PROLAB ORTHOTICS
Evidence-Based Medicine

Biomechanics & Orthotic Therapy Newsletter
May 2024

BIOMECHANICS AND FOOT ORTHOSIS TREATMENT OF PLANTAR PLATE TEARS

Injuries to the plantar plate of the lesser metatarsophalangeal joints (MPJ) are some of the most common injuries seen in the practices of many podiatrists. The plantar plate is a fibrocartilaginous structure which has a concave superior surface and which is congruous with the plantar aspect of the lesser metatarsal head. Distally, the plantar plate is attached directly to the base of the proximal phalanx of the lesser digits. Proximally, the plantar plate is attached to the digital slip of the plantar fascia and may, as such, be considered as a distal mechanical extension of the plantar fascia which helps transmit plantar fascial tension force to the digit and which aids with digital purchase during weightbearing activities.

Since the lesser metatarsal heads are weightbearing structures, the plantar plate will be subjected to considerable compression forces from ground reaction force (GRF) acting on the plantar metatarsal heads. In addition, the plantar plate will be subjected to large tension forces from the plantar fascia pulling on the plantar plate. In fact, the plantar fascia has been measured to be subjected to tension forces that peak close to one-times body weight during the late midstance phase of walking which means the plantar plate is also subjected to these high-tension forces from the plantar fascia (Erdimir A, Hamel AJ, Fauth AR, Piazza SJ, Sharkey NA: Dynamic loading of the plantar aponeurosis in walking. JBJS, 86A:546-552, 2004).

By far the most common MPJ to be affected by plantar plate tears is the 2nd MPJ. In research from Neary et al, it was reported that 63-90% of all plantar plate tears occur at the 2nd MPJ (Nery C, Coughlin MJ, Baumfeld D, Mann TS: Lesser metatarsophalangeal joint instability: Prospective evaluation and repair of plantar plate and capsular insufficiency. Foot Ankle Intl, 33(4): 301-311, 2012). Since the second metatarsal is the longest metatarsal in most feet, and since the 2nd ray has increased stiffness relative to the 1st ray in many feet (i.e. first ray "hypermobility"), the second MPJ is frequently subjected to large magnitudes of GRF and increased tension forces from the plantar fascia during weightbearing activities. These increased plantar loading forces and plantar fascia tension forces at the 2nd MPJ are likely the biomechanical factors which cause the 2nd MPJ to be most commonly affected by symptomatic plantar plate tears

During my years as a podiatric student and resident in the early 1980s, plantar plate injuries were commonly called *metatarsophalangeal joint capsulitis*. Gerard Yu and colleagues were the first to popularize the concept that plantar plate tears were a potential cause of digital deformities, which they named *predislocation syndrome* (Yu GV, Judge MS, Hudson JR, Seidelmann FE: Predislocation syndrome: Progressive subluxation-dislocation of the lesser metatarsophalangeal joint. JAPMA, 92: 182-199, 2002). Three years later, Joshua Gerbert named the condition of plantar plate tears *MPJ stress syndrome* (Gerbert J: How to handle second MTPJ stress syndrome. Podiatry Today, 18:44-50, 2005). However, in today's current medical literature, the term *plantar plate tear* seems to have become the most common moniker for this relatively common clinical condition.

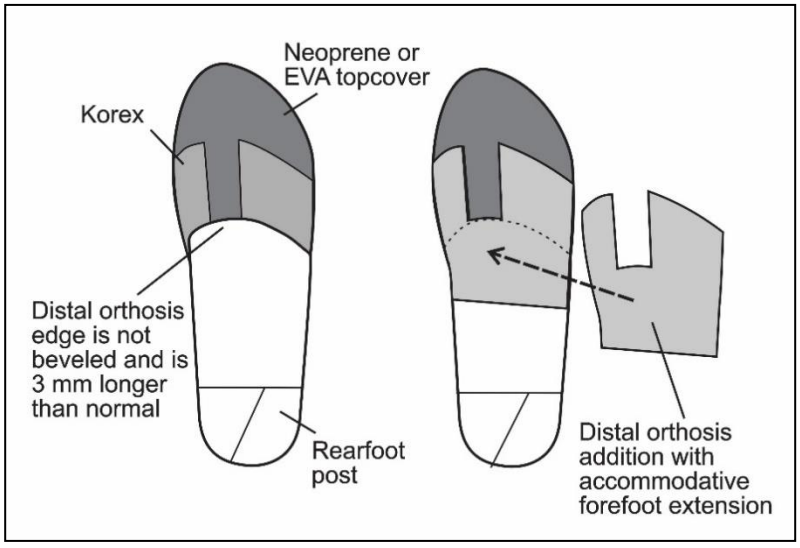

Figure 1. Custom foot orthoses must be specifically modified to reduce the compression and tension forces within the plantar plate in order to effectively treat plantar plate injuries (left). An additional distal accommodative forefoot extension may also be added to the plantar foot orthosis, as clinically necessary, to further relieve the plantar pain and swelling within the affected MPJ (right).

One of the most remarkable research findings regarding plantar tears is that they are extremely common and are likely to exist in many asymptomatic lesser MPJs without digital deformity. In one study on cadaver specimens, 96% of the 24 plantar plates examined were found to have tears, with one

fresh specimen from a 19-year-old having 6 of the 8 MPJs with measurable plantar plate tears. It is also interesting to note that all the plantar plate tears in this study were located at the insertion of the plantar plate into the plantar base of proximal phalanx of the digit (Gregg JM, Silberstein M, Schneider T, Kerr JB, Marks P: Sonography of plantar plates in cadavers: Correlation with MRI and histology. Am. J. Roentgenology, 186:948-955, 2006). In my clinical examination of literally hundreds of feet with plantar plate tears, the plantar aspect of the base of the proximal phalanx of the digit is nearly always the most tender aspect of the plantar MPJ when firmly palpated.

Since the most likely etiology of plantar plate injuries is excessive magnitudes and/or durations of both compression forces and tension forces acting within the plantar plate, effective conservative care of plantar plate injuries should revolve around not only reducing the inflammation of the plantar MPJ area, but should also focus on lessening the magnitudes of compression and tension forces acting within the plantar plate. Initially, the patient should be instructed on twice-daily plantar forefoot icing therapy, of 15-20 minutes per session, in order to help reduce the plantar swelling and inflammation commonly seen in acute plantar plate injuries. Patients should also be instructed to avoid walking barefoot and should be told to not walk in any shoe with an elevated heel (i.e. higher heel-height differential) and/or with a hard sole within the forefoot area of the shoe. I often also recommend the patient purchase softer foam "recovery sandals" (e.g. Oofos, Hoka) to wear at home to protect their MPJs from excessive plantar pressures. Digital plantarflexion taping is also an effective treatment method which patients may be taught to decrease the tension within the plantar plate and help relieve the symptoms of plantar plate injuries (Yu GV et al, 2002).

Custom foot orthoses can be an extremely effective therapeutic treatment option in order to relieve the pain and speed the recovery from plantar plate injuries. The goal of foot orthosis treatment in plantar plate injuries is to reduce not only the compression forces from GRF acting on the affected plantar metatarsal head and plantar plate, but also to reduce the tension forces within the plantar fascia so that the plantar plate tension forces are reduced during weightbearing activities. Due to the fact that most plantar plate injuries occur in only one of the lesser MPJs, special modifications to the custom foot orthoses must be made to result in optimum custom foot orthosis treatment of these plantar forefoot injuries.

In most patients, I will order custom foot orthoses with a 4-5 mm thick polypropylene shell with rearfoot posts. I will also include a special notation for the orthosis laboratory to make the orthoses 3 mm longer than normal and with no distal edge bevel to help reduce the GRF acting at the plantar MPJs. Either a full-length neoprene or ethylene-vinyl-acetate (EVA) topcover is ordered along with a metatarsal head accommodation of 3-6 mm thick korex to further decrease GRF at the affected plantar MPJ. Furthermore, a distal orthosis addition of 1/8" korex may be added to the plantar distal edge with an additional accommodation of the affected MPJ in order to relieve even more plantar pressure to the affected MPJ (Fig. 1). A metatarsal pad may also be sandwiched between the dorsal orthosis plate and the topcover, placed just proximal to the affected lesser MPJ, to further reduce GRF at the injured plantar plate.

Most of the failures that I have seen over the years in custom foot orthoses made for patients with plantar plate injuries are when orthoses have been ordered without any modifications which specifically reduce the GRF acting plantar to the affected MPJ. In other words, custom foot orthoses must have these specific modifications outlined above in order to provide patients with the optimum therapeutic result for their painful forefoot injury. Orthoses that are too thin, have no forefoot extension accommodations, that do not include anterior edge modifications and have no metatarsal pads are relatively ineffective in treating the symptoms and gait pathology seen with plantar plate tears. Podiatrists who have learned to effectively manage plantar plate injuries with these therapeutic measures will have very many grateful patients who will be happy to tell their friends and relatives about the excellent conservative care received at that podiatrist's office.

.

Kevin

Kevin A. Kirby, D.P.M.
Biomechanics Director