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Percutaneous Plantar Fascia Release With Needle: Anatomic Evaluation with Cadaveric Specimens

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ABSTRACT

Percutaneous plantar fascia release with needle is a novel procedure for the treatment of plantar fasciitis. The objective of this cadaveric study is to perform an anatomic evaluation of the percutaneous plantar fascia release method using a conventional hypodermic needle. In this study, we used 14 fresh-frozen cadaveric trans-tibial amputation specimens. Percutaneous plantar fasciotomy with a conventional hypodermic needle was performed. After a proper dissection, the width of the plantar fascia, the thickness of the medial border, and the width of the cut segment were measured and recorded. Any muscle damage on the flexor digitorum brevis and damaged area depth were recorded. Any damage on the lateral plantar nerve and the first branch of the lateral plantar nerve, also known as Baxter's nerve, and their distance to fasciotomy were also recorded. Mean width (± standard deviation) of the plantar fascia was measured as 20.34 ± 4.25 mm. The mean thickness of the medial border of the plantar fascia was 3.04 ± 0.54 mm. Partial fasciotomy was performed in all cadavers with 49.47% ± 7.25% relative width of the plantar fascia. No lateral plantar nerve, or its first branch Baxter's nerve, was damaged, and the mean distance from the deepest point of the fasciotomy up to the Baxter's nerve was 8.62 ± 2.62 mm. This cadaveric study demonstrated that partial plantar fasciotomy can be achieved via percutaneous plantar fascia release with a conventional hypodermic needle without any nerve damage.

Plantar fasciitis, reportedly the most common cause of pain in the inferior heel, is estimated to account for 11% to 15% of all foot symptoms requiring professional care among adults (1,2). In the United States, ~1 million patient visits per year are made to office-based physicians and hospital outpatient departments for the diagnosis and treatment of plantar fasciitis (3). Although the incidence reportedly peaks in people between the ages of 40 and 60, younger people (especially athletes, such as marathon runners) are susceptible to this condition as well (4–6).

Plantar fascia is the continuation of the deep foot fascia and consists of 3 parts. The central part of the plantar fascia is the thickest part, named plantar aponeurosis (PA). The PA is attached to the medial calcaneal tubercle on the posterior. The lateral plantar nerve (LPN) and artery and the first branch of the LPN are located in anatomic proximity to the PA calcaneal attachment side. The first branch of LPN, also called Baxter's nerve, provides motor innervation to the quadratus plantae, flexor digitorum brevis (FDB), and abductor digiti minimi muscles. Baxter's nerve also carries sensory information from the calcaneal periosteum and the long plantar ligament. The anterior PA widens and diverges into 5 digital slips, which attach to the fibrous flexor sheaths and plantar metatarsal plates. It supports the longitudinal arch, and it elongates with rising mechanical load. The PA covers the FDB muscle on the posterior. The medial and lateral portion of the plantar fascia, which are thinner, cover abductor hallucis and abductor digiti minimi muscles, respectively (7–9).

The site of abnormality in the plantar fasciitis is typically near the site of origin of the PA at the medial process of the calcaneal tuberosity. The high incidence seen in runners indicates the presence of recurrent microtrauma in the pathophysiology of the condition (10). Histological examination of the lesion shows degenerative changes in the plantar fascia with or without fibroblastic proliferation, in addition to chronic inflammatory changes (11,12).

Conservative therapies such as nonsteroidal antiinflammatory drugs, strapping, corticosteroid injections, platelet-rich plasma

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injection, botulinum toxin injection, orthotics, heel cups, night splints, and shock wave therapy have been used to treat this condition (13–33). In 90% of cases, plantar fasciitis can be successfully treated using these conservative measures (34). Surgical intervention might be indicated for patients in whom conservative measures have failed for at least 6 months (35,36). The first defined surgical procedure for the treatment of persistent heel pain owing to chronic plantar fasciitis is open plantar fasciotomy. This method is an effective treatment with a 50% to 95% success rate (37–39). This traditional open approach to plantar fascial release can be associated with a prolonged recovery period, often requiring the patient to remain nonambulatory for a period of 4 to 6 weeks, with a gradual return to full activity over an additional 8 weeks (40). This has led to endoscopic and percutaneous techniques that are associated with shorter postoperative recovery periods and more satisfactory outcomes (41,42). Today, these less invasive endoscopic and percutaneous techniques are widely used in the surgical treatment of plantar fasciitis by foot and ankle surgeons. The operating room environment and special equipment are required for most of these defined procedures.

The percutaneous release technique with needle was first used in trigger finger surgery. Eastwood et al (43) described trigger finger release as an office procedure in 1992 for the first time. Percutaneous trigger finger release with needle was shown as an effective and reliable technique in many clinical trials and has become a routinely used procedure in daily practice (44).

The objective of this cadaveric study is the anatomic evaluation of the percutaneous plantar fascia release method with a conventional hypodermic needle. Anatomic studies have been done previously to evaluate endoscopic techniques. However, to the best of our knowledge, this is the first cadaveric study that evaluates anatomic aspects of percutaneous plantar fascia release with a conventional hypodermic needle.

Materials and Methods

In this study, 14 frozen cadaveric trans-tibial amputation specimens were selected and stored at −20°C. Specimens were thawed at room temperature and prepared. Nine were right feet, and 5 were left feet; 11 were male, and 3 were female. The mean age at death was 66 (range 52 to 75) years old. The study included adult cadaveric samples without any prior foot or ankle surgery.

The feet were fixed with the ankle in dorsiflexion, and the landmark for the midline of the PA was marked according to the definition of Çatal et al (45). The midline of the PA passed from the second intermetatarsal web space distally. To determine the proximal landmark, another line was drawn between the medial and lateral tubercles of the calcaneus and equally divided into 3 parts. The one third medial and one third middle junction of this line was determined as the proximal intersection point of the midline. The midline of PA was drawn by connecting proximal and distal landmarks on the sole with a straight line. The midline of the PA and its distal and proximal landmarks are illustrated in Fig. 1. The medial malleoli posterior border was used as a landmark to determine the location of fasciotomy in the sagittal plane. Ogilvie-Harris and Lobo (46) investigated the safety of point of plantar fasciotomy and portals in cadaveric specimens. They stated that the posterior aspect of the medial malleolus provided a reliable guide to the point of transection of the plantar fascia. We used the same landmark, and another line was drawn from the posterior border of the medial malleolus toward the plantar region. The intersection point of this line with the midline of the PA was determined as the location for partial plantar fascia release, and a midline needle was inserted from that point. Afterward, the PA medial border was palpated, and a hypodermic 18-gauge needle (B. Braun Medical Inc., Melsungen, Hessen, Germany) was inserted percutaneously from medial to lateral with an angle of ~45° to the medial border of the plantar fascia. The stretched plantar fascia, with dorsiflexion of the metatarsophalangeal joint, was cut by the needle's up-and-down movements, until it reached the midline needle. Decreased tension of the plantar fascia during cutting was felt for all specimens (Fig. 2*A*).

After percutaneous partial plantar fascia release with needle was done for all specimens, the plantar fascia was exposed by posterior extensile calcaneal approach. Cutaneous and subcutaneous tissues with fat pads were removed from the posterior border of calcaneus to metatarsal heads (Fig. 2*B*). The width of the plantar fascia, the thickness of the medial border, and the width of the cut segment were measured. The FDB muscle was assessed to determine damage; if it was damaged, the depth of the damage was recorded. Then, a tarsal tunnel incision was made from the posterior border of the medial malleolus for dissecting the LPN and Baxter's nerve. Any nerve damage and distance to fasciotomy were recorded (Fig. 3). Descriptive statistics were used to report relative width of the cuts and the other measurements.

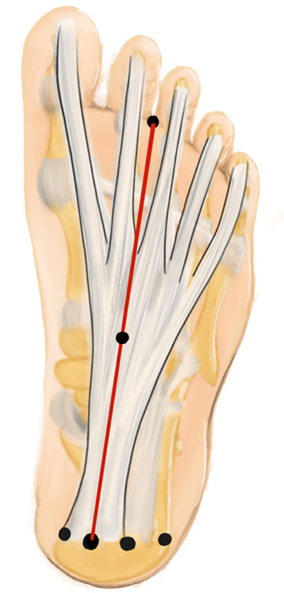

Fig. 1. The midline of the plantar aponeurosis, distal landmark, and proximal landmark.

Results

The mean ± standard deviation width of the plantar fascia was 20.34 ± 4.25 (range 15.96 to 28.56) mm. The mean thickness of medial border of the plantar fascia was 3.04 ± 0.54 (range 2.17 to 3.95) mm. Partial fasciotomy was performed in all cadavers. The relative width of all percutaneous cuts was 49.47% ± 7.25% (range 35.7% to 61.5%) of the plantar fascia. No damage of LPN or Baxter's nerve was seen in any of the specimens. The mean distance from the deepest point of the fasciotomy, cut to Baxter's nerve, was 8.62 ± 2.62 (range 3.72 to 12.35) mm. In 4 of 14 (28.5%) specimens, superficial FDB damage was observed. The Table shows the measurements in detail.

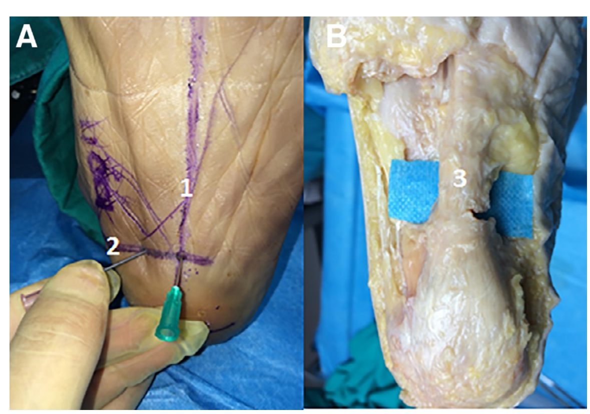

Fig. 2. Percutaneous plantar fascia release. (*A*) Left foot, percutaneous plantar fascia release with needle; (*1*) midline of the plantar fascia, (*2*) line passing through posterior of medial malleolus. (*B*) Right foot, dissected plantar fascia after fasciotomy; (*3*) plantar fascia.

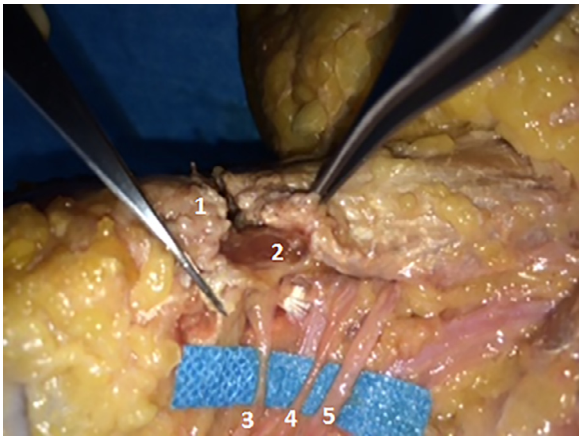

Fig. 3. Dissected neural structures. Dissected neural structures on a right foot, view from the medial. (*1*) Plantar fascia, (*2*) flexor digitorum brevis muscle, (*3*) Baxter's nerve, (*4*) lateral plantar nerve, (*5*) medial plantar nerve.

Discussion

While performing a percutaneous technique, the correct identification of landmarks is essential for an effective and safe surgery. Accurate identification of the midline of the plantar fascia is important to perform a partial plantar fasciotomy. It was reported that total plantar fasciotomy can cause problems such as destabilization of the medial longitudinal plantar arch, chronic pain in the middle foot, and gait disturbance (47). Brugh et al (48) reported that >50% release of plantar fascia increases the risk of developing lateral column syndrome, described as postoperative pain in the lateral column area. Murphy et al (49) stated that lateral column pain can be avoided when one third of the plantar fascia is released instead of a total release. Hofmeister et al (50) published an anatomic study of endoscopic plantar fascia release. They reported an average 81% release of total plantar fascia width. A similar cadaveric study by Hawkins et al (51) reported an average 82% of the width of the fascia, with a range of 53% to 100%. They also stated that controlling the exact proportion of the fascia released is a challenge. In our study, no total fasciotomy was observed in any specimens, and an average release of 49.47% of total PA width was obtained. We believe that percutaneous plantar fascia release with needle, using the landmark definition of Çatal et al (45), is an effective method for partial fasciotomy. The midline of the PA was not determined in other percutaneous plantar fasciotomy techniques in the literature (39,52,53).

We found the mean width of the PA to be 20.3 mm. In a study done by Barrett et al (54), the authors investigated endoscopic heel anatomy using 200 fresh-frozen cadaveric specimens. They reported the mean of total plantar fascia width as 28.8 mm and included the lateral band of PA in the calculation. When this value was subtracted, mean PA width was calculated as 18 mm. In another anatomic study, Hawkins et al (51) reported the mean width of PA to be 17.4 (range 14 to 29) mm. Our results of PA width are similar to those in the literature and are calculated as ~20 mm. Therefore, we argue that the cut should not exceed 10 mm to achieve partial plantar fasciotomy. The medial border thickness of PA was observed as a mean of 3.04 mm in our study. Hawkins et al (51) reported the mean medial PA thickness as 3.5 mm, whereas Barrett et al (54) reported it as 4.5 mm. Increased fascial thickness has been reported in patients with symptomatic plantar fasciitis. Berkowitz et al (55), using magnetic resonance imaging, found the mean maximum thickness of the PA in 15 asymptomatic patients to be 3.2 mm. The study also calculated a mean maximum thickness of the PA as 7.4 mm in 10 symptomatic patients. These measurements would correlate with this study's 3.04-mm mean measurement of the thickness of the medial border of the plantar fascia.

In a percutaneous or endoscopic plantar fasciotomy, preventing damage to the other structures within anatomic proximity is crucial for the reliability of the technique. The neural structures (LPN and Baxter's nerve) in this region might be at risk because of the inability to visualize them during percutaneous release. None of the LPN or its first branch Baxter's nerve were damaged in current study. The mean distance from the deepest point of the fasciotomy cut to Baxter's nerve was calculated as 8.6 mm. In similar anatomic studies, the authors preferred to calculate the distance between the superior medial edge of the plantar fascia and Baxter's nerve. Hawkins et al (51) reported the main distance as 11 mm, whereas Hofmeister et al (50) reported it as 12.3 mm. We believe that calculating the distance between the deepest point of fasciotomy to the nerve is more appropriate to determine the reliability of the technique. Superficial FDB damage was observed in 28.5% of all specimens in the current study. The FDB muscle acts as a protection layer for Baxter's nerve during the fasciotomy. Hofmeister et al (50) reported FDB damage in 6 of 13 (46%) specimens. They also stated that all FDB damage was superficial. According to our data, percutaneous plantar fascia release with conventional hypodermic needle is as reliable as the other endoscopic techniques defined in the literature.

Table
The measurements of specimens (N = 14 specimens)

Cadaveric Specimen	Width of Fascia (mm)	Width of Fascia Cut (mm)	Cut(%)	Fascia Thickness (mm)	Distance From Cut to Baxter's Nerve (mm)	FDB Muscle Cut (mm)
1	28.36	15.65	55.18	3.63	12.35	0
2	28.56	13.76	48.17	3.25	11.21	0
3	22.73	11.17	49.14	2.88	8.34	0
4	18.5	9.94	53.72	2.9	4.61	3.11
5	21.06	12.2	57.92	3.95	7.05	0
6	18.23	8.91	48.87	2.38	8.92	1.56
7	18.62	9.84	52.84	3.4	10.32	0
8	24.43	12.3	50.34	3.25	11.49	0
9	16.16	5.78	35.76	2.64	5.22	2.43
10	20.58	12.66	61.51	2.87	8.41	0
11	16.03	7.86	49.03	2.44	9.67	0
12	18.4	9.44	51.30	2.17	9.28	0
13	17.13	6.39	37.30	2.96	10.12	0
14	15.96	6.63	41.54	3.84	3.72	3.02
Mean ± standard deviation	20.34 ± 4.25	10.18 ± 2.94	49.47 ± 7.25	3.04 ± 0.54	8.62 ± 2.62	

Abbreviation: FDB, flexor digitorum brevis.

In the literature, there are also studies that use needles for plantar fascia release using techniques different from those described in our study. Yanbin et al (56) performed percutaneous latticed plantar fasciotomy with a needle-like flat-blade scalpel. They punctured the plantar fascia multiple times without an incision. They reported good to excellent results for all patients according to Mayo scores at a mean follow-up point of 13 months. Iborra et al (57) defined ultrasound-guided plantar fascia release with needles. They placed the needle horizontally and the transducer in a transverse position to perforate the plantar fascia repeatedly from medial to lateral. They reported significant improvements of visual analogue scale and foot and ankle disability index scale values at 12 months' follow-up duration. In both techniques, partial fasciotomy was attempted using multiple perforations using needles. However, in our study, we used the needle like a blade, and fasciotomy was performed by the vertical movement of the needle, as in trigger finger release. Moreover, we used a midline needle to obtain a partial fasciotomy. To the best of our knowledge, this technique was not previously reported in the literature.

There are some limitations to our study. One is that we did not know whether there was symptomatic plantar fasciitis in the cadavers we used. Because we know that the thickness of the plantar fascia increases in symptomatic patients (55), this increase in the thickness of the plantar fascia can cause changes in the measurements. Second, dissection of neural structures can also cause minimal changes in the measurements, but we believe those to be negligible. Another limitation is that we had a small number of cadaveric legs. The use of additional specimens would potentially increase the impact of this study. Finally, as with any cadaveric study, we cannot make definitive claims as to how this procedure translates into clinical practice. The ultimate test for any procedure is whether it is proven in controlled clinical studies. We believe that this easy and inexpensive technique has the potential to become a routinely used office procedure by foot surgeons.

In conclusion, this cadaveric study demonstrated that partial plantar fasciotomy can be achieved via percutaneous plantar fascia release with a conventional hypodermic needle without any nerve damage. Future clinical trials and longer series are required to demonstrate the effectiveness and safety of this novel technique.

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