

Hydro Dissection Therapy for the Treatment of Tarsal Tunnel Syndrome

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Abstract

Tarsal Tunnel Syndrome (TTS) is the entrapment of the tibial nerve and its branches at the ankle joint. It is commonly encountered focal neuropathy and should be considered in the differential diagnosis of foot pain and sensory alteration. Incident rates of TTS are unknown, studies suggest it is more prevalent in females and can occur at any age. Some studies suggest a prevalence of 0.4% - 0.5% based on electrophysiological investigations. A recent study which employed a more detailed interrogation of the tibial nerve suggests a higher prevalence rate. This thorough electrodiagnostic evaluation (EDX) can identify the location of the focal neuropathy as the tibial nerve complex has significant variability in its branching pattern at the tarsal tunnel. Surgical treatment of tarsal tunnel is invasive and has variable results. The current paper presents a noninvasive treatment, that of hydro dissection injection using ultrasound guidance. This procedure has been shown to give both short-term and long-term relief from this painful condition.

Keywords

Tarsal Tunnel Syndrome, Baxter Neuropathy, Hydro Dissection Injection, Ultrasound Guidance, EDX Guidance

1. Introduction

Hydro dissection injections have become popular in recent years as a conservative treatment for nerve entrapment syndrome in an effort to alleviate some of the symptoms caused by focal neuropathy.

Ultrasound guided hydro dissection injections are a minimally invasive technique used to deviate symptoms of neuropathy by separating the nerve from adhesions and soft tissue areas that may be compressing the neural structure. This treatment can reduce nerve compression and improve nerve mobility [1]. This

treatment has been shown to improve symptoms, function, decrease CSA of entrapped nerves and improve EDX changes in cases of CTS [2].

Tarsal tunnel syndrome is the entrapment of the posterior tibial nerve at the level of the ankle joint. The nerve entering the ankle through an anatomical space referred to as the tarsal tunnel. Tarsal Tunnel Syndrome is the most common lower limb focal neuropathy (**Figure 1**). In the past, there was a poor pickup rate among Electro diagnostic laboratories. This was due to no gold standard being available for the diagnosis of this common condition first identified in the early 1960's, by independent researchers [3]-[5].

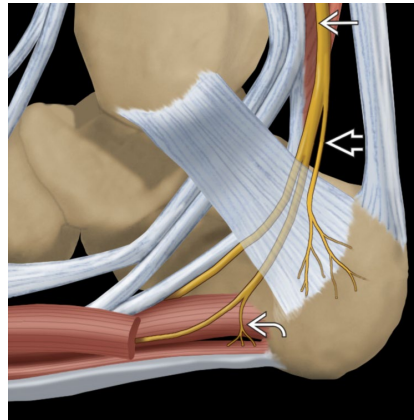


Figure 1. Medial ankle joint and posterior tibial nerve.

EMG/NCS (Electromyography/Nerve Conduction Studies) are diagnostic tools used to evaluate nerve and muscle function. While they can be helpful in diagnosing Tarsal Tunnel Syndrome (TTS), their pick rate, or the percentage of cases where they confirm the suspected diagnosis, is relatively low. This was in part due to the paucity of tests performed and the variation in testing protocols employed.

In 2017, research into the electrode diagnostic methodology of tarsal tunnel syndrome identified that performing all the known neurophysiological techniques at the tarsal tunnel, and assessing 12 parameters resulted in a higher diagnostic yield for this condition [6]. Prior to this paper, the pickup rate in EDX laboratories for TTS was of the order of 0.52% of the cases seen. This study which interrogated the tibial nerve at the tarsal tunnel using sensory and motor nerve conduction studies as well as needle EMG increased the diagnostic yield to 3.2% of cases seen.

2. Anatomy of the Posterior Tibial Nerve at the Level of the Tarsal Tunnel

The posterior tibial nerve is a branch of the sciatic nerve with a nerve root supply of lumbar nerve root 4 and 5 and sacral nerve roots 1, 2 and 3. (L4, L5, S1, S2 and S3). In its distal journey, it travels behind the medial malleolus through the proximal tarsal tunnel where it divides into terminal branches; the medial plantar nerve, the lateral plantar nerve and the calcaneal nerve (**Figure 2**). These 3 terminal branches have further branches. In 1984, Baxter described entrapment of the

first branch of the lateral plantar nerve which referred to the inferior calcaneal nerve or the Baxter nerve [7] [8]. This nerve branches separately from the main tibial nerve in 46% of feet. There is great variability in the branching patterns of the tibial nerve at this location. 9 specific patterns being identified. This results in a possible 110 permutations of the four branches of the posterior tibial nerve at the level of the tarsal tunnel.

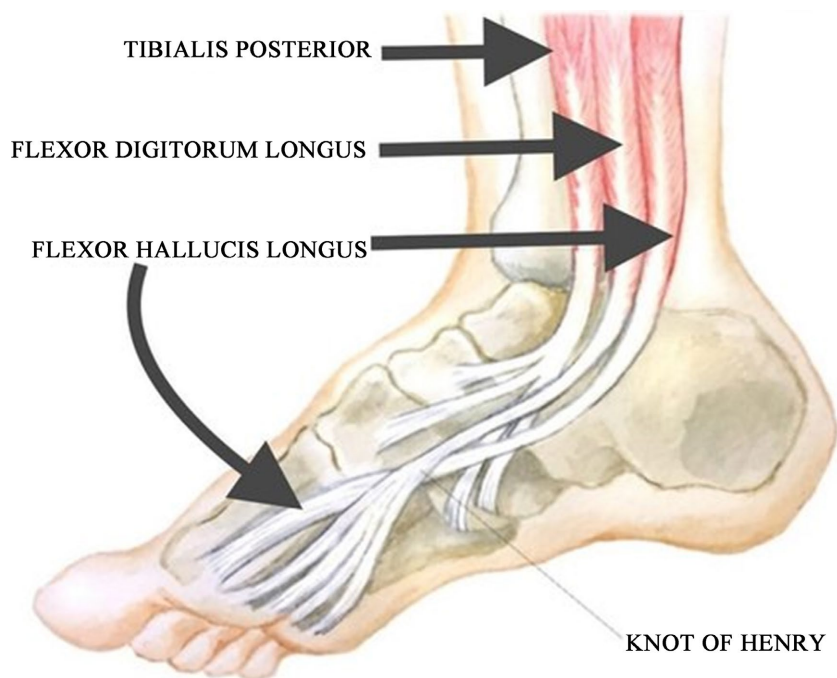


Figure 2. Tendons at the medial ankle joint and tarsal tunnel.

3. Tarsal Tunnel Syndrome Symptoms

Patients with TTS typically complain of numbness in the foot radiating to the big toe and the first 3 toes, pain, burning, electrical sensations, and tingling over the base of the foot and the heel.

The symptoms are dependent on the anatomical location of entrapment of the posterior tibial nerve. Symptoms can be very localized in the case of the calcaneal and Baxter nerves or more generalised if the entrapment is proximal. In high entrapments, the entire foot can be affected as varying branches of the tibial nerve can become involved. Ankle pain is also present in patients who have high level entrapments.

An accurate history is essential when assessing a potential TTS patient. Common symptoms include,

- Shooting pain in the foot
- Numbness
- Tingling or burning sensation
- Heel pain mimicking Plantar Fasciitis
- A history of ankle trauma or previous ankle surgery

Tarsal Tunnel Syndrome is frequently unrecognised and can greatly impact patients' quality of life. Patients may exhibit higher levels of stress and anxiety and dissatisfaction in relation to their ongoing and seemingly unresolvable condition.

4. Baxter Neuropathy

Baxter's nerve, or the first branch of the lateral plantar nerve, typically branches off just proximal to the abductor hallucis muscle. As Baxter's nerve descends deeper into the foot, it passes through a portal referred to as the porta pedis or "window to the foot". The porta pedis is a well-known location entrapment for Baxter's nerve, it can occasionally be compromised deep into the plantar fascia (**Figure 3**).

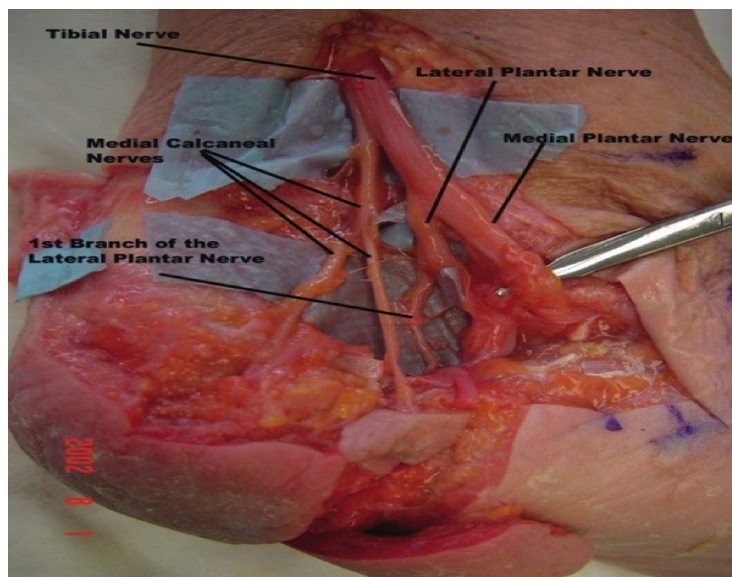


Figure 3. Anatomical dissection of the tibial nerve and branches at the tarsal tunnel.

As Baxter's Nerve reaches the plantar aspect (bottom) of the abductor hallucis muscle, the nerve turns to the lateral aspect of the foot and passes anteriorly and medial to the calcaneus (heel bone). This location is known as the calcaneal tuberosity and is the location where a heel spur may form and the nerve can also be compromised. Entrapment of this nerve results in medial plantar heel pain, which can be described as burning tingling or aching.

5. Electrodiagnostic Evaluation of Tarsal Tunnel Syndrome

Tarsal Tunnel Syndrome [TTS] is the most common lower limb focal neuropathy, but it has a poor pick up rate in most Electrodiagnostic (EXD) Laboratories. There is no gold standard for assessing TTS. The tibial nerve has a complex branching system with 4 main branches and 9 different patterns of division.

TTS has a low pick-up rate using current standard assessment methods accounting for between 0.5% and 0.6% of positive cases referred to electrodiagnostic laboratories. This is in part due to the lack of standardisation in testing protocols.

In certain institutions 2 to 3 tests are only performed, and these are nerve conduction studies to the tibial motor and sensory nerves.

A recent study [6] had a significantly higher pick up rate of 3.3% with 40 positive cases identified out of a population of 1210 patients referred to an electrodiagnostic laboratory in a calendar year. A combination of positive findings was observed.

In this study, 7 EDX tests were performed, assessing 12 parameters:

- Medial plantar sensory study [assessing distal latency and amplitude of response]
- Lateral plantar sensory study [assessing distal latency and amplitude of response]
- Calcaneal sensory study [assessing distal latency and amplitude of response]
- Tibial motor study to the AH muscle [assessing distal latency and amplitude of response]
- Tibial motor study to the ADQ muscle [assessing distal latency and amplitude of response]
- Needle EMG to the Abductor Halucis muscle (AH muscle)
- Needle EMG to the Abductor Digiti Quinti muscle (ADQ muscle)

In this study, there were on average 4.3 positive parameters. The calcaneal sensory study and the needle EMG to the distal AH and ADQ muscles were the most sensitive tests. These tests are not routinely performed in many institutions.

6. Ultrasound Evaluation of Tarsal Tunnel Syndrome

Ultrasound evaluation of tarsal tunnel syndrome (TTS) involves visualizing the structures within the tarsal tunnel, including the posterior tibial nerve and its branches, to identify potential nerve entrapment or other abnormalities. It's a useful tool for confirming clinical suspicion and can help determine the cause of the syndrome such as a mass in the Tarsal Tunnel, an intraneural ganglion cyst, nerve trauma, nerve sheath tumours or a varicosed vein. Ultrasound which is an excellent adjunct investigation often fails to be specific in diagnosing the focal branch of the tibial nerve that is compromised. This is more readily achieved by detailed EDX examination.

The tibial nerve and its branches are well visualized with high frequency ultrasound. The peripheral nerve is identified by the fascicular pattern that is distinct from other tissues in the short axis view. The tibial nerve can be described as having a honeycomb pattern. The use of Color Doppler also assists specifically in identifying the tibial nerve at the level of the tarsal tunnel, the nerve having a specific relationship to the vasculature.

7. Treatment of Tarsal Tunnel Syndrome

The surgical release of the tibial nerve at the level of the tarsal tunnel is the surgical treatment for this condition. However, patient satisfaction after tarsal tunnel surgery varies between 55% and 72%. Mickelson reported a 72% patient satisfaction following decompression of the tarsal tunnel in 1998 and Marco and Jiang re-

ported a 57% satisfaction rate following the procedure in 2003. Between 20% and 30% of patients report moderate satisfaction or dissatisfaction following surgery. Hence surgery is only undertaken when all other therapeutic options fail.

The increased availability of ultrasound technology in the clinical setting has opened the way for the treatment of this painful condition in an outpatient setting. Hydro dissection injections have a significant role to play in the clinical management of individuals with tarsal tunnel syndrome.

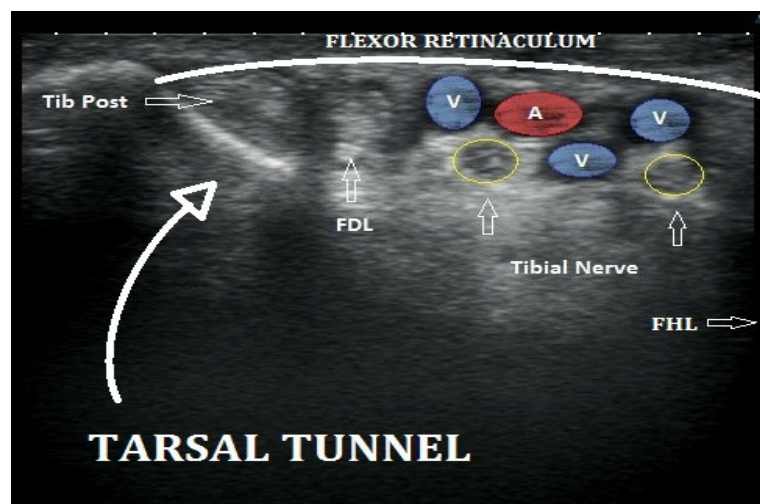
Hydro dissection injections, using ultrasound and EDX guided injections have been used in the successful treatment of carpal tunnel syndrome by freeing the median nerve relieving numbness, tingling, and wrist pain. This technique is also used in a variety of peripheral nerve entrapments such as cubital tunnel syndrome. There isn't a universally established protocol for these procedures and further research will be required to establish the most suitable protocols [9].

8. Procedure to Perform a Hydro Dissection Injection of TTS

The posterior tibial nerve and its branches can be identified at the level of the tarsal tunnel syndrome. A high frequency linear probe [10 - 18 hz] is used.

The landmark of the medial malleolus is employed as a starting point as the ultrasound probe is placed in transversely [short axis].

The ultrasound image can identify the flexor retinaculum which forms the roof of the tarsal tunnel and the anatomical structures that are housed within the tunnel, namely anterior to posterior (**Figure 4**).



Tibialis Tendon Posterior (Post Tib)); Flexor Digitorum Longus (FDL); A (Artery); V (Vein); Tibial nerve and branches) Flexor Hallucis Longus (FHL).

Figure 4. Ultrasound image of the Tarsal Tunnel in short Axis view. Identifying.

- posterior tibial tendon [T]
- flexor digitorum longus tendon [D]
- posterior tibial artery [A]
- posterior tibial veins [V]

- posterior tibial nerve and its branches [N]
- flexor hallucis longus tendon [H]

The posterior tibial nerve lies posterior and lateral to the blood vessels. The blood vessels are easily identified using the Color Doppler mode on the ultrasound. The nerve appearing as a hyperechoic oval structure. The fascicular patterns which are frequently visualized in other nerves are not always present in the posterior tibial nerve. The nerve can be followed distantly towards the heel. The nerve typically bifurcates one to three centimeters distal to the medial malleolus. Each of the branches can be followed by using the ultrasound probe in both the transverse and longitudinal modes. Needle EMG using nerve stimulation is also helpful in localizing the branches of the tibial nerve.

Linear fascicles can be identified in the long axis mode. At this time care should be taken to identify space occupying lesions which may be compressing the nerve or its branches.

In the case of suspected Baxter neuropathy, the nerve should be followed down by ultrasound from its origin as the first branch of the lateral calcaneal nerve to the calcaneal tuberosity. Nerve stimulating injecting needle can be of value to follow the nerve along this course if it not readily visualized on ultrasound [10].

9. Treatment Options in Cases of Tarsal Tunnel Syndrome

Treatment for tarsal tunnel syndrome typically starts with conservative methods aimed at reducing nerve compression and inflammation and may progress to surgery if conservative approaches are not successful. Conservative treatments include rest, ice, anti-inflammatory medications, orthotics, physical therapy. Utilization of steroid injections are often employed if these treatments fail. If these conservative measures fail, surgical options such as surgical tarsal tunnel release like may be considered.

Hydro dissection injection using ultrasound guidance, is a promising, safe and effective treatment for tarsal tunnel syndrome (TTS), offering pain relief and improved function. While studies indicate potential benefits, more research is needed to improve patient selection and where this treatment fits in the TTS treatment algorithm.

10. Hydro Dissection Injection

Having identified the neural structures and with EDX assessment of the site of entrapment, the ultrasound system can assist in guiding the hydro dissection injection.

A solution of fluid which can contain a steroid with a local anesthetic, saline or dextrose solution is injected around the nerve using a fine needle which is inserted near the nerve using ultrasound guidance. This can be visualised in real time on the ultrasound screen. The fluid, which is slowly injected will separate the nerve from the surrounding tissue, such as tendons, fascia or scar tissue, which may be compressing it. It can also release adhesions and improve nerve mobility. In cer-

tain instances, an EMG needle, which can be used to stimulate nerves and as an injecting tool, is also used to more accurately locate the neural structure and location of compression, which can be between fascial planes. Disposable Hypodermic Needle Electrode can be used to stimulate neural structure, to record EMG activity, while allowing injection of medication. This aids in the accuracy of the placement of the injectate.

11. Efficacy and Safety of Ultrasound-Guided Hydro Dissection Injections for Peripheral Nerve Entrapment

Ultrasound-guided hydro dissection is a safe and effective treatment for peripheral nerve entrapment [11]. Injectate selection can range from dextrose, saline or corticosteroids and local anaesthetic. Choice of the injectate solution should be based on the injectate mechanism, effectiveness, and safety profile. Most of the research relates to median neuropathy at the wrist (Carpal Tunnel Syndrome) [12] Complications are rare but may include swelling at the injection site and infection. Patients can usually return to their normal activities the day after the procedure.

The US-guided injection of anaesthetics with corticosteroids into the tarsal tunnel has been reported as a safe and effective nonsurgical treatment option for patients with TTS [13].

12. Outcome of Hydro Dissection of TTS

Patients often experience immediate relief from symptoms if local anaesthetic is used as part of the injectate. Studies suggest that ultrasound-guided hydro dissection can be an effective treatment for tarsal tunnel syndrome, with patients experiencing pain relief and improved function. Hydro dissection therapy for TTS is a minimally invasive procedure and a good alternative to more invasive surgical option [14] [15].

13. Complications Following a Hydro Dissection Injection

Hydro dissection injection is a minimally invasive procedure and the generally considered a safe procedure complications can occur. Common minor complications improve include pain injection site, bruising or swelling especially if a blood vessel has been nicked during the needle insertion. There can also be a temporary increase in symptoms. As with all injections, infections and an allergic reaction to the injected substance are common complications and, as with all medical procedures, should take place in a sterile field. More severe complications would include a nerve injury if the needle or injectate damages the tibial nerve or its branches. Hematoma and intramural injections are rare but can result in intense pain. The use of guidance, both ultrasound and nerve stimulation will lessen these rare but potential complications.

14. Conclusion

Tarsal Tunnel Syndrome is a common and frequently unrecognised condition,

which results in both physical and psychological distress. Improved diagnostic protocols for assessment of this condition have improved resulting in greater pick-up rates. Surgical outcomes can be variable when treating this condition. Ultrasound guided minimally invasive surgical approach for the release of the flexor retinaculum using a hydro dissection technique is a new promising effective, and safe decompression technique treating selected patients with a proximal Tarsal Tunnel Syndrome.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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