PROLAB ORTHOTICS
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IMPORTANCE OF ORTHOSIS MEDIAL LONGITUDINAL ARCH IN TREATING PRONATION

Custom foot orthoses are amazing therapeutic in-shoe medical devices that not only have the ability to improve the function of the foot and lower extremity, but also have the ability to reduce the pathological stresses within injured tissues of the foot and lower extremity, promoting healing of those injured tissues. One of the most important parts of orthoses that affect both gait function and the ability of the orthosis to heal the patient's injuries is the medial longitudinal arch (MLA) of the orthosis.

A foot orthosis can be defined as being "an in-shoe medical device which is designed to alter the magnitudes, locations and temporal patterns of reaction forces acting on the plantar foot in order to optimize foot and lower extremity function and to decrease pathologic loading forces on the structural components of the foot and lower extremity during weightbearing activities" (Kirby KA: Foot and Lower Extremity Biomechanics II: Precision Intricast Newsletters, 1997-2002. Precision Intricast, Inc., Payson, AZ, 2002, p.8). In other words, foot orthoses alter the ground reaction force (GRF) acting on the plantar foot by creating an *orthosis reaction force* (ORF) that can improve gait function and reduce stresses on the injured structures of the foot and lower extremity in order to allow more rapid healing of the patient injury.

As such, like all other parts of the custom foot orthosis, variations in the morphology and stiffness of the MLA of the orthosis can have a profound effect on the comfort, function and therapeutic effect of the orthosis. Since the shape of the MLA and its stiffness (i.e., how much it flexes under foot loading forces) can greatly affect the magnitude, location and timing patterns of GRF acting on the MLA of the foot during weightbearing activities, understanding how to optimize the design of the orthosis MLA to improve the function and heal the injuries of the patient is of critical importance to the podiatrist.

One of the main functions of the MLA of the orthosis is to shift the GRF acting on the plantar foot to a more medial location on the plantar midfoot. This medial shift in the GRF on the plantar midfoot is caused by the orthosis MLA creating ORF on the plantar MLA of the foot which, in turn, increases the supination moments acting across the subtalar joint (STJ) axis (Figure 1). By transferring GRF from lateral to medial on the plantar foot with a well-designed MLA in a foot orthosis that doesn't flatten excessively under weightbearing forces, the overall STJ supination moments acting on the foot during weightbearing activities will be increased (Kirby KA, Green DR: Evaluation and Nonoperative Management of Pes Valgus, pp. 295-327, in DeValentine, S.(ed), Foot and Ankle Disorders in Children. Churchill-Livingstone, New York, 1992).

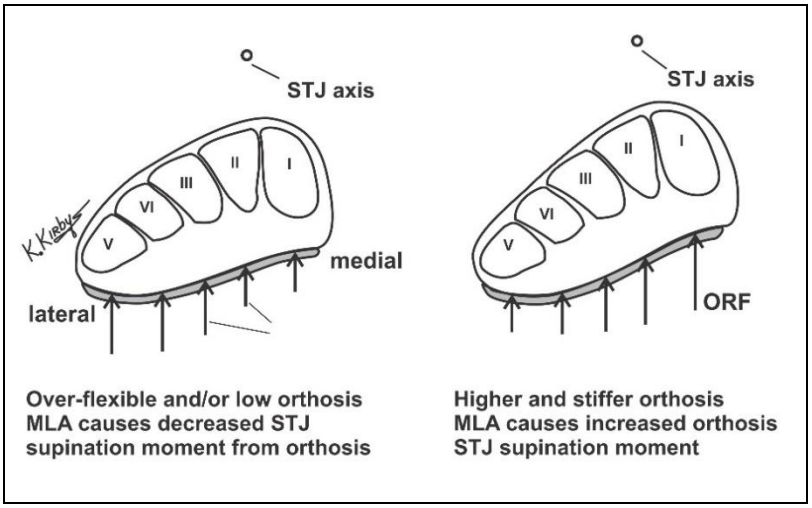


Figure 1. In this illustration of a frontal-plane cross-section of the midfoot at the metatarsal bases, the lower-arched, overly-flexible medial longitudinal arch (MLA) in the orthosis (left) will have minimal effect at shifting orthosis reaction force (ORF) medially on the plantar midfoot relative to the subtalar joint (STJ) axis. However, in an orthosis with a higher, stiffer-arched MLA (right), ORF will be significantly shifted medially on the plantar midfoot relative to the STJ axis, thus producing much greater orthosis STJ supination moments from the orthosis (right).

Therefore, in any mechanically-based foot and lower extremity pathology that is caused by excessive magnitudes of STJ pronation moments, the orthosis MLA must be designed to significantly support the MLA of the plantar foot in order to optimize the function of the custom foot orthosis in treating that pathology. For example, in the case of the patient with posterior tibial (PT) tendon dysfunction, the constant finding of the medially-deviated and internally-rotated talar head and neck will cause medial deviation of the STJ axis.

This medial deviation of the STJ axis, which is always present in cases of posterior

tibial tendon dysfunction (PTTD), will cause the central nervous system (CNS) of the patient to increase the contractile activity of the PT muscle in order to resist the foot being "over-pronated". The increase in PT muscle contractile activity, in turn, causes an increase in tension forces within the PT tendon which is magnified due to the loss of effective supination moment arm for the PT tendon. Then, if the PT tendon becomes partially torn or stretched as a result of the increased tension stress within it during daily weightbearing activities, this loss of effective strength within the PT muscle-tendon complex due to tearing or elongation of the PT tendon will cause a decrease in STJ supination moment. Over time, this weakening of the PT muscle-tendon complex may lead to progressive flattening of the MLA and foot abduction in PTTD (Kirby KA: Conservative treatment of posterior tibial dysfunction. Podiatry Management, 19:73-82, 2000).

In order for the custom orthosis to be able to reduce the mechanical demand on the PT muscle-tendon complex during weightbearing activities, the MLA of the orthosis must push upwards on the foot MLA sufficiently to shift GRF from a more lateral location, to a more medial location, on the plantar midfoot to increase the overall STJ supination moment acting on the foot from the orthosis (Fig. 1). By increasing the STJ supination moment with a well-designed foot orthosis that has a relatively stiff and supportive MLA, the CNS will then reduce the PT muscle contractile activity which will, in turn, reduce the PT tendon tension forces to promote proper healing of the PT tendon. In effect, the foot orthosis that creates additional STJ supination moments by having a more stiff and higher-shaped MLA will lessen the need for the PT muscle-tendon complex to create needed STJ supination moments which will, in turn, lessen PT tendon tension during weightbearing activities and more rapidly reduce the pain and disability of PTTD (Kirby KA, 1992).

Of course, a custom foot orthosis that is designed to treat pronation-related pathologies, such as PTTD, needs to have more than just a stiff and high MLA. In order for the podiatrist to design the best custom foot orthosis for the treatment of any pronation-related pathology and improve the orthosis treatment of these pathologies, the podiatrist must also design the other parts of the custom foot orthosis to work along with the relatively stiff and supportive orthosis MLA in order to optimize transfer of GRF from a more lateral to a more medial location across the entire foot orthosis. Other common custom foot orthosis modifications that I have used over the past decades of treating these pathologies include deep heel cups, thicker and stiffer orthosis plate materials, inverted balancing positions, rigid rearfoot posts and the medial heel skive technique (Kirby KA: The medial heel skive technique: improving pronation control in foot orthoses. JAPMA, 82: 177-188, 1992). When each of these orthosis design modifications are included in the orthosis design, they will function synergistically together to shift GRF from a more lateral location to a more medial location in the rearfoot, midfoot and forefoot. As a result, the patient's foot orthoses will be more comfortable, will better improve gait function and will also allow faster healing from pronation-related pathologies.

One thing that the clinician should be aware of is that problems may occur when the orthosis is designed to push up vigorously on the MLA in an "overly-pronated" foot, without the anti-pronation benefit from a medial heel skive, a rigid rearfoot post and/or a deep heel cup. An orthosis with just a high MLA, and without other anti-pronation features, will likely cause pain and/or blistering of the plantar skin of the MLA in a foot with PTTD. Likewise, if a medial heel skive, rigid rearfoot post and deep heel cup were used in an anti-pronation orthosis, but the orthosis MLA was too low and/or too flexible, the orthosis wouldn't work as well at "controlling pronation" since there would be minimal shifting of the GRF medially in the plantar midfoot. Therefore, the carefully-constructed anti-pronation foot orthosis, with the MLA being designed to shift the GRF more medially in the midfoot and the heel cup portion also being designed to shift GRF more medially in the rearfoot, will allow synergistic actions of the rearfoot and midfoot portions of the orthosis to optimize its effects at improving the gait function and injury-healing ability of the custom foot orthosis.

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