcer size compared to Group B (9.23 ± 2.04 vs 7.35 ± 3.30 cm², P = 0.05). Also, mean ulcer duration was significantly longer in Group A (2.53 ± 0.75 vs 1.09 ± 0.49 months, P < 0.001). Group A showed significantly shorter healing time (3.14 ± 0.79 vs 7.05 ± 1.56 months, P < 0.001), shorter follow-up period (5.32 ± 1.6 vs 8.25 ± 2.94 months, P = 0.001) and lower reintervention rate (5.26% vs 56.25%, P < 0.001) compared to Group B. Functional assessment showed more limitation in heel-rise in total excision group, yet without significant limitation in other functional parameters, including walking ability.

Conclusion: Total excision of infected Achilles tendon in diabetic patients can give higher healing success rates with minimal functional impairment compared to partial tendon excision.

Key words: Achilles Tendon, diabetes, limb Salvage, total Excision.
Patients were divided into 2 groups

**Group A:** In which resection of the entire length and thickness of the Achilles tendon and its sheath from the tendomuscular junction to the calcaneal insertion and extensive debridement of all surrounding necrotic tissues were performed. Patients with osteomyelitis of calcaneus were also assigned for this group.

**Group B:** In which debridement only of the necrotic superficial parts of the tendon with preservation of the healthy part alongside with extensive debridement of all surrounding necrotic tissues were performed.

Patients were not freely randomized into both groups and the decision to perform either total tendon excision or partial preservation was according to the intraoperative findings regarding the extension of infection and necrosis. Whenever possible, partial preservation of tendon was attempted to theoretically maintain as much function as possible.

**Selection criteria**

Patients were included in the study if they were diabetics with partial or complete necrosis of exposed Achilles tendon.

Patients were excluded from the study if they had small ulcer over intact Achilles tendon with possibility of spontaneous healing, an associated tear of another tendon in the ipsi- or contralateral limb, extension of infection to the ankle joint, and non-salvageable limb due to extensive necrosis and infection.

**Preoperative assessment**

All patients underwent thorough history taking and clinical examination (To detect associated comorbidities, walking ability and the etiology of infection of the Achilles tendon). Also, for each patient, duplex study, ankle–brachial index, x ray of calcaneus, and MRI in selected cases (where suspicion of osteomyelitis of calcaneus) were performed.

**Operative procedure**

It included radical debridement of necrotic and infected tissue till reaching healthy edges then resection of the necrotic Achilles tendon [complete in group A (Figures 1,2) and partial in group B.

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![Intraoperative images for exploration, dissection of the tendon (A) and its total excision (B, C).](image1)

![Intraoperative images for infected necrotic Achilles tendon (A), dissection of the tendon (B) and its total excision (C, D).](image2)
Decision to completely excise Achilles tendon was made when extensive infection and necrosis involved the entire tendon, its paratenon and the soft tissue around it. Partial calcaneotomy alongside with total tendon excision was needed in some cases that showed evidence of calcaneal osteomyelitis (Figure 3). However, mild tendon infection, intact paratenon and favorable local soft tissue conditions to cover exposed tendon would justify partial tendon excision and preservation of remaining intact tendon and its sheath.

Fig 3: Intraoperative image showing partial calcaneectomy and total tendon excision.

After debridement, thorough pressurized lavage with saline solution was applied. Effort was done to approximate edges of the wound using non-absorbable sutures and negative pressure wound therapy was then applied to promote healing of the defect by secondary intention.

Postoperative regimen

In all cases, a broad-spectrum antibiotic therapy was initiated empirically then shifted into targeted therapy once culture results became available. Wounds were inspected and vacuum-assisted wound dressing was changed twice weekly.

All patients after the procedure were immobilized with foot splinted in slight plantar flexion position for 2 weeks. After that, patients were placed into non-weight-bearing offloading footwear until the wound healed, usually 4 to 8 weeks. Patients were then transitioned into a removable walking boot with gradual return to activities and were provided a physical therapy program focused on strengthening.

At the end of 1st, 2nd and 3rd week, the wound was examined for the presence of further extension of infection, remaining necrotic tissue and stability of the ankle joint.

Follow-up

Regular monthly follow-up visits were scheduled to evaluate wound size, healing rate, and walking ability. After complete healing of the wound, the conditions of the scars were inspected, and attention paid to the use of offloading walking aid.

Functional outcome

The functional examination of the affected foot was carried out in comparison to the healthy opposite side using both objective and subjective methods.

We applied the heel rise test which is an objective test and also used other subjective methods based on some parameters of the American Orthopedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale13 to assess the functional outcome.

These parameters included

Activity limitation which is classified into: "No limitation" where no support needed; "Mild-Moderate limitation" with limitation of recreational activities with/out limited daily activities where cane was needed; and "Severe limitation" of all activities with need of walker, crutches, or wheelchair.

Walking surface difficulty, classified into: "No difficulty” on any surface; “Some difficulty” on uneven terrain, stairs, incliners, ladders; and “Severe difficulty” on uneven terrain, stairs, incliners, ladders.

Gait abnormality was classified into: “No/slight”, “Obvious” or “Marked” gait abnormality.

Statistical analysis

Numeric variables were presented as mean and standard deviation, while categoric variables as number and percentage. Student t test was used to compare means for numeric data, and chi-square or Fisher's exact tests for categoric variables. P-value ≤ .05 was considered significant.

Results

Demographic and co-morbid data

Over the study period, 35 diabetic patients underwent surgical debridement of infected leg ulcers with exposed Achilles tendon. Nineteen patients underwent total excision of the tendon (Group A), while in 16 patients, partial excision of tendon was performed (Group B).

Patient demographics and clinical characteristics are summarized in (Table 1). Hypertension (N: 18, 51.43%) and coronary artery disease (N: 13, 37.14%) were the most predominant co-morbid conditions among studied patients, and with the numbers available, no significant difference could be detected between both groups. Associated peripheral arterial disorder was revealed in 10 patients (28.57%) with mean ankle-brachial index of 0.96 ± 0.19, half of them needed revascularization via percutaneous transluminal angioplasty before
debridement. Interestingly, all of re-vascularization patients underwent complete Achilles-tendon excision.

**Ulcer history and operative data**

Preoperative assessment of ulcer revealed that 8 patients (22.86%) had previous history of heel ulcers, while 10 patients (28.57%) experienced previous leg ulcers. However, none of these numbers could reveal significant difference in the studied groups as illustrated in (Table 2). Overall, patients had ulcer history of 1.87 ± 0.97 months before surgery where group A patients had significantly longer ulcer history (2.53 ± 0.75 months) and larger mean ulcer size (9.23 ± 2.04 cm²) in comparison to group B patients (1.09 ± 0.49 months, p < 0.001 and 7.35 ± 3.30 cm², p=0.05 respectively). Unsurprisingly, more patients of group A (those with longer ulcer history) underwent previous debridement procedures (n: 11, 57.89%) rather than group B (n: 5, 31.25%), yet without statistical significance according to data available. Intraoperatively, total excision of the tendon required slightly longer operative time than partial excision.

Preoperative radiological evaluation revealed calcaneal osteomyelitis in 5 patients. In these patients partial calcaneectomy and total tendon excision were performed.

**Follow-up and healing outcome data**

Regular follow-up visits were scheduled for all patients until complete wound healing was achieved. Mean follow-up period for the studied patients in both groups was 6.66 ± 2.71 months.

Results of wound culture and organisms identified are summarized in (Table 3)

In group A complete wound healing was achieved in 14 patients while 3 patients showed partial healing due to resistant heel ulcer and 2 patients showed no healing with extension of infection which necessitated major amputation. Those latter 5 patients had osteomyelitis of the calcaneus and underwent partial calcaneectomy alongside with total tendon excision.

In group B complete wound healing was achieved in only 7 patients while 2 patients showed partial healing, but the tendon was covered by granulation tissue leaving resistant ulcer. In the remaining Group B patients (n: 7), total excision of the exposed tendon was required after many interventions to achieve healing and considered failure of the procedure. It was noted that healed ulcers in this group were significantly smaller (4.80 ± 1.06 cm²) than non-healed ones (9.33 ± 3.07 cm²) (p < 0.001).

Nevertheless, group A showed significantly shorter healing time (3.14 ± 0.79 months) and lower re-intervention rate (5.26%) than group B (7.05 ± 1.56 months, p < 0.001 and 56.25%, p < 0.001 respectively) (Table 4, Figure 4).

**Fig 4: Kaplan-Meier curve for freedom from re-intervention rate during follow-up.**
Fig 5: Preoperative image of chronic lower leg ulcer with exposed necrotic Achilles tendon (arrow) (A) and postoperative images showing wound healing 2 months after complete tendon excision (B) and complete healing after 4 months (C).

Fig 6: Postoperative images showing resistant ulcers and incomplete healing after total tendon excision.

Repeated debridement was needed in some cases (10 patients, 28.57%) to eradicate infection and to remove residual devitalized tissue. A second debridement was enough to control infection in 6 patients (22.86%), while 2 patients (5.71%) required a third one, and 2 other patients (2.71%) were unsalvageable despite the repeated attempt.
**Functional outcome data**

In this study, heel rise test was done for all patients (Figure 7), but 4 patients were severely handicapped and could not perform the test. As illustrated in (Table 5), most of group A patients were unable to raise ipsilateral heel (N: 12, 63.16%), in contrary to group B patients who showed significantly better functional outcome (Positive heel rise in 62.5%, p = 0.03).

Additionally, subjective methods including activity limitation, walking ability on different surfaces and gait abnormalities were also used to assess functional outcome post-operatively. Generally, partial tendon excision was linked to better functional outcome data in all three parameters used (Activity limitation, walking surface difficulty and gait abnormality), yet no statistically significant difference could be detected according to numbers available (Table 5).

![Fig 7: Positive heel-rise test.](image)

**Table 1: Demographic and co-morbid data of the studied patients**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (N=19)</th>
<th>Group B (N=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>59.63 ± 6.53</td>
<td>55.75 ± 7.84</td>
<td>0.12</td>
</tr>
<tr>
<td>Male gender</td>
<td>15 (78.95%)</td>
<td>11 (68.75%)</td>
<td>0.70</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>88.13 ± 12.35</td>
<td>84.63 ± 12.22</td>
<td>0.41</td>
</tr>
<tr>
<td>HTN</td>
<td>11 (57.89%)</td>
<td>7 (4.75%)</td>
<td>0.51</td>
</tr>
<tr>
<td>CAD</td>
<td>5 (26.32%)</td>
<td>8 (50%)</td>
<td>0.18</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>3 (15.79%)</td>
<td>2 (12.5%)</td>
<td>0.59</td>
</tr>
<tr>
<td>Smoking</td>
<td>4 (21.05%)</td>
<td>7 (43.75%)</td>
<td>0.27</td>
</tr>
<tr>
<td>PAD</td>
<td>7 (36.84%)</td>
<td>3 (18.75%)</td>
<td>0.29</td>
</tr>
<tr>
<td>Revascularization</td>
<td>5 (26.32%)</td>
<td>0 (0%)</td>
<td>0.05 *</td>
</tr>
<tr>
<td>ABI</td>
<td>0.91 ± 0.22</td>
<td>1.03 ± 0.13</td>
<td>0.06</td>
</tr>
</tbody>
</table>

ABI: Ankle-brachial index, CAD: Coronary artery disease, DM: Diabetes mellitus, HTN: Hypertension, n: Number, PAD: Peripheral arterial disorder P ≤ 0.05 is considered significant (*).
Table 2: Ulcer history and operative data of the studied groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (N=19)</th>
<th>Group B (N=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous heel ulcer</td>
<td>5 (26.32%)</td>
<td>3 (18.75%)</td>
<td>0.70</td>
</tr>
<tr>
<td>Previous leg ulcer</td>
<td>6 (31.58%)</td>
<td>4 (25%)</td>
<td>0.72</td>
</tr>
<tr>
<td>Ulcer duration (month)</td>
<td>2.53 ± 0.75</td>
<td>1.09 ± 0.49</td>
<td>&lt; 0.001 *</td>
</tr>
<tr>
<td>Ulcer size (cm²)</td>
<td>9.23 ± 2.04</td>
<td>7.35 ± 3.30</td>
<td>0.05 *</td>
</tr>
<tr>
<td>Previous debridement</td>
<td>11 (57.89%)</td>
<td>5 (31.25%)</td>
<td>0.18</td>
</tr>
<tr>
<td>Operative time (min.)</td>
<td>22.00 ± 4.84</td>
<td>18.50 ± 6.85</td>
<td>0.09</td>
</tr>
</tbody>
</table>

P ≤ 0.05 is considered significant (*).

Table 3: Wound culture results

<table>
<thead>
<tr>
<th>Isolated organism</th>
<th>Group A (n=19)</th>
<th>Group B (n=16)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus Aureus</td>
<td>8 (42.11%)</td>
<td>4 (25%)</td>
<td>12 (34.29%)</td>
</tr>
<tr>
<td>E-Coli</td>
<td>3 (15.79%)</td>
<td>4 (25%)</td>
<td>7 (20%)</td>
</tr>
<tr>
<td>Klebsiella</td>
<td>3 (15.79%)</td>
<td>0</td>
<td>3 (8.57%)</td>
</tr>
<tr>
<td>Pseudomonas</td>
<td>1 (5.26%)</td>
<td>1 (6.25%)</td>
<td>2 (5.71%)</td>
</tr>
<tr>
<td>MRSA</td>
<td>0</td>
<td>1 (6.25%)</td>
<td>1 (2.86%)</td>
</tr>
<tr>
<td>Mixed</td>
<td>4 (21.05%)</td>
<td>5 (31.25%)</td>
<td>9 (25.71%)</td>
</tr>
</tbody>
</table>

MRSA: Methicillin-resistant Staphylococcus aureus.

Table 4: Healing outcome data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (N=19)</th>
<th>Group B (N=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete wound healing</td>
<td>14 (73.68%)</td>
<td>7 (43.75%)</td>
<td></td>
</tr>
<tr>
<td>Partial wound healing</td>
<td>3 ' (15.79%)</td>
<td>2 (12.5%)</td>
<td>0.10</td>
</tr>
<tr>
<td>No wound healing</td>
<td>2 ' (10.53%)</td>
<td>7 (43.75%)</td>
<td></td>
</tr>
<tr>
<td>Follow-up period (month)</td>
<td>5.32 ± 1.6</td>
<td>8.25 ± 2.94</td>
<td>0.001 *</td>
</tr>
<tr>
<td>Healing time (month)</td>
<td>3.14 ± 0.79</td>
<td>7.05 ± 1.56</td>
<td>&lt; 0.001 *</td>
</tr>
<tr>
<td>Re-intervention</td>
<td>1 (5.26%)</td>
<td>9 (56.25%) #</td>
<td>&lt; 0.001 *</td>
</tr>
<tr>
<td>Limb salvage</td>
<td>17 (94.44%)</td>
<td>14 (87.5%)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

' All had calcaneal osteomyelitis and underwent partial calcanectomy.

#: Five cases (Out of 9 reinterventions in Group B) needed total excision of the tendon to achieve complete healing. P ≤ 0.05 is considered significant (*).
The Achilles tendon is the strongest tendon in the human body. It enables the superficial posterior leg muscles to plantarflex the foot and stabilizes the ankle joint during the gait cycle. As tough as the Achilles tendon is, it is still susceptible to wear and tear due to the superficial location of the tendon. Furthermore, the Achilles tendon has a poor blood supply which makes it difficult for this tendon to bounce back quickly from injury.

Most cases of Achilles tendon injury are traumatic sports rupture. Another less common cause is extension of infection from nearby ulcer specially in diabetic patients which may end with partial or complete necrosis of the tendon.

Restoration of injured Achilles tendon integrity and function is needed specially in young healthy people. Upon acute rupture, open primary repair is usually needed, while reconstruction for chronic ruptures is based on the length of gapping between the ends of the Achilles tendon. Nevertheless, with infection and necrosis, restoration of Achilles tendon integrity will be difficult and treatment goals would include eradicating infection, covering the wound, and restoring function if possible.

Multiple options for treatment of skin and tendon defects have been described in the literature. Numerous locoregional or free flap transfers have been suggested to treat tendon defects. Also reinforcement flaps (E.g. tensor fascia lata, palmaris longus, extensor carpi radialis, musculus plantaris or Achilles tendon autograft with fascial flap wrapping) have been described to manage necrosis of Achilles tendon.

Most of data about the treatment of infected Achilles tendon comes from the postoperative wound infection after treatment of tendon rupture. Various case reports and small series proposed different approaches to manage the resultant tendon and soft tissue defects. Many authors opted to perform initial radical debridement followed by reconstruction of the tendon and coverage of the overlying soft tissue. In their report of 3 cases, Lee et al. used anterolateral thigh free flap with integral fascia-lata strip. Boopalan and colleague also used fascia-lata for tendon reconstruction but depended on reverse-flow sural flap for soft tissue coverage. DeFazio et al. described rectus femoris myofascial flap. Finally, Zheng et al. applied peroneus brevis tendon transfer and reversed sural flap for management of 10 cases with complete tendon rupture and overlying soft tissue infection.

Nevertheless, debridement and soft tissue coverage without tendon reconstruction has been initially
During our study we used heel rise test, activity controversy.

Despite being totally different from rupture and injury of the tendon which occur in athletes, no study addressed the management of infected and necrotic Achilles tendon in diabetic patients. In diabetic patients, although tendon preservation to maintain walking and daily activity is important but when diabetic foot infection occurs limb salvage becomes a priority accepting the trade-off of potential limitations of movement.

The purpose of this study is to elucidate the clinical and functional outcomes of diabetic patients who have undergone total excision of infected and necrotic Achilles tendon without any form of repair. In the presence of extensive soft tissue infection around the tendon that was not responding to systemic antibiotics and tissue drainage procedures, removal of infected tendon would be considered as a limb salvage procedure to avoid major amputation.

Our management of infected Achilles tendon included radical debridement of necrotic tissue with complete or partial excision of the tendon. In total excision group, we obtained complete healing in 73.68 % of patients in mean period of 3.14 months with re-intervention rate of 5.26%.

Healing process following debridement of infected Achilles tendon has been dictated by technique used for soft tissue coverage. Fourniols et al. managed 15 patients with postoperative tendon infection and necrosis on the basis of radical debridement, tendon resection, immobilization and gradual suture wound closure. They achieved complete healing in 13 patients (86.67%) after 30-100 days (61 days in mean) and reported re-intervention in 13.33% of patients. Additionally, healing occurred after 48 days for Dautry et al. whose rapid healing may be attributed to use of skin grafting in half of the cases. Furthermore, Bae et al. reported healing in 8-30 days (Mean of 17 days) after debridement of postoperatively infected tendon and primary closure of the wound. Leaving the defect open and applying negative pressure wound therapy to achieve healing by secondary intention might explain the longer healing time in our study.

Management of Achilles tendon infections have arisen many concerns about possible substantial functional deficits. Despite development of various objective and subjective measures and rating systems to evaluate functional outcomes following Achilles tendon surgery, the optimal tools for reporting such outcomes remains a matter of controversy.

During our study we used heel rise test, activity limitation, walking difficulties on different surfaces and gait abnormalities. Despite the hamper in performing heel-rise test in most patients (63.16%), other functional results were considered to be satisfactory with severe activity limitation being reported in 36.84%, severe walking difficulties in 31.58% and marked gait abnormalities in only 15.79% of patients.

Being the benchmark for management of postoperative Achilles tendon infection, studies that described debridement followed by tendon reconstruction and soft tissue flap coverage have been associated with early and adequate restoration of walking ability and performing tip-toe standing.

Our results were consistent with those reported by other studies. In their study on 15 patients with postoperative tendon infection, Bae et al. reported good functional results after radical debridement of the infected tendon with 100% ability to walk on uneven surfaces, 66.67% ability to perform single-limb heel-rise and 73.33% of patients were able to return to their usual sportive activities.

In a previously described study, Fourniols et al. reported 60% ability to do heel-rise and 50-80% recovery of range of motion after 6 months with only 26.7% pf patients had full recovery to the same range of motion as the other limb at final follow-up.

Additionally, Bowers et al. have worked on 20 patients with tendon infection. They used different procedures for wound closure after radical debridement ranging from primary closure, vacuum-assisted closure and skin grafting to local or free flaps and measured functional outcomes using the Foot and Ankle Ability Measure (FAAM) Activity of Daily Living (ADL) scale. With average score of 86.6%, most of patients rated their function to be “normal” or “Nearly normal”.

Finally, Yuan et al. in their small case series achieved excellent functional results following infected tendon excision with all patients could perform heel-rise and subsequently returned to their preoperative activity.

Some theories have been offered to explain maintaining fair functional ability after tendon excision. Fourniols et al. Monnerie et al., and Rider et al. reported long-term development of neotendon (Scar tissue continuity evidenced by MRI) after complete tendon excision. Others suggested compensatory hypertrophy of deep posterior leg compartment muscles (Tibialis posterior, flexor hallucis longus and flexor digitorum longus). Yuan et al. noticed evident contracture of ipsilateral toes after tendon excision, while Boorboor et al. who reported good AOFAS score (84.7/100) despite 44.5% loss of plantar flexion, found significant size increase of this compartment muscles after non-
reconstruction of infected tendon.

Added to the above theories, there are already limited activities and functional demands in those old fragile diabetic patients, especially with peripheral neuropathy.

Numerous studies have addressed the mobility limitation at level of ankle and foot in diabetics. It was found that patients with DM have distal muscle weakness, reduced ankle flexibility, and increased stiffness. Reduced passive ankle dorsiflexion has been associated with more plantar loading. To compensate those functional abnormalities, diabetic patients adopt different gait strategies such as slowing their walking velocity, shortening their stride length, and shifting their workload from distal to proximal by using hip flexor muscles (Hip strategy) instead of weak plantar flexor muscles (Ankle strategy) during walking.

All the aforementioned factors are responsible for better toleration of diabetic patients to total tendon excision without considerable loss of their walking ability, making it a worthy management option in cases of severe infections.

In our study we tend to compare functional ability between complete and partial tendon excision. However, this study was limited by being non-randomized, inability to quantify the amount of tendon that was partially excised and lack of postoperative MRI imaging to confirm neotendon formation. Nevertheless, we can still conclude that total tendon excision provides better healing outcome and limb salvage chances without major significant effect on daily activity compared to partial excision.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The Authors declare that there is no conflict of interest

References


