Functional and Limb Salvage Outcomes after Excision of Infected Achilles Tendon in Diabetic Patients; a Comarative 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.

Introduction

The Achilles tendon, the common tendon attaching both gastrocnemius and soleus muscles to the calcaneus, can claim the double honor of being both the largest and strongest tendon in the human body.[1]

Alongside with being the main plantar flexors of the foot at the ankle joint, Achilles tendon and its attaching muscles have a major role in propulsion and balance during gait. So, many of our daily activities, such as walking, running, and climbing stairs depend on them.[2]

Consequently, if injury of the Achilles tendon occurred, it is essential to maintain the tendon and covering skin integrity to preserve the tendon function. Numerous locoregional, free flaps as well as tendon transfer techniques have been suggested to treat postoperative skin and tendon defects after Achilles tendon injury.[3–7]

However, not all patients and in particular diabetic patients are suitable for tendon repair because of either poor limb vascularity or systemic conditions. These conditions predispose them to poorer outcome with increased incidence of nonhealing and sepsis.[8]

An alternative procedure is Achilles tendon excision, which avoids the need for flap coverage because the resultant exposed soft tissue is often well vascularized. Furthermore, excision of the tendon makes the soft-tissue defect smaller.[9]

Ankle plantar flexion strength is expected to be impaired after Achilles tendon excision; however, the exact effect on gait and function is less clear. This is especially true in such fragile patients who have lower functional demands as well as pre-existing mobility limitation due to diabetic neuropathy and therefore can cope with reduced ankle plantar flexion strength.[10–12]

In diabetic patients, although walking and daily activity are important but when diabetic foot infection occurs, limb salvage becomes a priority and therefore more aggressive procedure such as total Achilles tendon excision can be considered.

This study aimed at comparing between total excision of the Achilles tendon and tendon preservation strategy as regard the eradication of infection, wound healing, limb salvage, and preservation of the walking ability.

Patients and methods

Study design and population

This is a prospective study which included 35 limbs in 35 diabetic patients with infected exposed Achilles tendon presented during the period from May 2018 to April 2021. An informed detailed consent was obtained from all patients before enrollment in the study, as well as an approval from the authorized ethical committee of Tanta Faculty of Medicine.

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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.

Fig 1: Intraoperative images for exploration, dissection of the tendon (A) and its total excision (B, C).

Fig 2: Intraoperative images for infected necrotic Achilles tendon (A), dissection of the tendon (B) and its total excision (C, D).

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 calcanectomy 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 clacenectomy 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 calcanectomy 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 calcanectomy 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).**

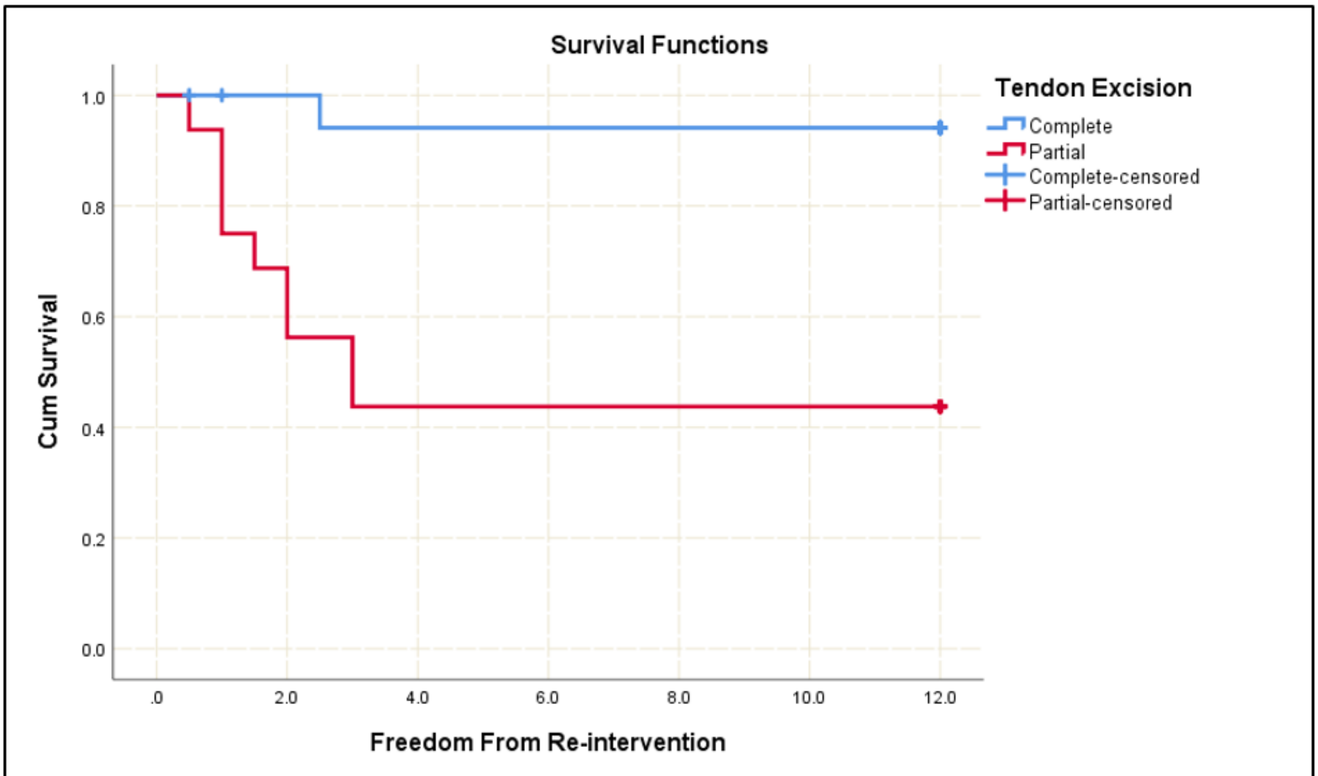

Fig 4: Kaplan-Meier curve for freedom from re-intervention rate during follow-up.

Fig 5: Preoperative image of chronic lower leg ulcer with exposed necrotic Achilles tendon (arrow) (A) and post-operative 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.

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

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

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

Variable	Group A (N=19)	Group B (N=16)	P
Previous heel ulcer	5 (26.32%)	3 (18.75%)	0.70
Previous leg ulcer	6 (31.58%)	4 (25%)	0.72
Ulcer duration (month)	2.53 ± 0.75	1.09 ± 0.49	< 0.001 *
Ulcer size (cm^2)	9.23 ± 2.04	7.35 ± 3.30	0.05 *
Previous debridement	11 (57.89%)	5 (31.25%)	0.18
Operative time (min.)	22.00 ± 4.84	18.50 ± 6.85	0.09

P ≤ 0.05 is considered significant (*).

Table 3: Wound culture results

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

MRSA: Methicillin-resistant Staphylococcus aureus.

Table 4: Healing outcome data

Variable	Group A (N=19)	Group B (N=16)	P
Complete wound healing	14 (73.68%)	7 (43.75%)	
Partial wound healing	3 † (15.79%)	2 (12.5%)	0.10
No wound healing	2 † (10.53%)	7 (43.75%)	
Follow-up period (month)	5.32 ± 1.6	8.25 ± 2.94	0.001 *
Healing time (month)	3.14 ± 0.79	7.05 ± 1.56	< 0.001 *
Re-intervention	1 (5.26%)	9 (56.25%)ǂ	< 0.001 *
Limb salvage	17 (94.44%)	14 (87.5%)	1.00

†: All had calcaneal osteomyelitis and underwent partial calcanectomy.

ǂ: 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 (*).

Table 5: Functional outcome data in both groups

Heel Rise Test				
	Yes	**No**	**N/A**	**P**
Group A (N=19)	5 (26.32%)	12 (63.16%)	2 (10.53%)	0.03*
Group B (N=16)	10 (62.5%)	4 (25%)	2 (12.5%)	
Activity Limitation				
	No	**Mild/Moderate**	**Severe**	**P**
Group A (N=19)	2 (10.53%)	10 (52.3%)	7 (36.84%)	0.09
Group B (N=16)	7 (43.75%)	4 (25%)	5 (31.25%)	
Walking Surface Difficulty				
	No	**Some**	**Severe**	**P**
Group A (N=19)	2 (10.53%)	9 (47.37%)	6 (31.58%)	0.41
Group B (N=16)	5 (31.25%)	6 (37.5%)	3 (18.75%)	
Gait Abnormality				
	No/Slight	**Obvious**	**Marked**	**P**
Group A (N=19)	5 (26.32%)	9 (47.37%)	3 (15.79%)	0.22
Group B (N=16)	9 (56.25%)	3 (18.75%)	2 (12.5%)	

N/A: Test could not be done.

P ≤ 0.05 is considered significant (*).

Discussion

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.[14–17] Numerous locoregional or free flap transfers have been suggested to treat tendon defects.[3–7] 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.[18–21]

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.[6] used antero-lateral thigh free flap with integral fascia-lata strip. Boopalan and colleague,[22] 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.[23] 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.[24]

Nevertheless, debridement and soft tissue coverage without tendon reconstruction has been initially described by Dautry et al.[25] in 1975. Thereafter, many authors reported similar strategy for management of their cases with infected Achilles tendon.[15,26–28]

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.[15] 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.[25] whose rapid healing may be attributed to use of skin grafting in half of the cases. Furthermore, Bae et al.[27] 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.[21–23]

Our results were consistent with those reported by other studies. In their study on 15 patients with postoperative tendon infection, Bae et al.[27] 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.[15] 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.[29] 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.[9] 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.,[15] Monnerie et al.,[28] and Rider et al.[30] 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.[9] noticed evident contracture of ipsilateral toes after tendon excision, while Boorboor et al.[26] who reported good AOFAS score (84.7/100) despite 44.5% loss of plantar flexion, found significant size increase of this compartment muscles after nonreconstruction 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.[11,12,31,32] Reduced passive ankle dorsiflexion has been associated with more plantar loading.[11] To compensate those functional abnormalities, diabetic patients adopt different gait strategies such as slowing their walking velocity,[33] shortening their stride length,[11,12] 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.[12,32]

All the forementioned 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.

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Conflict of Interest

The Authors declare that there is no conflict of interest

References

1. Doral MN, Alam M, Bozkurt M, et al: Functional anatomy of the Achilles tendon. Knee surgery, sports traumatology, ***Arthroscopy.*** 2010; 18(5): 638-643.

2. Dayton P: Anatomic, vascular and mechanical overview of the Achilles tendon. ***Clinics in Podiatric Medicine and Surgery.*** 2017; 34(2): 107-113.

3. Soons J, Rakhorst HA, Ruettermann M, Luijsterburg AJM, Bos PK, Zöphel OT: Reconstruction of defects involving the Achilles tendon and local soft tissues. ***The Bone & Joint Journal.*** 2015; 97-B(2): 215-220.

4. Dekker TJ, Avashia Y, Mithani SK, Matson AP, Lampley AJ, Adams SB: Single-stage bipedicle local tissue transfer and skin graft for Achilles tendon surgery wound complications. ***Foot & Ankle Specialist.*** 2017; 10(1): 46-50.

5. Michlits W, Gruber S, Windhofer C, Macheiner P, Walsh M, Papp C: Reconstruction of soft tissue defects overlying the Achilles tendon using the super extended abductor hallucis muscle flap. The Journal of Trauma: ***Injury, Infection, and Critical Care.*** 2008; 65(6): 1459-1462.

6. Lee JW, Yu JC, Shieh SJ, Liu C, Pai JJ: Reconstruction of the Achilles tendon and overlying soft tissue using antero-lateral thigh free flap. ***British Journal of Plastic Surgery.*** 2000; 53(7): 574-577.

7. Ando J, Sakuraba M, Sugawara A, et al: Free flap reconstruction of Achilles tendon and overlying skin defect using ALT and TFL fabricated chimeric flap. ***Case Reports in Plastic Surgery and Hand Surgery.*** 2019; 6(1): 82-85.

8. Marchesi A, Parodi PC, Brioschi M, et al: Soft-tissue defects of the Achilles tendon region: Management and reconstructive ladder. Review of the literature. ***Injury.*** 2016; 47: S147-S153.

9. Yuan W, Satkunanantham M, Sechachalam S: Results of Achilles tendon excision for purpose of wound closure: Case series. ***The Journal of Foot and Ankle Surgery.*** 2019; 58(1): 184-186.

10. Bryant A, Tinley P, Singer K. Radiographic measurements and plantar pressure distribution in normal, hallux valgus and hallux limitus feet. ***The Foot.*** 2000; 10(1): 18-22.

11. Rao S, Saltzman C, Yack HJ. Ankle ROM and stiffness measured at rest and during gait in individuals with and without diabetic sensory neuropathy. ***Gait Posture.*** 2006; 24(3): 295-301.

12. Mueller MJ, Minor SD, Sahrmann SA, Schaaf JA, Strube MJ: Differences in the gait characteristics of patients with diabetes and peripheral neuropathy compared with age-matched controls. ***Physical Therapy.*** 1994; 74(4): 299-308.

13. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M: Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. ***Foot & Ankle International.*** 1994; 15(7): 349-353.

14. Haas F, Seibert FJ, Koch H, et al: Reconstruction of combined defects of the Achilles tendon and

the overlying soft tissue with a fascia lata graft and a free fasciocutaneous lateral arm flap. ***Annals of Plastic Surgery.*** 2003; 51(4): 376-382.

15. Fourniols E, Lazennec JY, Rousseau MA. Salvage technique for postoperative infection and necrosis of the Achilles tendon. Orthopaedics & traumatology. ***Surgery & Research.*** 2012; 98(8): 915-920.
16. Dalton GP, Wapner KL, Hecht PJ: Complications of Achilles and posterior tibial tendon surgeries. ***Clin Orthop Relat Res.*** 2001; (391): 133-139.
17. Bullocks JM, Hickey RM, Basu CB, Hollier LH, Kim JY: Single-stage reconstruction of Achilles tendon injuries and distal lower extremity soft tissue defects with the reverse sural fasciocutaneous flap. ***Journal of Plastic, Reconstructive and Aesthetic Surgery.*** 2008; 61(5): 566-572.
18. Pajala A, Kangas J, Ohtonen P, Leppilahti J: Rerupture and deep infection following treatment of total Achilles tendon rupture. ***Journal of Bone and Joint Surgery - Series A.*** 2002; 84(11): 2016-2021.
19. Ademoğlu Y, Özerkan F, Ada S, et al: Reconstruction of skin and tendon defects from wound complications after Achilles tendon rupture. ***Journal of Foot and Ankle Surgery.*** 2001; 40(3): 158-165.
20. Leppilahti J, Kaarela O, Teerikangas H, Raatikainen T, Orava S, Waris T: Free tissue coverage of wound complications following Achilles tendon rupture surgery. ***Clinical Orthopaedics and Related Research.*** 1996; (328): 171-176.
21. Prasetyono TOH, Sisca F: Achilles tendon reconstruction with a half-width Achilles graft and wrap-around fascial flap. ***Arch Plast Surg.*** 2019; 46(3): 267-271.
22. Boopalan PRJVC, Jepegnanam TS, Titus VTK, Prasad SY, Chittaranjan SB: Open infected Achilles tendon injury-reconstruction of tendon with fascia lata graft and soft tissue cover with a reverse flow sural flap. ***Foot Ankle Surg.*** 2008; 14(2): 96-99.
23. de Fazio MV, Han KD, Evans KK: Functional reconstruction of a combined tendocutaneous defect of the Achilles using a segmental rectus femoris myofascial construct: A viable alternative. ***Arch Plast Surg.*** 2014; 41(3): 285-289.
24. Zheng L, Zhang XS, Dong ZG, Liu LH, Wei JW: One-staged reconstruction of Achilles tendon and overlying skin defects with suppuration: using peroneus brevis tendon transfer and reversed sural neurofasciocutaneous flap. ***Arch Orthop Trauma Surg.*** 2011; 131(9): 1267-1272.
25. Dautry P, Isserlis G, Apoil A, Moinet P, Vivier J: Treatment of necrosis of the Achilles tendon (author’s transl). ***Ann Chir.*** 1975; 29(12): 1093-1098.
26. Boorboor P, Lahoda LU, Spies M, Kuether G, Waehling K, Vogt PM: Resection of infected Achilles tendon. Results after soft tissue coverage without tendon reconstruction. ***Der Chirurg.*** 2006; 77(12): 1144-1151.
27. Bae SH, Lee HS, Seo SG, Kim SW, Gwak HC, Bae SY: Debridement and functional rehabilitation for Achilles tendon infection following tendon repair. ***J Bone Joint Surg Am.*** 2016; 98(14): 1161-1167.
28. Monnerie C, le Nen D, Hu W, Letissier H, Kerfant N: Treatment of necrosis of Achilles tendon without tendon reconstruction: About four cases. ***Annales de Chirurgie Plastique Esthetique.*** 2019; 64(2).
29. Bowers MW, Turner NS, Ryssman DB, Moran SL: Outcomes following treatment of the infected Achilles tendon. ***Foot & Ankle Orthopaedics.*** 2019; 4(2): 247301141984694.
30. Rider CM, Hansen OB, Drakos MC: Clinical management and functional outcomes of postoperative Achilles tendon infections: How do these really do? ***Foot Ankle Orthop.*** 2022; 7(1): 2473011421S0041.
31. Rao S, Saltzman CL, Yack HJ: Relationships between segmental foot mobility and plantar loading in individuals with and without diabetes and neuropathy. ***Gait and Posture.*** 2010; 31(2): 251-255.
32. Henderson AD, Johnson AW, Ridge ST, et al: Diabetic gait is not just slow gait: Gait compensations in diabetic neuropathy. ***Journal of Diabetes Research.*** 2019; 2019.
33. Petrofsky J, Lee S, Bweir S: Gait characteristics in people with type 2 diabetes mellitus. ***European Journal of Applied Physiology.*** 2005; 93(5-6): 640-647.