

Impact of Achilles Tendon Lengthening (ATL) on the Diabetic Plantar Forefoot Ulceration

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ABSTRACT

Achilles tendon gradually loses its flexibility in diabetic patients and the foot fails to dorsiflex during gait placing abnormal forces on the midfoot and these pressures in the neuropathic patient can lead to forefoot ulceration. 29 diabetic patients with plantar forefoot ulceration were allocated in two groups to be managed by local ulcer care and either below knee total contact plaster cast (TCC) or Achilles tendon lengthening (ATL). We reported ulcer healing in 78.6% and in 93.3% after a median duration of 49 days and 30 days in TCC and ATL groups respectively. Ankle dorsiflexion with ATL measured 18.46 ± 2.94 degrees and gradually diminished to 12.60 ± 3.04 degrees after 2 years follow up. Recurrent forefoot ulceration was detected in 14.3% with TCC while none was recorded with ATL procedure after 6 months follow up, while by the end of 24 postoperative months, the ulcer recurred in 57.1% and 20% with TCC and ATL techniques respectively. We concluded that ATL is effective in healing of plantar neuropathic forefoot ulcer in diabetics and the recurrence rate of ulceration in such patients is significantly low but extreme ankle dorsiflexion should be avoided because of the risk of heel ulceration.

INTRODUCTION

Plantar ulcers produced by diabetic foot disease are devastating and costly. Better understanding of the ulcer-producing process is important to improve detection of feet that are at risk and to improve intervention. The association between peripheral neuropathy and high plantar pressure has been studied with regard to diabetic plantar forefoot ulceration [1-3]. Changes in the normal biomechanics of the diabetic foot include skeletal abnormalities, changes in muscle function, and loss of flexibility in the joints and tendons [4-6]. Other biomechanical abnormalities may have a contribution to the specific plantar ulceration such as hammer toe, prominent plantar metatarsal heads and prominent sesamoids [7]. The accepted hallmarks of care for plantar forefoot ulceration are meticulous wound care, nutrition, management of infection and non-weight bearing of the ulcerative area [8].

The loss of flexibility in the Achilles tendon has been underappreciated as a cause for plantar foot ulceration in diabetics. Traditionally, lengthening of the gastrocnemius aponeurosis has been used to treat spastic conditions and the procedure has been studied extensively in the pediatric orthopedic literature [9]. Because of the loss of Achilles tendon flexibility, the foot gradually loses its ability to dorsiflex during gait and placing abnormal forces on the midfoot and these pressures in the neuropathic patient can lead to ulceration [10].

The aim of this work is to evaluate the effect of Achilles Tendon Lengthening (ATL) on the management of plantar diabetic forefoot ulceration.

MATERIAL AND METHODS

Twenty nine diabetic patients with plantar forefoot ulceration were randomized into two groups:

- *Group I (GI)*: 14 patients were managed by local wound care and total contact cast alone (TCC).
- *Group II (GII)*: 15 patients were treated by local ulcer care and Achilles tendon lengthening (ATL).

Postoperatively, the patients were followed up for 24 months and the outcome measures were:

- Time to healing of the plantar forefoot ulcer.
- Local complications.
- The range of ankle dorsiflexion.
- Ulcer recurrence rate.
- Calcaneal gait and heel ulcer.

In Both groups the ulcer was debrided and dressed while systemic antibiotic was given according to culture sensitivity results:

- 1- *In (GI)*: Below knee cast was applied with a window for daily dressing of the ulcer.
- 2- *In (GII)*: The ankle dorsiflexion measurements were taken with the knee straight and again

with the knee flexed (Fig. 1a,b). If the foot cannot be dorsiflexed with the knee straight but dorsiflexes beyond 10° with the knee flexed, it means that the gastrocnemius portion of the Achilles tendon is tight and gastrocnemius recession is needed. If the foot will not dorsiflex with the knee straight or flexed, both portions of Achilles tendon are tight, and the percutaneous Achilles tendon lengthening (ATL) is required.

According to the ankle dorsiflexion measurements, the (ATL) procedures were done using:

- a- Tongue in groove gastrocnemius recession when the gastrocnemius portion of the tendon is tight [11].
- b- Percutaneous triple hemisection of the Achilles tendon when both portions of the tendon are tight [12].

Surgical Procedures:

A- Tongue in Groove Procedure for Gastrocnemius Aponeurosis Recession:

- The patient was given either spinal or general anesthesia and put in the prone position.
- The ulcer was debrided, dressed and isolated from the operative field.
- A longitudinal skin incision was placed on the central posterior aspect of the leg just below the distal bulk of the gastrocnemius muscle.
- The Achilles tendon was dissected after incision of the superficial and deep fasciae with securing and retracting the short saphenous vein and sural nerve. Cutting the paratenon vertically will visualize Achilles tendon (Fig. 2a).
- A Tongue in groove incision in the tendon was performed (full thickness transverse incisions of the lateral 1/3rd of the aponeurosis, then 2cm downward vertical, central 1/3rd transverse followed by upward 2cm vertical one and medial 1/3rd full thickness cut of the tendon complete tongue in groove lengthening of the tendon) (Fig. 2b).
- The foot was dorsiflexed manually for about 10°-15° past neutral.
- The vertical limbs of the gastrocnemius tendon were slid and the gap between the horizontal edges of the incised aponeurosis measured 2-3cm (Fig. 2c). The vertical limbs of the tongue in groove procedure were sutured together with absorbable monofilament suture.
- The wound was sutured and dressed.

B- Percutaneous Triple Hemisection of Achilles Tendon:

- General or spinal anesthesia was used and the patient was put in the supine position.
- The ulcer was debrided, dressed and isolated from the operative field.
- The foot was put in a dorsiflexion by the assistant to make Achilles tendon more prominent.
- Three stab incisions were made vertically with no. 11 blade (Fig. 3a).
 - a- The first stab was made along the midline over the Achilles tendon 4cm above its insertion into the os calcis. As the stab just advanced through the tendon, the blade was turned medially to section the medial half of the Achilles tendon.
 - b- The second stab was done 2-3cm above the first one then the blade was turned laterally to section the lateral half of the Achilles tendon.
 - c- A third stab was put 2-3cm above the second one and the blade was turned medially to cut the medial half of the tendon.
- Steady pressure was applied on the dorsiflexed foot till ankle dorsiflexion measured 10°-15° past neutral and Achilles tendon fibres were felt sliding longitudinally (Fig. 3b).
- The stabs were closed with 4/0 Nylon stitches and the wounds were dressed.

The ankle was kept in slight dorsiflexion with a posterior plaster splint.

The patients remained non-weight bearing for one week and the leg was placed in a walker with a heel lift for further 5 weeks then the patients were allowed to weight bear after the 6th postoperative week.

The sole ulcer was dressed daily and local care of the ulcer continued till complete healing.

RESULTS

- Mean age was 55±11 years.
- Body mass index (BMI) was 35±3kgm/m².
- Mean duration as a diabetic was 20±11 years.
- Median duration of the ulcer was 42 months (range 10-72 months).
- There were no significant differences in age, sex, BMI, duration of diabetes duration of the forefoot ulcer between both groups.

Fig. (1): The ankle dorsiflexion measurements
(a) with straight knee,
(b) with 90 degrees flexed knee
(after Nishimoto et al., 2003).

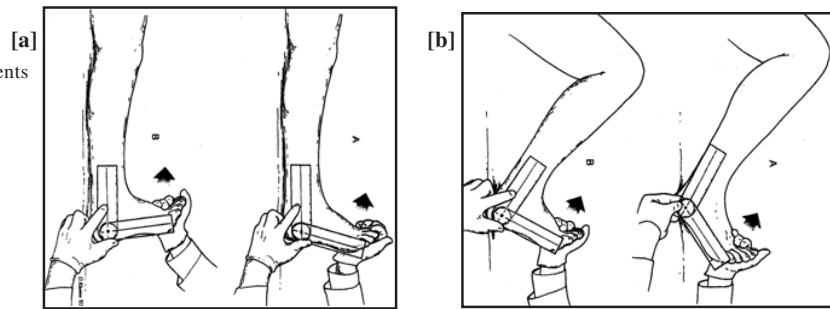


Fig. (2): Gastrocnemius tendon recession

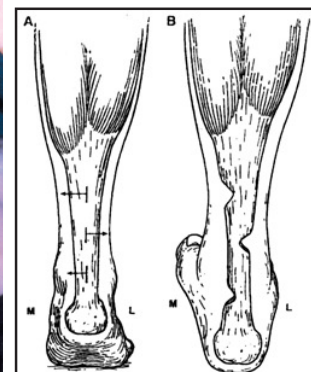
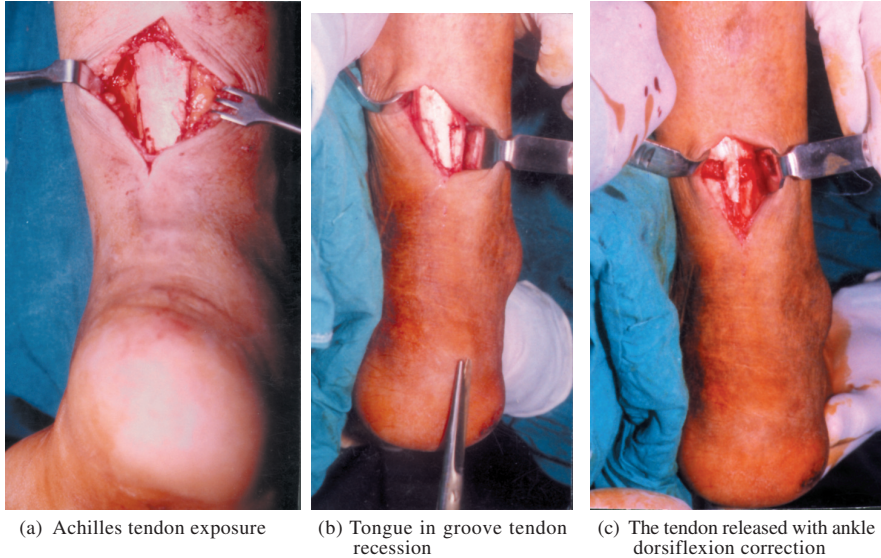


Fig. (3): Percutaneous Achilles tendon triple hemisection (after Nishimoto et al., 2003).

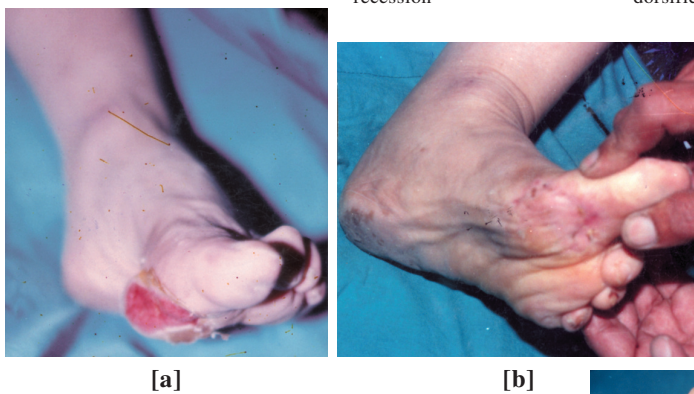


Fig. (4): Plantar forefoot diabetic ulcer treated with percutaneous Achilles tendon triple hemisection, (a) Preoperative, (b) The healed ulcer after 6 months postoperative.

Fig. (5): Plantar forefoot diabetic ulcer (with previous ulcer grafting), managed with gastrocnemius tendon recession, (a) Preoperatively, (b) The ulcer healed within 8 weeks.



We found that 78.6% in the total contact cast (TCC) group and 93.3% in ATL group healed in a median duration of 49 days (range 32-230 days) and 30 days (range 21-221 days) in the 1st and 2nd group respectively (Table 1) (Figs. 4a,b; 5a,b).

The most common early complications were partial soleus muscle injury and wound hematoma (22.2%) when gastrocnemius recession was applied and ruptured Achilles tendon was detected in one patient when gastrocnemius recession or percutaneous ATL were the operative procedures (Table 2). On follow up, we recorded unhealed forefoot ulcer in 21.4% after 6 months but all healed by the end of the 24th month in TCC group while it was

6.7% in ATL group after 6 months but all healed by the end of the 12th postoperative month. Recurrent forefoot ulceration was increasing from 14.3% to 57.1% in TCC group while it was only 20% in ATL group of the patients after 24 months follow up (Table 3). Among the ATL group recurrence of the ulcer after 24 months follow up was 22.2% with gastrocnemius recession procedure while it was recorded in 16.7% with percutaneous ATL (Table 4). In ATL group ankle dorsiflexion measured 18.46 ± 2.94 degrees immediately postoperative which was gradually decreased to 12.60 ± 3.04 degrees after two years follow up but still in the range to give normal gait (Table 5).

Table (1): Healing period for plantar forefoot ulcer (days).

	GI (TCC)	GII (ATL)
Min	32.00	21.00
Max	230.00	221.00
Median	49.00	30.00
<i>Mann-Whitney test:</i>		
Mean rank	20.8	9.5
Z		-3.59
p-value		0.00*

* Significant at 0.05.

Table (2): Early complications related to ATL.

	Gastrocnemius recession		Percutaneous ATL	
	N=9	%	N=6	%
Wound hematoma	2	22.2	1	16.7
Ruptured Achilles tendon	1	11.1	1	16.7
Calcaneal gait postop.	0	0.00	1	16.7

Table (3): Follow-up outcome measurements.

	GI (TCC)		GII (ATL)	
	N=14	%	N=15	%
<i>6 months postop.:</i>				
Unhealed forefoot ulcer	3	21.4	1	6.7
Recurrent forefoot ulcer	2	14.3	0	0.00
Calcaneal gait	0	0.00	2	13.3
Late heel ulcer	0	0.00	1	6.7
Ruptured Achilles tendon	0	0.00	1	6.7
<i>12 months postop.:</i>				
Unhealed forefoot ulcer	1	7.1	0	0.00
Recurrent forefoot ulcer	5	35.7	2	13.3
Calcaneal gait	0	0.00	2	13.3
Late heel ulcer	0	0.00	2	13.3
Ruptured Achilles tendon	0	0.00	1	6.7
<i>24 months postop.:</i>				
Unhealed forefoot ulcer	0	0.00	0	0.00
Recurrent forefoot ulcer	8	57.1	3	20
Calcaneal gait	1	7.1	2	13.3
Late heel ulcer	0	0.00	3	20
Ruptured Achilles tendon	0	0.00	2	13.3

Table (4): Recurrence of plantar forefoot ulcer (ATL group).

	Gastrocnemius recession		Percutaneous ATL	
Follow up	N=9	%	N=6	%
6 months	0	0.00	0	0.00
12 months	1	11.1	1	16.7
24 months	2	22.2	1	16.7

Table (5): Ankle dorsiflexion degree postop. (ATL group).

	Immediate	After 6 months	After 12 months	After 24 months
Min	15.00	12.00	10.00	8.00
Max	25.00	25.00	20.00	18.00
Mean \pm SD	18.46 ± 2.94	17.13 ± 3.46	14.86 ± 2.66	12.60 ± 3.04
<i>Paired t-test with immediate:</i>				
t		3.83	10.73	17.45
p-value		0.002*	0.00*	0.00*

* Significant at 0.05.

DISCUSSION

Limited ankle dorsiflexion has been implicated as a contributing factor to plantar ulceration of the forefoot in diabetes mellitus [6]. Of all diabetics, 15% experience foot ulceration in their lifetime which is a significant risk factor for lower limb amputation and 85% of these amputations are preceded by non healing foot ulceration [13,14].

Twenty nine patients with plantar forefoot ulceration with history of diabetes for a mean period of 20 ± 11 years were included in the present study. They were managed by local ulcer care and either total contact plaster cast (TCC) or Achilles tendon lengthening (ATL). The mean age was 55 ± 11 years, BMI of $35 \pm 3 \text{ kg/m}^2$ and median duration of the forefoot ulcer was 42 months (range 10-72 months). There were no significant differences in age, sex, or the duration of the plantar forefoot ulcerations between the studied groups.

We recorded healing of the plantar forefoot ulcer in 78.6% and in 93.3% after a median duration of 49 days (range 32-230 days) and 30 days (range 21-221 days) in the TCC and ATL groups respectively. Mueller and Colleagues [9] reported 88% healing in TCC and 100% in ATL groups within a duration of 58 ± 47 days and 41 ± 28 days in both groups respectively, while Holstien and Others [15], noticed ulcer healing in 91% when ATL was used and Nishimoto et al. [6], recorded healing forefoot ulceration after ATL in about 5 weeks. In the present study when ATL procedure was used, we detected early wound hematoma more frequent with gastrocnemius recession (22.2%) due to partial injury to soleus muscle, while ruptured Achilles tendon was recorded in 6.7% of the patients early in the study. On follow up, 6 months postoperatively, we found unhealed forefoot ulcer in 21.4% with TCC and in 6.7% when ATL was used, where as Birke and Other [16] with TCC reported 5.8% unhealed forefoot ulceration but Holstein and Colleagues [15], found that 6.7% of such ulcers never healed with ATL. Recurrent forefoot ulceration was detected in 14.3% with TCC while none was recorded in ATL group within 6 months postoperatively and the incidence of such complication increased to 35.7% in TCC group and 13.3% in ATL cases by the end of the first year of the follow up (11.1% with gastrocnemius recession and 16.7% with percutaneous tendon lengthening). By the end of the second postoperative year recurrence of the plantar forefoot ulceration was detected in 57.1% and 20% with TCC and ATL groups respectively. Among ATL group the forefoot ulceration recurred in 22.2% and 16.7% when gastrocnemius recession and percutaneous ATL respectively were used. Nishimoto and Others [6] recorded recurrent plantar forefoot ulceration in 16% with gastrocnemius recession while Lin and Colleagues [17] found no recurrence after about 17.3 months by ATL followed by TCC and Holstein et al. [15], reported ulcer recurrence in about 50% of the patients treated with ATL.

Ankle dorsiflexion immediately postoperatively with ATL measure 18.46 ± 2.94 degrees but we noticed that the degree of ankle dorsiflexion was gradually reduced to 12.60 ± 3.04 degrees after 2 years follow up but was still more than 10 degrees which is the range needed to the flexible ankle joint and normal gait. Hastings and Other [7], reported a sustained increase in ankle dorsiflexion (0 to 18 degrees) with ATL, while Mueller et al. [18] recorded increased dorsiflexion which remained increased up to 7 months postoperatively but Maluf and his Colleagues [19] found that ATL

leads to maintain increased ankle dorsiflexion in 74% postoperatively up to 8 months.

We found calcaneal gait and acute heel ulceration in 16.7% with percutaneous ATL while late heel ulcer in 6.7%, 13.3% and 20% after 6, 12, 24, months postoperatively among ATL cases and such complication was correlated with excessive ankle dorsiflexion due to Achilles tendon overstretch which confirmed the earlier report by Segal and Others [20].

Conclusion:

Lengthening of the Achilles tendon is effective in the management of the diabetic plantar neuropathic forefoot ulceration as it shortened its healing period and decreased the incidence of recurrent ulceration and to achieve these results extreme dorsiflexion should be avoided because of the risk of heel ulceration and the patient should be placed in proper foot wear as the failure to include these procedures to ATL may prevent healing or hasten ulcer recurrence. Future studies of the role of prophylactic ATL should be addressed to prevent equino varus deformity and possible plantar foot ulceration.

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