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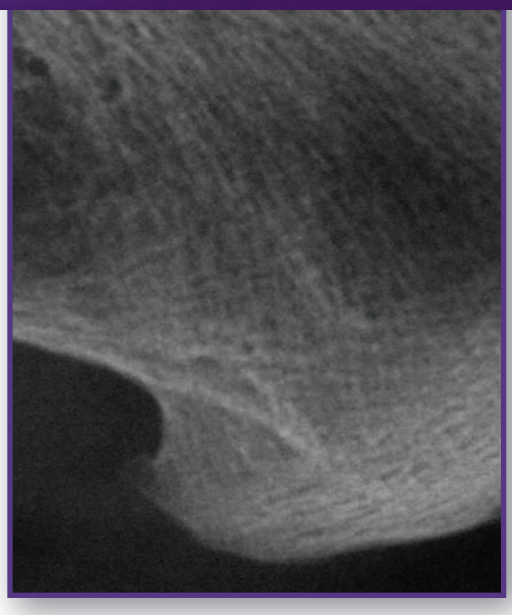


# Mechanically Induced Plantar Fasciitis and Subcalcaneal Pain



GIVEN THE LARGE number of articles written in the medical literature about heel pain and plantar fasciitis, practitioners may wonder whether there is anything new to learn. The prevalence of this condition accounts for the amount of press that it gets, both in the medical community and in the news, motivating an average of one million visits a year to just primary care physicians in 2004.[1] The numerous opinions and conflicting data may indicate that heel pain is more complicated than people realize. Most of the evidence-based articles use different definitions, different custom devices, and devices of varying quality, making it difficult to compare the studies. Maybe the large variability and conflicting outcomes of these studies are due to different materials, casting techniques, and manufacturing techniques.

The medical investigation of the origins of heel pain began in 1954, when Hicks described the mechanics of the plantar aponeurosis, generating the concept that the symptoms could be mechanical in origin.[2] The assumption was often made in this and other articles that any foot type or joint position that lowered the arch stretched the plantar fascia and could produce heel pain. The literature failed to

mention that patients with normal or high arch height also presented with heel pain symptoms. Conversely, many patients with lower arches never develop symptoms. It is possible and even probable that the explanation of pathomechanic etiology has never been properly discovered and described.

The medical community uses, interchangeably, a number of terms to describe heel pain: plantar fasciitis, plantar heel pain syndrome, heel bursitis, heel spur syndrome, subcalcaneal pain, chronic plantar heel pain, and others. Are these terms truly discussing the same condition, or are people using plantar fasciitis as a generic term for heel pain from different etiologies? Perhaps this situation is similar to how chondromalacia patellae became a catchall term for knee pain. Could this confusion be why some patients respond well to treatment with an orthoses regimen and others do not?

## Etiology, Diagnosis, and Pathomechanics of Subcalcaneal Pain

Differentiating heel pain by its etiology is essential to successful orthotic treatment. It is also important to establish clear definitions of the standard nomenclature in order to distinguish one type of heel pain from another. This can only help in future discussions, allowing practitioners and researchers to compare "apples to apples" and helping to reduce confusion regarding appropriate treatment choices for patients. Even the names plantar fasciitis, plantar fascial strain, calcaneal bursitis, and heel pain can cause confusion.

Lemont demonstrated that a histological examination of the most proximal aspect of the plantar aspect of the plantar fascia in patients who had plantar fasciotomies for symptoms showed no inflammatory cells.[3] If there is no inflammation in the plantar fascia, then should we call it plantar fasciitis? Shama reported a large prevalence of heel spurs and/or enthesiopathies in patients with no symptoms.[4] If most patients with heel spurs do not have heel pain, then why refer to heel pain as heel spur syndrome? Plantar heel pain is also called calcaneal bursitis, but most anatomy texts do not show a bursa on the plantar aspect of the calcaneus. It is apparent how these misconceptions and misnomers can cause confusion in discussion, research outcomes, and treatment decisions.

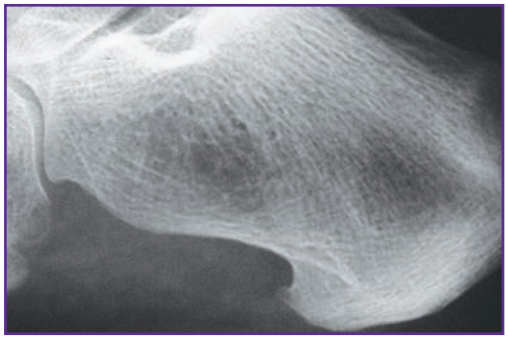
We have known since Manter's description of foot mechanics that actually the supinatory long-axis motion of the midtarsal joint produces stretch on the plantar fascia.[5] Whether this joint axis truly exists is presently in debate, but the motion of inversion of the forefoot on the rearfoot does exist and always tightens the plantar fascia. Therefore, this chapter will consider any dysfunction of the foot, most commonly eversion of the heel, that produces midtarsal joint supination as the pathomechanical event that stretches the plantar fascia.

Most practitioners believe that the dominant factor in mechanically induced subcalcaneal pain is pronation of the subtalar joint rather than the proximate cause, which is the resulting supination of the midtarsal joint. Upon palpation of the nonweight-bearing foot, practitioners will note that when the subtalar joint is pronated,

the plantar fascia does not become taut. When the midtarsal joint is supinated (inversion of the forefoot to the rearfoot), however, the plantar fascia always gets tight. If it were simply pronation of the subtalar joint that produced the mechanical strain on the plantar fascia, then most patients with excessive pronation would develop mechanically induced subcalcaneal pain. Conversely, many patients with true mechanically induced subcalcaneal pain should have a pronated subtalar joint in stance, but they do not, especially in the case of the cavus foot with heel pain.[6]

The preceding hypothesis of the pathomechanics of mechanically induced subcalcaneal pain proposes that the strain on the plantar fascia caused by the supination of the midtarsal joint disrupts by traction the periosteum at the point of insertion of the tuberosity of the calcaneus.[6] This disruption produces inflammatory periostitis and a subperiosteal hematoma. Eventually, the hematoma organizes and forms subperiosteal ossification in the direction of the strain. This is most probably the mechanism of the enthesiopathy or periostitis seen so commonly on lateral radiography. Why some patients develop the spur but no symptoms has not yet been delineated.

In 1991, researchers proposed a theory on the pathomechanics of mechanically induced subcalcaneal pain as a result of a clinical outcome study evaluating the effectiveness of custom foot orthoses for "heel spur syndrome."[7] The study authors' opinion of etiology of heel spur syndrome closely matches the aforementioned hypotheses of mechanically induced subcalcaneal pain. The initial stage of the study classified each subject's foot retrospectively to help determine whether certain foot types develop this syndrome. One hundred thirty-three heels were studied: 63 had a forefoot valgus deformity, 20 had a rigid plantar flexed first ray, 32 had an everted heel in stance, and 18 could not be identified as belonging to any obvious particular foot type.



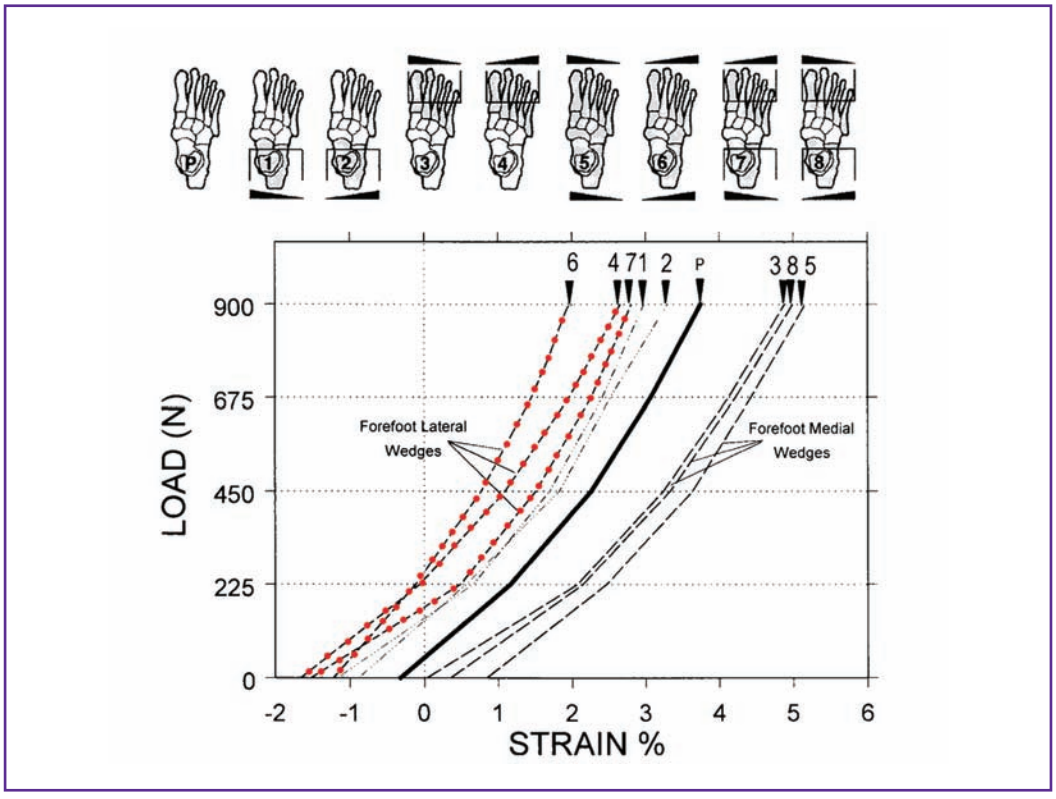
The symptoms from plantar fasciitis most probably originate from a periostitis at the calcaneal insertion of the fascia.

Since 115 of the 133 heels in this study had one of these deformities that, upon weight-bearing, would force the forefoot into a position of inversion on the rearfoot, the researchers theorized that supination (inversion) of the midtarsal joint placed increased tension on the plantar fascia and contributed to the periostitis that occurs in mechanically induced subcalcaneal pain.

This theory of midtarsal joint supination was supported by Kogler's work over a decade later.[8] He prepared a very sophisticated cadaveric subject study in which he placed varus or valgus wedges individually or in combination to the forefoot and rearfoot of the subjects. His apparatus allowed

normal and consistent weight-bearing of the subjects. The study found that when a valgus forefoot wedge was applied to a foot while a strain gauge was implanted proximally in the plantar fascia, the traction on fascia decreased significantly. The tension increased to a much greater degree than with a varus rearfoot or forefoot wedge. The important concept here is that a valgus forefoot wedge would have the opposite mechanical effect of inversion of the midtarsal joint. It would actually pronate the midtarsal joint.

Since over 86% of the feet in the original 1991 study previously described lists deformities that supinated the midtarsal joint, it might be logical to conclude that some sort of a forefoot valgus wedge should be incorporated into the type of orthoses used in the study in order to pronate the midtarsal joint.[7] The authors in the 1991 study postulated that this inversion of the forefoot due to a valgus heel (everted) or a valgus forefoot is "the primary biomechanical fault or primary etiology"[7] in mechanically induced heel pain.




Kogler demonstrated that a forefoot lateral wedge reduced the strain on the plantar fascia, implicating supination of the midtarsal joint as the etiology of mechanically induced subcalcaneal pain. Courtesy JBJS 1999, 31A.

## Mechanically Induced Subcalcaneal Pain Can Be Considered a Syndrome of Symptoms

- Nonradiating pain limited to the plantar area of the calcaneal tuberosity
- Occurrence of sharp pain upon the first step taken in the morning
- Pain exacerbated by the previous day's excessive activity
- Improvement of pain after walking

Many other disorders produce similar pain in the plantar heel region, including neuropathy, injury, and arthropathies. Care must be taken to identify and separate these disorders, since most would not respond to orthotic therapy. A long list of differential diagnoses, some published and some assumed, could mimic mechanically induced heel pain. It is not the intent of this chapter to instruct the reader in how to make these diagnoses but, rather, to alert her or him to the need for comprehensive history and examination to exclude these disorders that would not respond to orthotic therapy. Investigation into the etiology of heel symptoms is necessary to establish a treatment plan that will be effective. Without this effort, there is a strong possibility that the custom foot orthoses that control the excessive motion of the midtarsal joint will not relieve symptoms. Symptoms of plantar fasciitis will be relieved with a custom functional orthotic only if the etiology is mechanical in origin. The establishment of a valid, complete, differential diagnosis is essential to rule out other etiologies and to produce relief.

This critical investigation into the differential diagnoses that also cause heel pain is appropriate before one jumps to the conclusion that the heel pain symptoms are related to mechanical causes that can be treated with custom foot orthoses. The scope of the list that follows may shed some light on why orthotic therapy can fail if the clinician attempts to treat heel pain generically and without etiological investigation.

Articles published recently on nonsurgical and nonorthotic treatment of plantar heel pain include treatment with a pneumatic compression device[9]; tissue-specific stretching of the plantar fascia and Achilles tendon stretching programs[10]; the role of hamstring tightness on duration of forefoot loading[11]; the effects of topical wheatgrass cream[12]; the effectiveness of low-Dye taping in the short-term management of plantar fasciitis[13]; comparison of taping and/or stretching combined with different injections[14]; and extracorporeal shockwave therapy, which has a success rate of 34%.[15] These studies demonstrated variable success with heel pain treatment, and this perhaps may also be due to a poorly defined diagnosis in the study population.

One exhaustive study that was well publicized compared the effectiveness of stretching alone to stretching in combination with one of four different shoe inserts

## A Guide to Other Heel Pain Etiologies Unrelated to Foot Pathomechanics

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| Rheumatoid arthritis |
| Gout |
| Pseudo gout |
| Ankylosing spondylitis |
| Psoriatic arthritis |
| Neuropathy of the first branch of the lateral plantar nerve |
| Calcaneal stress fracture |
| Tarsal tunnel syndrome |
| Strümpell-Marie disease |
| Paget's disease |
| Reiter's syndrome related to HIV |
| Behçet's syndrome |
| Arterial insufficiency |
| Systemic lupus erythematosus |
| Inflammatory bowel syndrome |
| Unicameral bone cyst |

in the treatment of plantar fasciitis (n = 236).[16] Many surgical supply distributors and patient direct medical supply companies offer devices of various construction that stretch the Achilles tendon and profess effectiveness in reducing heel pain. This study attempted to demonstrate the degree of efficacy. The shoe inserts included three prefabricated pads (a silicone heel pad, a three-quarter-length felt pad, and a rubber heel cup) and custom foot orthoses. Though the conclusion states that using prefabs along with stretching "is more effective than custom orthoses," an analysis of the statistics shows that all five treatment groups had an improvement in both pain scales, with no statistically significant difference among the groups in the reduction of overall pain scores after eight weeks of treatment when controlled for covariates. The aforementioned misleading conclusion quote prompted a deeper look into the study details to determine why the authors would have made a statement that was not supported by their data.

A retrospective analysis by the text author shows that the type of device was not consistent from subject to subject. Forty-five percent of the custom orthoses were rigid polypropylene (normal width, 14 mm to 16 mm heel cup, no posts or top covers). Another 38% were similar except that the flexibility was semirigid. The flexibility variance was not evaluated in this study, nor mentioned as a variable that could affect outcomes. The remainder of the orthoses (17%) varied dramatically in construction. Variables other than shell flexibility were inconsistent and included heel cup depth

(range: 8 mm to 18 mm), width (narrow to wide), use of a rearfoot post, and use of a top cover.

The authors noted that patients were encouraged not to change their regular footwear. Did the authors believe that a narrow device with an 8 mm heel cup was equivalent to a wide device with an 18 mm heel cup for a patient with plantar fasciitis, or were they accommodating the patient's shoe choice as limited by their protocol? Improper footwear has been suggested as a contributing factor in plantar fasciitis, but this was not accounted for in the protocol.[16] Patients were told to wear whatever shoes they entered the study with, regardless of whether the orthoses fit properly.

In the study, the negative casting methods varied. Custom orthotic studies generally allow only a single experienced practitioner to cast each patient, minimizing any effect of the casting process on orthotic outcomes. It appears that 13 different practitioners casted the 42 subjects, with each practitioner learning to cast by watching a video. Consider the number of uncontrolled variables in the custom orthoses group. It is unclear how the authors drew any conclusions about the efficacy of custom orthoses in the treatment of plantar fasciitis or justified a comparison to the other treatment groups. Fortunately, there have been other outcome studies in the treatment of plantar fasciitis.

There also exists a debate over which casting techniques, orthotic materials, and orthoses type (custom or prefabricated) are superior for the treatment of subcalcaneal pain. One study compared medium-density EVA orthoses, both custom and prefabricated, made with a very soft material.[18] Subjects wore the devices for 8 weeks and were evaluated primarily by pain from walking or standing and also by direct palpation to the subcalcaneal area. There was a statistically significant improvement in pain for both groups but no significant difference between each group. Unfortunately, no results beyond 8 weeks were studied. One must wonder what deformation a material with such a low durometer rating would undergo after being worn in a shoe with adult weight upon it. We do not know if the symptoms would have returned as the material flattened, as it must have, and lost its mechanical effect upon the foot.[18]

The use of night splints has also been implemented as a successful treatment for plantar fasciitis. A Swedish study investigated the success of dorsiflexion night splints as compared to functional foot orthoses, as well the combination of both therapies. The study was randomized with 13 to 15 subjects in each group who were followed for one year. Pain, functional limitations, and quality of life were evaluated with the American Orthopedic Analog Scale score. The two groups that used foot orthoses either alone or with the night splints performed appreciably better than the group that used only the night splints. The differences were statistically significant. Better compliance was reported in the group that used the foot orthoses. At the end of the year, 19 of 23 patients who received orthoses were still using their de-

vices, while only 1 of 28 who received the night splints was still using the device.[17]

Another comprehensive evaluation of orthotic therapy for plantar fasciitis evaluated the effect of three widely accepted treatments: a nonsteroidal anti-inflammatory drug (NSAID) (both injected and oral), a soft accommodative device (viscose heel cup) and acetaminophen, and a mechanical device (low-Dye strapping followed by custom foot orthoses).[14] This randomized prospective study (n = 103) found that 70% of the patients in the mechanical therapy group had improvements in pain and function, which was significantly better than the accommodative (30%) or the anti-inflammatory (33%) group. Only 4% of the mechanical treatment group had treatment failure, as opposed to 42% for the accommodative group and 23% for the anti-inflammatory group. The authors concluded that mechanical control with custom orthoses is more effective than the anti-inflammatory therapy or soft accommodative therapy used in this study.

A 2001 published prospective randomized study (n = 255) evaluated the effectiveness of three different mechanical modalities used in the treatment of plantar fasciitis (over-the-counter arch supports, rigid custom-made orthoses with a heel post, and night splints).[19] Though all three devices were effective as initial treatments for plantar fasciitis (after 12 weeks of use), custom-made orthoses saw the greatest patient compliance.

Landorf, in 2006, conducted a randomized trial (n = 136) that evaluated the short-term (3 months) and long-term (12 months) effectiveness of foot orthoses in the treatment of plantar fasciitis.[13] The three treatment arms consisted of "sham" orthoses (soft, thin EVA foam molded over unmodified plaster cast), prefabricated foot orthoses (three-quarter-length retail model, firm density polyethylene foam), and customized foot orthoses (semirigid polypropylene with a heel post). Both the prefabricated and customized orthoses produced statistically significant improvements in symptoms at 3 months. The authors noted that more participants in the sham group and the prefabricated group broke the protocol than in the custom group, possibly because of the comfort issue.

Recently, Roos evaluated the effect of custom-fitted foot orthoses and night splints, alone or combined, in treating plantar fasciitis in a prospective randomized trial (n = 43) with a 1-year follow-up.[17] The authors concluded that custom foot orthoses and anterior night splints were effective in both the short term and long term in treating pain from plantar fasciitis, with all groups improving significantly in all outcomes evaluated across all times. "Parallel improvements in function, foot-related quality of life, and a better compliance suggest that a foot orthosis is the best choice for initial treatment of plantar fasciitis."[17]

Although at first glance the data on the efficacy of orthotic therapy for plantar fasciitis appear conflicting, every study supports the use of custom orthotics to some degree. Each study leaves little doubt that this pathology is mechanical in origin and that effective treatment is accomplished through mechanical control by custom orthoses. Future research may shed light on

which modifications of custom orthoses may be most effective in controlling the midtarsal joint motion to prevent stretching of the plantar fascia.

## Orthotic Therapy Goals for Subcalcaneal Pain

Several considerations must be made before prescribing an orthosis for mechanically induced heel pain. If the source is truly mechanical and not the result of other diagnoses or disorders, then treating mechanically induced subcalcaneal pain with orthoses should have a success rate of 86%, according to one outcome analysis.[7]

Since midtarsal joint supination appears to be the primary mechanism of origin for the dysfunction leading to the pathology, it is essential that the orthosis be made from a cast taken with this midtarsal joint pronated. Casting a foot with the midtarsal joint supinated or with the forefoot inverted and making an orthosis from that cast, which has a false forefoot varus twist, should be avoided at all costs, since the device will hold the midtarsal joint in its pathological position and produce a negative clinical outcome.

Two different scenarios produce a supinated midtarsal joint and tension on the plantar fascia. First is a dysfunction of the rearfoot that everts the heel.[7] This foot, without any forefoot deformity, will have a supinated midtarsal joint simply because for every degree of eversion of the heel, the midtarsal joint must supinate an equal amount to maintain the plane of the forefoot on the floor. The orthotic prescription should address this rearfoot eversion with a nonshallow heel cup depth, a medial skive, and a rearfoot post to decrease or attenuate the resulting traction on the plantar fascia.

The second scenario involves the patient with flexible forefoot valgus deformities. This foot type, which has an everted forefoot to rearfoot relationship, forces the medial side of the forefoot to come into contact with the ground at midstance sooner than normal with greater GRF for a longer period of time and creates an inver-

Casting a foot with the midtarsal joint supinated leaves the false impression that the patient has a forefoot varus (right). Both casts are made from the same forefoot valgus right foot.

A lateral forefoot wedge can be easily added to a custom foot orthosis to pronate the midtarsal joint.

sion moment on the forefoot, ultimately supinating the midtarsal joint.[7] It is essential that the amount of forefoot valgus deformity in the foot be captured in the cast to prevent this compensation. This allows the laboratory to balance the cast, resulting in a device that neutralizes the medial force by creating a greater lateral GRF similar to a valgus forefoot wedge. Another option is to actually add a valgus wedge to the front of the device, compensating for some of the forefoot valgus that might not have been captured in the cast.

A note should be made about the plantar fascial groove (PFG). This orthotic addition is an accommodation several millimeters deep that transverses the long axis of the orthoses. There are no published data on the effectiveness of this accommodation, although virtually all laboratories provide this option. Practitioners may be using anecdotal information in assuming that this groove allows for positioning of the medial slip of the plantar fascia if it is unusually prominent or very tender. Considerations should be made for this accommodation, especially if the patient has primary plantar fasciitis from an injury or overuse and not the proximal periostitis from mechanical dysfunction. No evidence exists demonstrating the groove's advantages or efficacy.

A plantar fascial groove (PFG) can be created into custom orthoses and filled with Poron for patients with fascial irritation.

Heel cushions as an addition to a pathology-specific orthosis fall into a similar category as plantar fascial grooves. This device addition may simply accommodate the sensitive area in acute cases but likely provides no advantage to reversing the pathomechanics of this problem, if motion, particularly supination, of the midtarsal joint is the mechanical fault.

A combination of a semirigid device with a rearfoot post and a valgus forefoot extension fabricated from a negative cast with the midtarsal joint fully pronated, minimum fill, creates the recommended orthoses for plantar fasciitis. A 4 mm medial skive is recommended if the patient's heel is everted in stance.

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# Chapter 3

## Pathology-Specific Orthotic Recommendation for Mechanically Induced Subcalcaneal Pain and Plantar Fasciitis

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|---|---|
| Negative cast | neutral suspension cast with the midtarsal joint fully pronated and the ankle fully dorsiflexed |
| Positive cast correction | perpendicular |
| Material | semirigid polypropylene |
| Heel cup | 14 mm minimum |
| Width | wide |
| Cast fill | minimum fill |
| Heel skive | 2 mm medial skive for patients with a less than 4° everted heel in stance; 4 mm medial skive for patients with a greater than 4° everted heel in stance |
| Positive cast modification | plantar fascial groove for patients with an inflamed medial slip |
| Rearfoot post | flat rearfoot post, although consideration must be made for no post since the study that produced an 86% success outcome did not use an orthosis with a rearfoot post |
| Top cover | top cover does not seem to be required but definitely stabilizes the device in athletic shoes |
| Forefoot extensions | forefoot valgus extension generally 4°, for patients who stand with a perpendicular heel |