The Influence of Medial and Lateral Placement of Orthotic Wedges on Loading of the Plantar Aponeurosis

Article by Geza F. Kogler, Franklin B. Veer, Stephan E. Solomonidis, and John P. Paul, J Bone Joint Surg Am 1999;81-A(10):1403-1413
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CONDENSATION

Purpose of Study

To determine if any of eight placement combinations of orthotic wedges under cadaveric feet reduce strain in the plantar aponeurosis

Approach

Nine fresh frozen cadaveric lower limbs were obtained. The limbs had been disarticulated at the knee, their mean weight was 3.1 kg (range, 2.0-4.0 kg), five were from men, and the donors had ranged in age from 45 to 73 years at the time of death. After thawing, the limbs were fitted with differential variable reluctance transducers (MicroStrain, Burlington, VT). A longitudinal incision was made beginning 1.0 cm dorsally from the plantar surface of the heel, and the plantar aponeurosis was exposed. The transducer was then implanted into the central band of the aponeurosis and secured in place. Care was used to insure the transducer was placed in the tautest segment and parallel to the major orientation of the fibers. The lower limbs were then fitted into a Scott electromechanical testing machine (model CRE/500:GCA Precision Scientific, Chicago IL) that permitted the transmission of loads perpendicular to the base, anteroposterior and mediolateral.

Specimens were conditioned by cycle loading 50 times, and the zero position and reference length of the strain transducer was determined. The orthotic wedges were milled from Plexiglas and shaped to a 6° angle, the most common wedge angle used clinically. Test data were obtained for nine conditions: one with the foot plantigrade (no wedges) and eight with different placement combinations of wedges. Wedges were placed under the medial and lateral aspect of the hindfoot, under the medial and lateral aspect of the forefoot, and in combinations under the hindfoot and forefoot. Specimens were loaded through 60 cycles with a crosshead speed of 508 mm/m

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with loads varying from 0 to 900 newtons. Load and strain data were collected continuously but only data at loads of 0, 225, 450, 675, and 900 newtons were tabulated. Test data were not recorded during the first 10 loading cycles of each condition to allow for first time variability. Percent strain was calculated (change in length)/(original length) times 100.

What Investigators Accomplished

- Percent strain in the plantar aponeurosis with no wedges in place under the foot (neutral control) ranged from 2.14 ± 1.69 with a load on the specimen of 225 newtons, 3.57 ± 1.99 with a load of 450 newtons, 4.61 ± 2.17 with a load of 675 newtons, and 5.49 ± 2.31 with a load of 900 newtons.
- Placement of wedges under the lateral aspect of both the hindfoot and forefoot resulted in the smallest strains in the plantar aponeurosis. Percent strains were 0.89 ± 1.66 with a load on the specimen of 225 newtons, 2.38 ± 1.66 with a load of 450 newtons, 3.44 ± 2.03 with a load of 675 newtons, and 4.31 ± 2.18 with a load of 900 newtons.
- Significantly less strain in the plantar aponeurosis was seen when a wedge was placed under the lateral aspect of the forefoot rather than under the medial aspect:
    - At a load of 225 newtons (percent strain 1.61 ± 1.52 vs. 2.88 ± 1.38, respectively) ($p < 0.05$).
    - At a load of 450 newtons (percent strain 3.04 ± 1.98 vs. 4.31 ± 1.69, respectively) ($p < 0.05$).
    - At a load of 675 newtons (percent strain 4.13 ± 2.22 vs. 5.40 ± 1.89, respectively) ($p < 0.05$).
    - At a load of 900 newtons (percent strain 5.02 ± 2.41 vs. 6.31 ± 2.03, respectively) ($p < 0.05$).

Investigators' Observations

Results from this study suggest that the use of an orthotic wedge under the lateral aspect of the forefoot may be effective for the treatment of plantar fasciitis because use of the wedge results in a locking of the calcaneocuboid joint and decreased strain in the plantar aponeurosis.

COMMENTARY

The authors of the above paper have shown that a forefoot wedge will decrease the load of the central band of the plantar fascia. They feel that this is akin to a low-gear push-off type of foot function associated with the research of Bojsen-Møller. They also feel that this wedging will pronate the lateral column of the foot, locking the calcaneo-cuboid joint and may possibly increase the range of pronation motion available at the subtalar joint.

I must disagree in part with the authors and their conclusions derived from Bojsen-Møller's paper regarding the calcaneocuboid joint. A common misconception regarding Bojsen-Møller's paper is that high-gear push-off, which goes from the heel to the first metatarsal phalangeal joint (MPJ) and to the hallux, causes an unnaturally high tension in the plantar fascia and that low-gear push off reduces this tension in the plantar fascia.

It seems to me that there are two types of tension in the plantar fascia, especially in the medial band. One type is high-gear, with the hallux able to extend eliminating functional hallux limitus. I would associate this as good desirable tension and would actively seek this outcome in the majority of my patients treated with orthoses. The second type of tension is associated with low-gear push-off, where the medial column of the foot does not completely load, especially at the first MPJ, and the pressures of the foot stay lateral until the contralateral limb contacts the ground. This type of tension I associate with a blockage in sagittal plane progression and functional hallux limitus. The load at the hallux may be increased, but at the expense of the decreased loads of the first metatarsal head and a dorsiflexed medial column.

The authors also talk about a possible increase in range of pronation motion of the subtalar joint due to the lateral forefoot wedging. I would tend to disagree here as well. The range of motion of the subtalar joint will not change; it is what it is. But, by wedging the lateral column, what they have done is to increase the available range of plantarflexion motion of the medial column by raising or dorsiflexing the lateral column of the foot. Essentially, they have given the peroneus longus tendon a more optimum position in which to function and more available range of plantarflexion motion of the first ray in which to actively plantarflex the first metatarsal head. This will, in turn, provide some inherent stability to the midfoot as the tendon will now be able to oppose the posterior tibial tendon, which will be actively attempting to supinate the foot away from a locked or blocked first MPJ motion pattern.

While I will not disagree with the conclusion of the authors that the tension in the plantar fascia decreases with a lateral forefoot wedge, I do disagree with the conclusion that they derive in comparison to Bojsen-Møller's paper and in their explanation of the change in midtarsal joint and subtalar joint positions. While much more needs to be done to explain exactly why the tension decreases in the plantar fascia with lateral forefoot wedging, it is definitely a treatment option worth contemplating and possibly utilizing in the ongoing battle of chronic plantar fasciitis.

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