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The Effect of Percutaneous Flexor Tenotomy on Healing and Prevention of Foot Ulcers in Patients With Claw Deformity of the Toe

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ABSTRACT

Claw deformity of the foot is frequently seen in patients with diabetes mellitus. Percutaneous flexor tenotomy is a simple surgical procedure for the treatment of foot ulcers on the distal end of the toe caused by this deformity. This procedure can also be performed to prevent ulcers in claw toes that are at risk of ulceration. The aim of this study is to investigate whether percutaneous flexor tenotomy is an effective surgical method for treatment and prevention of toe ulcers in patients with claw deformity. This retrospective study, with a median follow-up of 13.4 (1 to 66.7) months, included all consecutive patients who underwent percutaneous flexor tenotomy in 2 hospitals between July 2012 and April 2017. In total, 101 feet underwent flexor tenotomy: 84 (83.3%) therapeutic and 17 (16.7%) prophylactic. Of the 84 therapeutic procedures, 95.1% healed, with a median healing time of 27 days. In 11 (13.3%) therapeutic procedures, a reulceration was recorded. In the therapeutic group, 4 (4.8%) infections and 1 (1.2%) amputation of the digit occurred. In the 17 prophylactic procedures, local bleeding was recorded in 1 (5.9%). In the prophylactic group, 2 ulcers occurred. In 77 (76.2%) of all procedures, patients had diabetes mellitus. In conclusion, percutaneous flexor tenotomy is an effective, safe, and minimally invasive procedure for the treatment and prevention of toe ulcers in patients with claw deformity.

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The annual incidence of a foot ulcer in patients with diabetes mellitus (DM) is ~2% (1). Foot ulcers develop in almost 15% of people with DM in a lifetime and are associated with a major loss of quality of life, mostly because of mobility limitations (2). Conservative measures such as supportive shoe wear and orthotics can help to offload the dorsal and plantar pressure of the foot (3). Despite appropriate conservative treatment, ulcers still occur and can be difficult to heal (4). Between 6% and 43% of all foot ulcers will need a minor amputation because of infection and gangrene (5).

The most common deformity in patients with diabetic neuropathy is a claw toe, present in at least 3% of patients with DM (6). The claw toe is usually attributed to motor neuropathy affecting the intrinsic foot muscles (6). The unopposed action of the extensor digitorum longus muscle and the flexor digitorum longus muscle results in a hyperextension deformity of the metatarsophalangeal joint and in a flexion contracture of the distal and/or proximal interphalangeal joints (6). Ulcers can develop in a toe with an anatomic abnormality, causing increased pressure in a specific region, which is often the tip of the toe (5,6).

Besides DM, various underlying illnesses can cause anatomic abnormalities: neurologic disorders, rheumatic joint disorders, and acute or borderline compartment syndrome of the foot. Poor nerve conductivity is correlated with muscle weakness, which causes more foot deformities (7).

A simple surgical procedure for correcting claw toe deformity is tenotomy of the flexor digitorum longus (4-10). This procedure can be performed percutaneously and under local anesthesia (8). It corrects the clawing of the toe and eliminates the pressure on the tip and dorsum of the toe (6). Healing ulcer rates of between 92% and 100% and a mean time to heal of between 22 and 60 days are described (7-10).

When abundant callus is present on the distal end of claw toes and hammertoes, flexor tenotomy can be performed for prevention of foot ulcers. The complications and preventive effects of this prophylactic procedure are described in only a few studies. These studies presume that prophylactic flexor tenotomy is a safe procedure with few complications (4,9).

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The main purpose of this retrospective study is to evaluate whether percutaneous flexor tenotomy is an effective intervention to treat and prevent toe ulcers. We describe a larger group than the few published reports on flexor tenotomy (4-10). Another aim is to evaluate whether prophylactic percutaneous flexor tenotomy is a safe and effective intervention to prevent ulceration.

Patients and Methods

Study Design

We reviewed the medical files of patients with claw toe deformities who consecutively underwent percutaneous flexor tenotomies at Rijnstate Hospital in Arnhem and Slingeland Hospital in Doetinchem in the Netherlands between July 2012 and April 2017. This work was approved by the appropriate ethics committees related to the institutions in which it was performed. Ulcers were classified according to the University of Texas Wound Classification System (11). Classification of DM, comorbidities (including cardiovascular events), smoking, medication use, toe distribution, time to healing, reulceration, transfer ulcers, and complications were recorded from the file. Complications were defined as local infection, local bleeding, amputation, or re-intervention. A recurrence of ulceration at the same place was noted as reulceration. A transfer/migrating ulcer was defined as a new neighboring ulcer caused by a changed pressure exposure within 6 months after flexor tenotomy.

Flexor tenotomy was performed in all toes with ulceration and also in toes that were at risk for ulceration. Patients who underwent at least 1 flexor tenotomy on a toe with an ulcer were included in the therapeutic group. Patients who underwent only prophylactic treatments were included in the prophylactic group. Patients without DM were also included.

Patients visited the outpatient clinic 2 to 4 weeks after the procedure for the first time and were followed up until healing of the ulcer was achieved. Thereafter, follow-up was redirected to the general practitioner and podotherapist in a regional cooperation protocol. If a transfer ulcer, reulceration, or infection occurred, the patient was referred to the hospital again.

Surgical Procedure

The patient is in supine position, and the surgical area is iodized and exposed in a sterile manner. In 91 (90.1%) patients, local anesthesia with lidocaine (in later cases, lidocaine with adrenaline was used to prevent local bleeding) was administered, except for the diabetic patients with severe sensory neuropathy who received no anesthesia. With the toe hold in dorsiflexion, a transverse incision with a scalpel (no. 11 blade) is made at the midline of the base of the middle or proximal phalanx. The tendon is cut carefully by little movements of the blade, or a true percutaneous technique is used with a needle. A sudden increase in dorsiflexion of the toe and an absence of ability to active flexion is considered a complete cut of the tendon. A skin suture is seldom necessary. Pressure dressing is applied, and the patient is advised to elevate the leg and limit mobility for 2 days (Figs. 1-4 and Video 1).

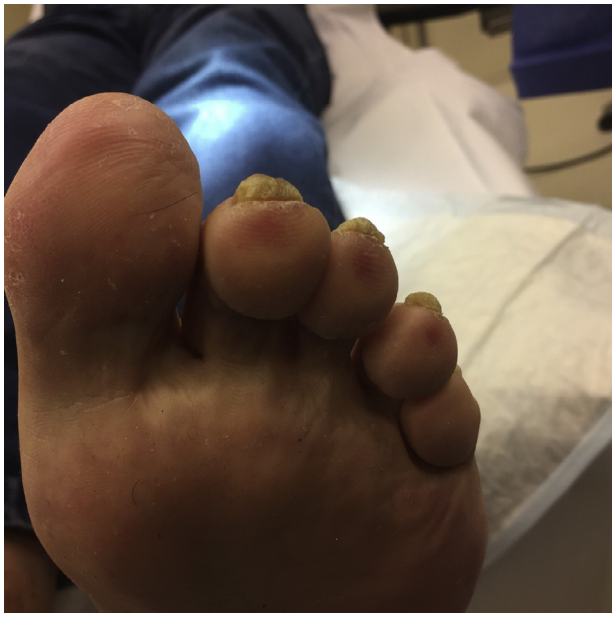

Fig. 1. Flexor tenotomy digits 2 to 5.

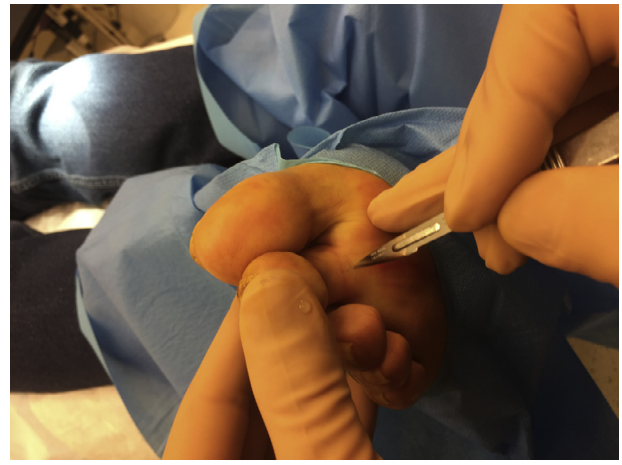

Fig. 2. Flexor tenotomy digits 2 to 5.

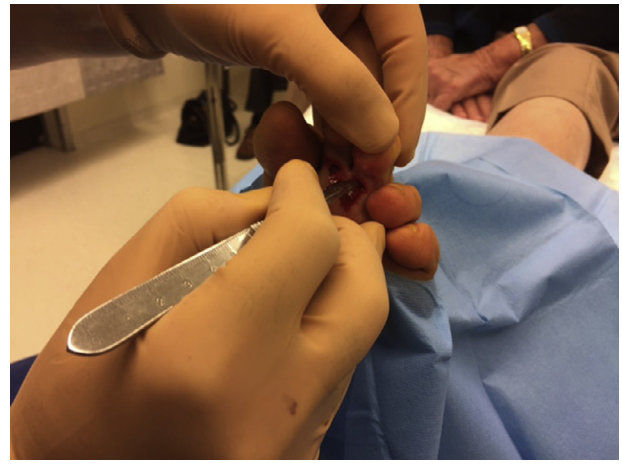

Fig. 3. Flexor tenotomy digits 2 to 5.

Statistical Analyses

Descriptive statistics were presented as mean with standard deviation for normally distributed continuous data, as median and range for skewed continuous variables, and

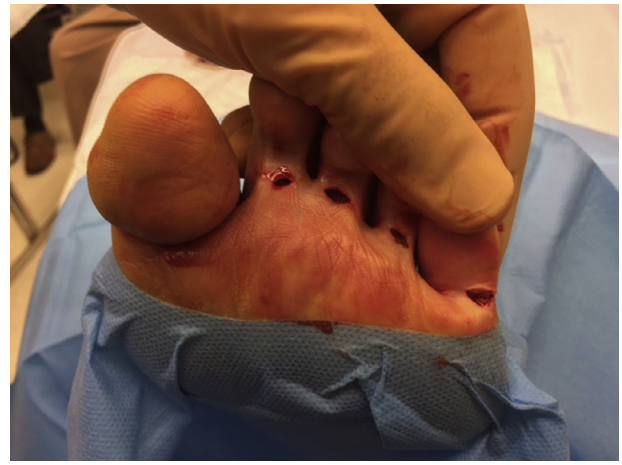

Fig. 4. Flexor tenotomy digits 2 to 5.

as frequency counts and percentages for dichotomous and categorical variables. Tests of the null hypothesis were used to compare the variables between patient groups.

Results

Flexor tenotomy was performed in 75 patients (63.4% males) on 101 feet with a mean age of 71.4 (range 41 to 100) years. Tenotomy was used therapeutically in 84 (83.3%) feet and prophylactically in 17 (16.7%) feet (Table 1). In 77 (76.2%) procedures, the patient had suffered from DM for a mean duration of 17.8 (range 1.1 to 56.8) years. In 12 (11.9%) feet, a custom-made sole was used before flexor tenotomy; in 36 (35.6%) feet, a full orthopedic shoe was used; and in 7 (6.9%) feet, a semi-orthopedic shoe was used. The amount of unilaterally treated toes ranged from 1 to 5. A total of 265 tenotomies were conducted. The distribution of the tenotomies of both groups is shown in Table 2. Median follow-up duration was 13.4 (0 to 66.7) months.

The cause of ulceration in the therapeutic subgroup was neuropathic in 64 (77.1%) feet, ischemic in 1 (1.2%) foot, and neuro-ischemic in 18 (21.7%) feet. The median duration of these ulcers was 124 (range 7 to 1569) days. In the therapeutic group, 77 (95.1%) of the ulcers healed, 58 (71.6%) of these by 2 months postoperatively. Healing of the ulcer was determined when there was no wound at the outpatient clinic visit. The median healing time was 27 (3 to 392) days. In 3 (3.6%) feet, there was missing data about healing or the time to heal. Healing rates and complications of therapeutic and prophylactic percutaneous flexor tenotomies are reported in Table 3. Ulcers that did not heal were all in diabetic feet (Table 4).

Furthermore, in the therapeutic group, 4 (4.8%) feet developed an infection. In 1 (1.2%) foot, the affected toe was amputated. This toe had an infected ulcer at the time of flexor tenotomy, which later expanded to the joint. After healing of the ulcer, 11 (13.3%) feet had a recurrent ulceration. These recurrent ulcerations healed again in a median time of 110 (range 90 to 120) days. In 2 (2.4%) feet, the ulcer migrated to the tip of the toe. In patients with DM, 60 (93.8%) ulcers healed in a median time of 22 (range 3 to 398) days, and in patients without DM, 17 (100%) ulcers healed in a median time of 37 (6 to 304) days. Except for 3 (15.8%) recurrent ulcerations, all complications occurred in patients with DM. Results and differences between diabetic and nondiabetic feet are presented in Table 4.

In the therapeutic group, 42 (51.9%) feet underwent a prophylactic tenotomy at other toes simultaneously, making a total of 162 prophylactic tenotomies (Table 2). As shown in Table 3, pure prophylactic tenotomy was performed in 17 (16.7%) feet. Two (11.8%) feet had postoperative complications: 1 (6%) foot was treated with a pressure bandage because of bleeding, and 1 (6%) foot needed a second intervention because of insufficient tenotomy. In 2 (11.2%) feet, a dorsal ulcer occurred, caused by changed pressure exposure after tenotomy, which healed without complications after conservative treatment.

Table 2
Distribution of tenotomies per toe (N = 265 toes in 75 patients)

Anatomic toe number	Therapeutic	Prophylactic	*p* Value*
1 (hallux)	11 (11)	4 (2)	<.001
2	39 (39)	31 (19)	
3	35 (35)	32 (20)	
4	9 (9)	51 (31)	
5	9 (9)	44 (27)	
Total: 265 toes	103 toes	162 toes	

Data are n (%).
* Fisher's exact test.

Table 3
Healing and complications of flexor tenotomy

	Therapeutic (n = 84 feet)	Prophylactic (n = 17 feet)	*p* Value*
Healed (n = 81 feet)	77 (95.1)	Not applicable	
Median healing time (days)	27 (3 to 398)	Not applicable	
Postoperative complications			
Infection	4 (4.8)	0	1.000
Bleeding	0	1 (5.9)	.188
Amputation	1 (1.2)	0	1.000
Re-intervention	0	1 (5.9)	.188
Recurrent ulceration	11 (13.3)	Not applicable	
Median healing time (days)	110 (90 to 120)	Not applicable	
Appearance	Not applicable	2 (12.5)	
Migrated ulcer	2 (2.4)	Not applicable	

Data are n (%) or mean (range).
* Fisher's exact test

Discussion

Foot ulceration is a common problem that can lead to high morbidity because of mobility limitations and infection (6,10). The treatment of foot ulcers and the prevention of ulcer development are complex (5). Despite conservative treatment such as supportive shoes and orthotics, a substantial number of patients eventually undergo an amputation because of infection or gangrene (4).

The current study shows that after percutaneous tenotomy of the flexor digitorum longus tendon, 95.1% of the ulcers healed, with a median healing time of 27 (3-392) days, and that 71.6% of the ulcers

Table 1
Characteristics of all patients (N = 101 feet in 75 patients)

Patient characteristic	Therapeutic (n = 84 feet in 58 patients)	Prophylactic (n = 17 feet in 17 patients)	*p* Value*
Age (years)	71.3 (41 to 100)	71.4 (50 to 90)	.939
Male sex	51 (62.2)	13 (68.4)	.612
Diabetes mellitus (n = 100 patients)	64 (79.0)	13 (68.4)	.323
Duration of diabetes (years) (n = 58 patients)	18.2 (1.1 to 56.8)	19.4 (3.5 to 54.5)	.522
Cause of ulceration (n = 83 patients)		Not applicable	
Neuropathic	64 (77.1)		
Ischemic	1 (1.2)		
Neuro-ischemic	18 (21.7)		
Median presence of ulcer (days) (n = 79 ulcers in 56 patients)	124	Not applicable	
Custom-made footwear (n = 99 feet in 73 patients)			.153
Custom-made sole	9 (11.3)	3 (15.8)	
Custom-made shoe	33 (41.3)	3 (15.8)	
Semi-custom-made shoe	5 (6.3)	2 (10.5)	
No custom-made footwear	33 (41.3)	11 (57.9)	

Data are mean (range) or n (%).
* Independent-samples *t* test for "age" and "duration of diabetes mellitus"; χ^2 test for "sex" and "diabetes mellitus"; and Fisher's exact test for "custom made footwear."

Table 4
Differences in therapeutic group between diabetic and nondiabetic patients

Therapeutic group (n = 81 feet)	Diabetic (n = 64 feet)	Nondiabetic (n = 17 feet)	*p* Value
Healed	60 (93.8)	17 (100)	.574
Median healing time (days)	22 (3 to 398)	37 (6 to 304)	.488
Postoperative complications			
Infection	4 (6.3)	0	.569
Amputation	1 (1.6)	0	1.000
Other	0	0	
Recurrent ulceration	8 (12.5)	3 (15.8)	.708
Migrated ulcer	2 (3.1)	0	1.000

Data are n (%) or mean (range). Fisher's exact test for "healed," "postoperative complications," "recurrent ulceration," and "migrated ulcer"; independent-samples Mann–Whitney *U* test for "healing time."

healed within 2 months. Because healing of the ulcer was determined when there was no wound at the outpatient clinic visit, the healing could have taken place earlier, making the healing time even shorter than reported.

In 3 (3.6%) feet, there is missing data about healing or time to heal. These patients did not show up for the appointment in the outpatient clinic. Because of incomplete files, in some patients, there is missing data about the duration of DM, cause of ulceration, and duration of the presence of ulceration (Table 1).

This study describes a larger group than the few published reports on flexor tenotomy. The healing rate found in this study corresponds to recently published retrospective studies. Those reports describe healing rates between 92% and 100% (6-8,10). Netten et al (9) reported a healing rate of 92% (in 35 patients), with a mean time of 22 days. In that study, 3 amputations occurred, and 7 reulcerations were found. Kearney et al (8) reported a healing rate of 98.3% with a mean time of 52 days in 48 patients with 58 flexor tenotomies and found 3 infections and 2 amputations of the digit. In a retrospective study of 55 patients with 103 tip-of-the-toe ulcers, in 2014 Tamir et al (6) reported a healing rate of 98%. In that study, 9 transfer ulcers and 1 infection occurred. Laborde (10) reported 28 ulcers in 18 patients, with a 100% healing rate. Three reulcerations were reported, but healing time was not reported.

In this study, in 101 procedures, 4 (4.0%) infections, 1 (1.0%) bleeding, 1 (1.0%) second intervention, and 1 (1.0%) amputation of the digit occurred. In 11 (10.9%) feet, recurrence of ulceration occurred. In 2 (12.5%) of the prophylactic treated feet, an ulcer occurred. The occurrence of complications and reulceration corresponds to rates found in recently published studies (6-8,10). In this study, a mixed population of diabetic and nondiabetic patients were treated, which may have influenced the results.

A few studies describe prophylactic flexor tenotomies. Netten et al (9) described the effectiveness of prophylactic flexor tenotomies. None of the 9 prophylactic procedures they performed resulted in an ulcer. Tamir et al (4) described prophylactic flexor tenotomy as well, but did not describe the effectiveness of the procedures. In this study, in 17 feet, a pure prophylactic procedure was performed because of a high risk of ulceration and shoe-fitting problems in the presence of severe claw toes. The few complications seen in the prophylactic treated toes from the therapeutic group suggest that the procedure is safe and effective as a prophylaxis. In our opinion, prophylactic flexor tenotomy should be performed more often in preventing the development of ulceration and enhance orthopaedic shoe fitting.

The current study did not include a control group without treatment or a control group with another treatment. Therefore, a direct comparison could not be made.

In conclusion, percutaneous tenotomy of the flexor digitorum longus is a highly effective and safe minimally invasive procedure for the treatment and prevention of ulcers and therefore should be integrated and considered in the daily standard care for each diabetic foot patient.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1053/j.jfas.2019.03.004.

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