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EFFECTIVE TREATMENT OF PLANTAR HEEL PAIN WITH CUSTOM FOOT ORTHOSES

Plantar heel pain, also known as proximal plantar fasciitis, is the most common diagnosis seen in the offices of many podiatrists. In my practice, the diagnosis of plantar heel pain accounts for at least 25% of the patients I see on a daily basis. In addition, plantar heel pain seems to have increased in frequency during the 38 years I have been in practice and does not seem to be lessening in frequency over the last few years. Even though there is considerable controversy regarding the etiology of plantar heel pain, it is clear that biomechanical causes of plantar heel pain are much more frequent than any other cause of plantar heel pain.

In 1988, two podiatry students and I published a radiological study of 100 feet which showed that the portion of the plantar calcaneus that was most prominent and plantarly located was the medial calcaneal tubercle and not the lateral calcaneal tubercle (Kirby KA, Loendorf AJ, Gregorio R: Anterior axial projection of the foot. JAPMA, 78: 159-170, 1988). Therefore, since the medial calcaneal tubercle is the most prominent and plantarly located osseous structure of the plantar heel, then this portion of the plantar calcaneus will be routinely subjected to the greatest compression forces during weightbearing activities.

Research has also shown that the plantar fascia is subjected to extremely large tension forces. In a "dead man walking" experiment conducted on 7 fresh-frozen cadaver foot-leg preparations at the Center for Locomotion Studies at Penn State University, Erdemir and coworkers demonstrated that the plantar fascia was subjected to tension forces as large as 0.96 times body weight during each walking stride (Erdemir A, Hamel AJ, Fauth AR, Piazza SJ, Sharkey NA: Dynamic loading of the plantar aponeurosis in walking. JBJS, 86A:546-552, 2004). Since the plantar fascia originates from the medial calcaneal tubercle, the medial calcaneal tubercle is thus also subjected to very significant tension forces during weightbearing activities.

No other part of the human body is regularly subjected to larger magnitudes of external forces than the weightbearing structure of the plantar calcaneus, the medial calcaneal tubercle. As a result, the medial calcaneal tubercle is subjected to intense magnitudes and durations of compression forces from GRF and also large magnitudes and durations of tension forces from the plantar fascia. In fact, from a biomechanical aspect, the medial calcaneal tubercle of the plantar calcaneus is likely subjected to a larger combination of magnitudes and durations of compression and tension forces than any other structure of the human body. It therefore seems no wonder that plantar heel pain, located specifically at the medial calcaneal tubercle, is the part of the foot which is the source for so much pain and misery in the patients of podiatrists.

With this in mind, the goal of my treatment of plantar heel pain is to reduce not only the plantar fascia tension forces but also the compression forces from GRF acting on the medial calcaneal tubercle. Initial treatments of plantar heel pain should include the avoidance of barefoot activities, wearing cushioned sandals at home (e.g., Oofos sandals), plantar strapping, three-times-a-day gastrocnemius and soleus stretching exercises, and the use of plantar fasciitis night splints for periods of inactivity. Of course, both over-the-counter (OTC) and custom foot orthoses are always used in the treatment of my patients with plantar heel pain. OTC orthoses are generally used initially and custom

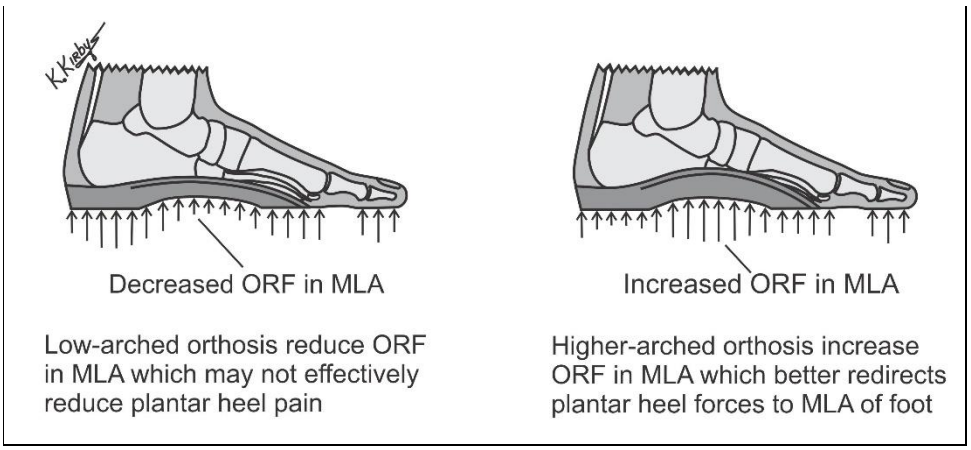

Figure 1. When a foot orthosis is made with a low and/or overly flexible medial longitudinal arch (MLA), there will be decreased orthosis reaction force (ORF) in the MLA of the foot (left). In order to optimize the relief of plantar heel pain, the foot orthosis must have a stiffer and more congruent MLA in order to best reduce the compression forces from ground reaction force and the plantar fascia tension forces acting on the plantar calcaneus during weightbearing activities (right).

foot orthoses are used when patients have not responded satisfactorily to treatment with OTC orthoses. Since the durability and customization potential of custom foot orthoses is far greater than that of OTC orthoses, custom foot orthoses are my treatment-of-choice for all patients who do not immediately respond to OTC orthosis therapy.

When deciding on what modifications of custom foot orthosis design will be best for every one of my patients with plantar heel pain, I first perform a number of assessments. First of all, I take a history of the plantar heel pain to see if an increase in intensity and duration of weightbearing activities on firm surfaces preceded the plantar heel symptoms. Secondly, I assess the longitudinal arch height and the thickness of the plantar heel fat pad. Patients with higher longitudinal arch height (i.e. pes cavus) and thinner plantar heel fat pads are likely suffering from plantar heel pain due to higher compression stresses on the plantar calcaneus due to an increase in plantar heel pressure or a reduction in thickness in the energy-absorbing fat tissues within their plantar heels, respectively. Patients with lower longitudinal arch height (i.e. pes planus) will invariably have larger magnitudes of plantar fascia tension forces which may be the more likely cause of plantar heel pain in these patients. And lastly, during gait examination, I ask the patient when during gait that the greatest plantar heel pain occurs, at heel contact, when plantar heel compression forces are at a maximum, or just before heel-off, when plantar fascia tension forces are at a maximum. This *Heel Pain Gait Test*, (Kirby KA: Foot and Lower Extremity Biomechanics III: Precision Intricast Newsletters, 2002-2008. Precision Intricast, Inc., Payson, AZ, pp. 187-188, 2009), is a valuable clinical tool to decide whether plantar heel compression forces or plantar heel plantar fascia tension forces are the most responsible for the plantar heel symptoms the patient is experiencing.

With these facts in mind, it becomes obvious that in order to optimize the treatment of plantar heel pain with custom foot orthoses, orthoses should be designed to: 1) reduce the compression forces from GRF on the plantar calcaneus, and 2) reduce the tension forces within the plantar fascia during weightbearing activities. The orthosis design features that I used to accomplish these biomechanical goals include the use of at least a 14-16 mm deep heel cup to reduce the GRF acting on the plantar calcaneus by redirecting orthosis reaction force (ORF) toward the periphery of the non-weightbearing portions of the plantar calcaneus. I also make certain that the medial longitudinal arch (MLA) of the orthosis is stiff enough and fits congruently to the MLA of the foot in order to increase the ORF on the plantar MLA which will reduce the compression force from GRF on the plantar calcaneus during weightbearing activities (Fig. 1). In addition, this congruent and relatively stiff MLA of the orthosis will also tend to lessen the plantar fascial tension force by reducing the arch-flattening forces acting on the foot which will also likely reduce the plantar heel pain.

In order to decrease the impact energy acting on the plantar heel during heel contact during walking or running, I will often also use an extra thick, full-length topcover over the whole foot orthosis in order to better cushion the plantar aspect of the medial calcaneal tubercle. I will often use a 3 mm layer of Poron under a 3 mm layer of Nylene (i.e. neoprene) to make a full 6 mm (1/4") thick full-length topcover or a 6 mm layer of neoprene full-length topcover to reduce the heel contact impact energy acting on the plantar calcaneus. This simple orthosis modification, of using a thicker layer of energy-absorbing topcover material, can often make the difference between orthosis success and orthosis failure in patients with plantar heel pain.

Custom foot orthoses with these design modifications, when combined with thicker-cushion-sole shoes (e.g. Hoka) will greatly reduce the impact energy acting on the plantar heel during weightbearing activities for those patients with plantar heel pain caused by plantar fat atrophy, a pes cavus foot structure or prolonged weightbearing on firm surfaces. If, however, plantar fascial tension forces are determined to be more responsible for the plantar heel pain, then making certain the patient's shoes are relatively stable to better allow the custom foot orthosis to reduce the flattening of the patient's MLA is important. These biomechanical considerations will allow the treating podiatrist to achieve much better treatment results with their custom foot orthoses when confronted with the very common clinical pathology of plantar heel pain.

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