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DIAGNOSIS AND ORTHOSIS TREATMENT OF TARSAL TUNNEL SYNDROME

The posterior tibial nerve is the largest nerve in the ankle. It travels deep to the flexor retinaculum in the *tarsal tunnel* along with the posterior tibial tendon, flexor digitorum longus tendon and flexor hallucis longus tendon and the posterior tibial artery and veins. As these structures pass into the plantar foot from the ankle, they travel deep to the abductor hallucis muscle in a "canal" known as the *porta pedis*. Before the posterior tibial nerve enters into the porta pedis, it splits into two branches, the medial plantar nerve and lateral plantar nerve. The medial plantar nerve supplies plantar sensation to the medial three digits and medial half of the 4th digit. The lateral plantar nerve supplies sensation to the 5th digit and to the lateral half of the 4th digit. The abductor hallucis, flexor hallucis brevis and first lumbrical all receive their motor supply from the medial plantar nerve, whereas the rest of the plantar intrinsic muscles receive their motor supply from the lateral plantar nerve (Kelikian AS (ed): Sarrafian's Anatomy of the Foot and Ankle: Descriptive, Topographic Functional. 3rd ed. Lippincott Willaims & Wilkins, Philadelphia, 2011).

The pathological condition known as *tarsal tunnel syndrome* is thought to occur due to a compression or entrapment neuropathy of the posterior tibial nerve within the region of the medial ankle. Patients with tarsal tunnel syndrome will complain of numbness, tingling, burning and/or a shooting sensation in the plantar aspect of the foot. The first description of the symptoms of tarsal tunnel syndrome was made in 1960 by Kopell and Thompson (Kopell HP, Thompson WA: Peripheral entrapment neuropathies of the lower extremity. New England J Med, 262(2):56-60, 1960). However, the first use of the term "tarsal tunnel syndrome" was made in 1962 by Lam (Lam SJ: A tarsal-tunnel syndrome. Lancet 2:1354–1355, 1962).

Tarsal tunnel syndrome occurs when the posterior tibial nerve becomes abnormally compressed within the medial ankle. Many authors have reported that tarsal tunnel syndrome occurs due to excessive compression forces acting on the posterior tibial nerve, such as from a single traumatic event such as a medial ankle crush injury or from repetitive microtrauma from an enlarged tumor or engorged veins pressing on the nerve within the tarsal tunnel. However, the most likely etiology of tarsal tunnel syndrome in many cases is due to repetitive microtrauma to the posterior tibial nerve caused by abnormal compression and/or tension forces acting on and within the posterior tibial nerve as it passes medial and posterior to the medial malleolus and deep to the flexor retinaculum of the medial ankle.

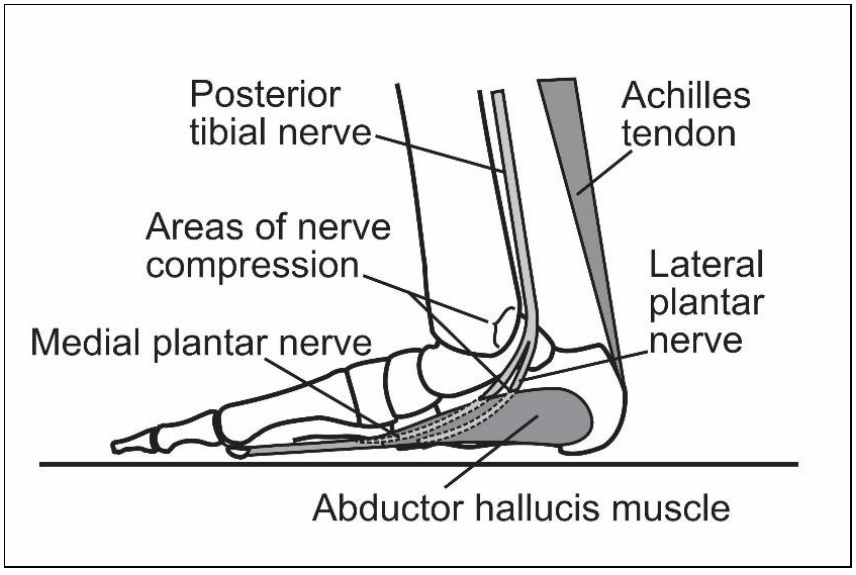

Figure 1. The posterior tibial nerve passes medial and plantar to the subtalar joint (STJ) axis so that excessive STJ pronation will place increased tension force on the posterior tibial nerve and increased compression force and pressure on the nerve, leading to increased risk of tarsal tunnel syndrome.

Since the posterior tibial nerve is anatomically located posterior and medial to the subtalar joint (STJ) axis, then any excessive pronation motion during weightbearing activities will increase the tension force acting on the posterior tibial nerve and likewise will increase the pressure acting on the posterior tibial nerve within the tarsal tunnel (Fig. 1). Previous cadaver research from Trepman et al. in 1999 showed that there were significantly higher pressures on the posterior tibial nerve when the foot was pronated, versus when the foot was placed in a neutral or supinated position (Trepman E et al.: Effect of foot and ankle position on tarsal tunnel compartment pressure. Foot Ankle Int, 20:721–726, 1999). In a more recent study in 2009, Rosson et al. found that the pressures on

the posterior tibial nerve were also greatest when cadaver feet were placed into a pronated position (Rosson GD et al.: Tibial nerve decompression in patients with tarsal tunnel syndrome: pressures in the tarsal, medial plantar, and lateral plantar tunnels. Plast Reconstr Surg, 124:1202–1210, 2009).

In addition, in 2006, Bracilovic et al. measured the volume of the tarsal tunnel compartment in 13 feet of 9 healthy adults using magnetic resonance imaging (MRI). The results from this MRI study of the tarsal tunnel showed that the volume of the tarsal tunnel was maximized with the STJ in neutral position, was at its minimum in full STJ pronation and was at an intermediate volume in STJ supination (Bracilovic A et al.: Effect of foot and ankle position on tarsal tunnel compartment volume. Foot Ankle Intl, 27:431-437, 2006). Therefore, from the findings of prior research, it seems likely that any individual who has increased STJ pronation during gait, is likely have an increased risk of developing tarsal tunnel syndrome over time.

In my four decades of treating tarsal tunnel syndrome conservatively with custom foot orthoses and shoe gear modifications, patients will invariably have some level of improvement of their tarsal tunnel symptoms when the pronated position of their foot is reduced with anti-pronation custom orthoses, as long as they have not had any previous direct trauma to the posterior tibial nerve. In addition, since ankle joint dorsiflexion will tend to increase the tension force and pressure on the posterior tibial nerve and ankle joint plantarflexion will tend to decrease the tension and pressure on the posterior tibial nerve, instructions are always given to my patients with tarsal tunnel syndrome to avoid barefoot walking and to try wearing the tallest heel shoe (i.e., high heel-drop shoe) as possible. In other words, it has been my clinical experience that an anti-pronation custom foot orthosis combined with a taller-heeled shoe works better at relieving tarsal tunnel symptoms than wearing these same orthoses in a flat heeled shoe (i.e., 0 mm heel drop).

Ideally, patients with tarsal tunnel syndrome should wear shoes with at least a 12 mm heel height differential (i.e., heel of shoe sole is 12 mm thicker than shoe sole thickness in the forefoot) and anti-pronation foot orthoses should be worn as much as possible. Orthosis modifications which work the best in treating the symptoms of tarsal tunnel syndrome include using a 4 mm polypropylene plate, ordering a 3-4 mm medial heel skive, 18 mm heel cup, and balancing the orthosis 2-4° inverted. A 4°/4° rearfoot post and minimal arch fill is also used to increase the pronation-reducing function of these anti-pronation custom foot orthoses. In addition, the heel height (i.e., heel contact point thickness) is increased to 3 mm to further plantarflex the ankle and further reduce the tension and compression forces acting on the posterior tibial nerve during weightbearing activities. Non-steroidal anti-inflammatory medications and 5-20 minutes of icing therapy twice daily also seems to help reduce the pain and inflammation in the posterior tibial nerve, thereby reducing the frequency and intensity of the symptoms of the patient suffering from tarsal tunnel syndrome.

It is possible that some patients with tarsal tunnel syndrome will have symptoms in only one branch of the posterior tibial nerve due to compression of the nerve within the porta pedis. In a published case-report from my early years of practice, I treated a 6’ 4”, 340-pound male power-lifter with custom foot orthoses who complained of a burning pain within his lateral-plantar foot when he lifted weights during his workouts. The diagnosis of lateral plantar entrapment neuropathy was made and a nerve conduction velocity test showed reduced nerve conduction within the lateral plantar nerve. The patient happily reported near immediate relief of the lateral-plantar pedal burning pain while weight-lifting while wearing the orthoses and he became completely asymptomatic within seven weeks of continually wearing the orthoses. In addition, his lateral plantar nerve conduction velocity returned to normal once he had worn his foot orthoses for about two months (Johnson ER, Kirby KA, Lieberman JS: Lateral plantar nerve entrapment: Foot pain in a power lifter. Am J Sports Med, 20 (5):619-620, 1992). Cases such as this help illuminate the importance of understanding the etiology and biomechanics of posterior tibial nerve pathology so that the podiatrist may offer their patients more effective conservative treatment methods for the painful condition of tarsal tunnel syndrome.

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