

The Medial Oblique Shell Inclination Technique

A Method to Increase Subtalar Supination Moments in Foot Orthoses

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A medially deviated axis has been cited as an etiologic factor in increasing pronatory moments across the subtalar joint axis. Orthoses are often used to reduce these pronatory moments, aiming to off-load related injured structures. By aligning the posting or incline of an orthosis shell medial to the axis and parallel to it, the amount of moments applied will be theoretically greater than if prescribed at a less-than-optimal angle. We first published the medial oblique shell inclination as a method to increase supinatory moments to a medially deviated subtalar joint axis in 2008. This paper summarizes the theoretical reasons for use and introduces original methods of construction. (J Am Podiatr Med Assoc 101(6): 523-530, 2011)

The Medially Deviated Subtalar Joint Axis

Kevin Kirby, DPM, first published work on variations in the subtalar joint axis in 1987.¹ It was proposed via a concept of rotational equilibrium that the position of the subtalar joint axis would have a direct consequence on the moments acting about it. A foot with a medially deviated subtalar joint axis would experience an increase in pronation moments, whereas a foot with a laterally deviated subtalar joint axis would experience an increase in supination moments.

Kirby² proposed that when the foot is in a normal position in relaxed bipedal stance, the subtalar joint axis passes through the posterolateral calcaneus posteriorly and above the first intermetatarsal space anteriorly. In the case of a medial axis, the talus is more internally rotated and medially translated, creating a more oblique angle from the posterolateral aspect of the calcaneus to the medial aspect of the foot. Such variations in subtalar joint axis location and their effect on moments across the subtalar joint axis can be represented by a seesaw analogy.² The seesaw demonstrated in Figure 1 is a

classic type 1 lever, in which the fulcrum is located between the input effort and the output load. However, in terms of orthoses and their effect, it seems more valid for us to think of the subtalar joint axis as an inverted seesaw, in which the ground reaction forces and orthosis reaction forces are acting upwards onto the foot (Fig. 2). When an axis moves medially, the lever will be longer on one aspect of the axis and the applied force will increase (Fig. 3). A motion will, therefore, occur; in this example, the motion is pronation. It can be concluded that when the subtalar joint axis is

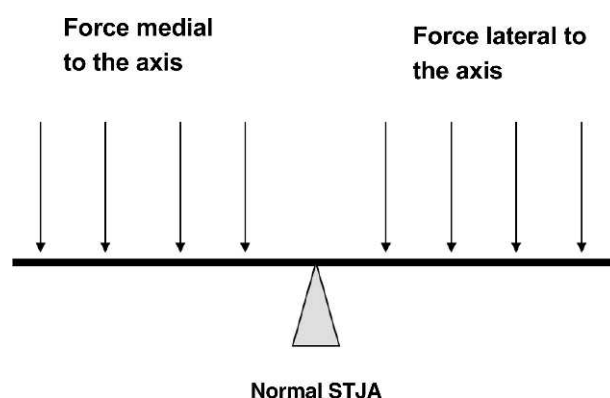


Figure 1. The classic seesaw model demonstrates forces acting down on both sides of a pivot. In this case, the forces are acting down on the medial and lateral aspects of a normal subtalar joint axis (STJA).

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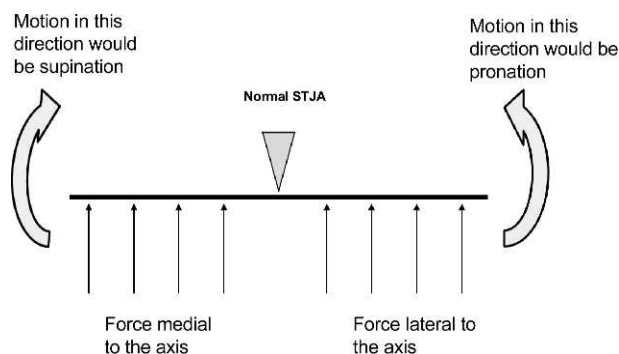
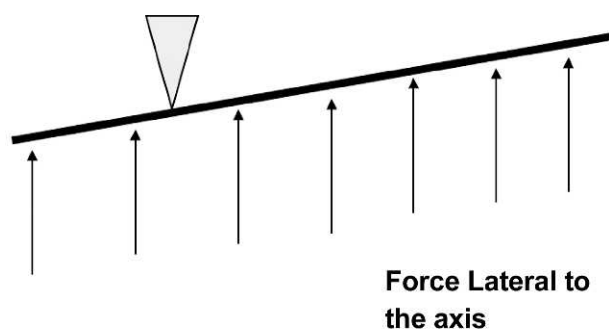


Figure 2. The inverted seesaw model demonstrates ground reaction forces acting on both sides of a normal subtalar joint axis (STJA).

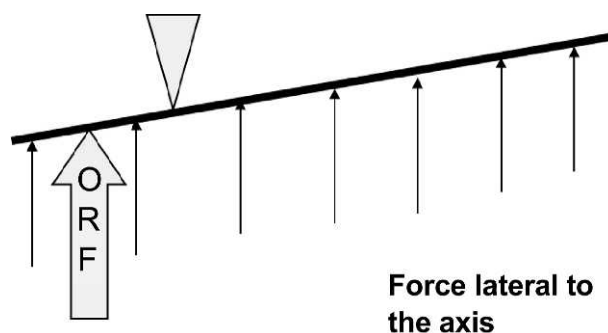
medially deviated, an increase in pronation moment is experienced. This increased pronation moment will produce a stress in tissues that oppose it. Foot-based theories that highlight the importance of tissue stress link such an increased moment to factors relating to injury,^{3,5} including the plantar fascia and posterior tibial tendon, which may exceed their loading capacity with a medially deviated subtalar joint axis, resulting in injury.⁶

Functional foot orthoses are often used to reduce pronation moments. Rearfoot posting may be prescribed to apply an orthosis reaction force to the medial aspect of the subtalar joint axis via the thicker amount of material present plantar to the medial aspect of the heel cup. This is demonstrated by the orthosis reaction force arrow in Figure 4. The



Force medial to the axis

Figure 3. The axis of rotation moves closer to one end of the lever, as is the case in the foot with a medially deviated subtalar joint axis. As a result, the lever will be longer on one side of the axis, which will increase the moment of the forces on that side of the axis and decrease the moment of the forces on the opposite side of the axis. Motion around the axis may occur, shown here as subtalar joint pronation.



Force medial to the axis

Figure 4. The larger grey arrow represents additional force from the orthosis, the orthosis reaction force (ORF). By applying a force medial to the axis, an increase in subtalar joint supination moments results. If the applied ORF is large enough, it may result in supination around the axis.

greater the rearfoot post, the theoretically greater the applied orthosis reaction force and the greater the reduction of pronation moments.

In 1992, Kirby⁷ published an orthoses shell modification called the medial heel skive. The medial inclination of the orthotic shell is achieved by “skiving” away the desired amount of plaster from the medial heel of a positive cast. This theoretically places greater orthosis reaction force on the medial aspect of the subtalar joint axis than does a rearfoot post alone, although working on the same orthosis reaction force principle. This incredibly useful modification is now well recognized^{7,11} and is available from most commercial foot orthosis laboratories.

The Medial Oblique Shell Incline Modification

As previously stated, a medially deviated subtalar joint axis runs at a greater oblique angle from lateral posterior to anterior medial across the foot¹ than does a normal subtalar joint axis. Although the medial heel skive and rearfoot post apply a force to the medial aspect of a medially deviated subtalar joint axis, they do not apply this force perpendicular to it in the transverse plane.¹² Instead of lining up parallel to the medial subtalar joint axis, the angle of application lies parallel to the orthotic shell (Fig. 5). The total vertical component of the orthotic reaction force that applies the supination moment to the foot is, therefore, reduced due to the component of horizontal force. This theoretical loss

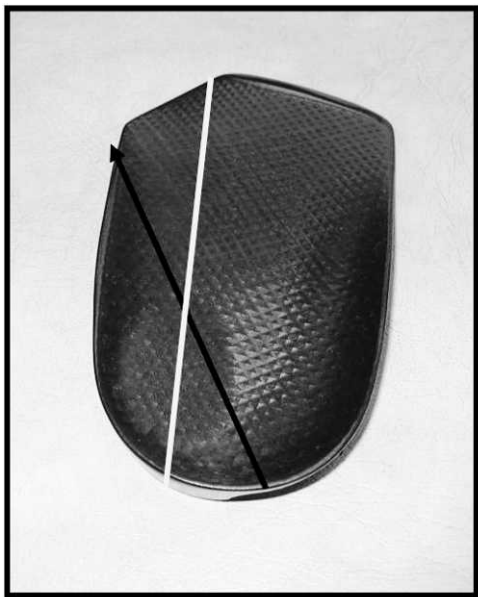


Figure 5. The medial heel skive applies a force, which may be described as an orthosis reaction force, to the medial aspect of a medially deviated subtalar joint axis. However, it does not apply this force perpendicular to it. A medially deviated subtalar joint axis runs at an oblique angle from lateral posterior to anterior medial (black line), but the classic medial heel skive (or extrinsic heel post) places a force at an angle approximately parallel to the edge of the shell (white line).

of force can be demonstrated using the inverted type 1 lever seesaw analogy. In Figure 3, the force was greater on one side of the axis because of the longer lever arm and increased area of application. Figure 4 demonstrates that the orthosis reaction force placed on the medial side of the axis will increase the supination moment, which will, in turn, decrease the net pronation moment. However, the force is shown to be applied vertical to the lever, but this does not represent the force applied to a medial subtalar joint axis by a medial heel skive or an extrinsic medial post. Instead, a graphic representation with example calculation of the force applied is shown in Figure 6. As demonstrated using a simple two-dimensional vector diagram, the force applied consists of a force not only in the vertical direction but also in the horizontal direction. This may, therefore, reduce the supination moment applied to the subtalar joint axis. Clinically, the vertical force lost to horizontal force may, in principle, increase lateral shear or “slipping” on an orthotic shell.

If a force could be applied at 90° to the medially

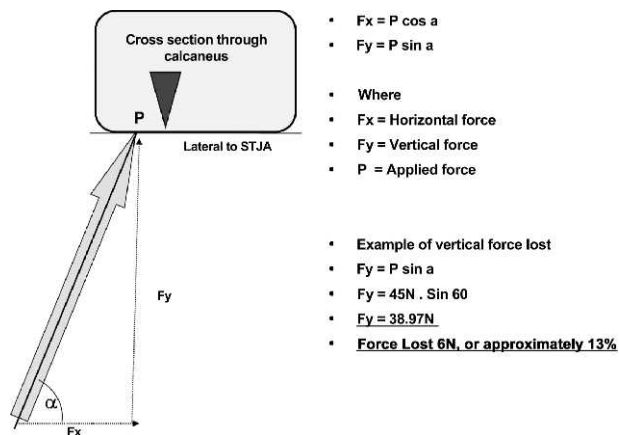


Figure 6. With classic rearfoot posting, or medial heel skive, the orthosis reaction force is applied at an angle to the axis. This may result in some of the orthosis reaction force meant to increase subtalar joint supination moment being lost due to the resultant horizontal force component from the orthosis reaction force. STJA indicates subtalar joint axis.

deviated subtalar joint axis, as demonstrated in Figure 7, the vertical component of the force would be greater. Less force would be lost to the horizontal component, and greater force would be applied to reduce pronation moment. It can,

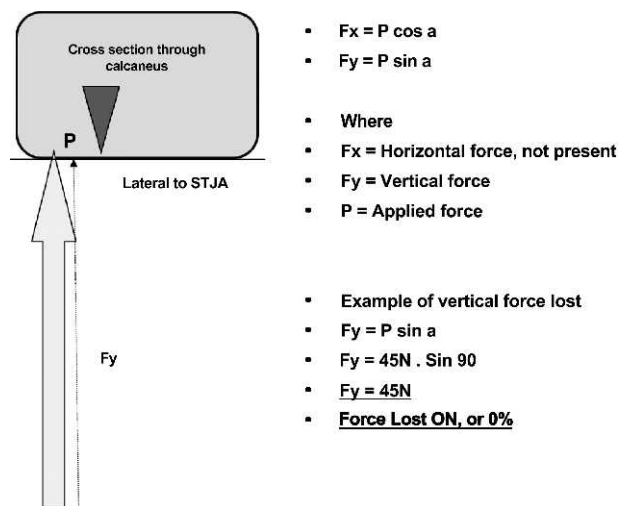


Figure 7. The orthosis reaction force should be as perpendicular to the subtalar joint axis (STJA) as possible to maximize the vertical component and reduce the force lost to the horizontal moment. Shown is the ideal situation, where the orthosis reaction force has been aligned perpendicular to the axis, and no horizontal component has been created.

therefore, be seen that by aligning the orthosis reaction force more perpendicular to the subtalar joint axis by running the shell inclination parallel to it, a greater supination force may theoretically be applied to the subtalar joint. The medial oblique shell incline is a rearfoot shell modification that attempts to align the application of the orthosis reaction force at a more optimal angle to the subtalar joint axis. However, the subtalar joint axis translates and rotates through weightbearing activities. It becomes more medial with pronation and more lateral with supination.^{2, 13, 14} The medial oblique shell incline modification itself, therefore, has limitations as to how parallel it can run to the subtalar joint axis. The subtalar joint axis is not fixed in space, although the medial oblique shell incline is. However, in patients with a medial axis, the hypothetical reduction of the horizontal component of orthosis reaction force via the oblique angulation of shell incline may be beneficial if not absolute.

Patients with a medially deviated axis often present to podiatric medical clinics with symptoms related to structures that oppose the resultant increased pronation moment, eg, plantar fascia and posterior tibial tendon. The medial oblique shell incline can, in theory, be used in these patients to aid in reducing stress on injured structures by applying a greater amount of vertical orthosis reaction force medial to the subtalar joint axis. Past work has focused on new methods of manufacture not widely used in the podiatric medical community.⁸ This paper describes the recommended production method using positive plaster cast foot impressions.

Medial Oblique Shell Incline Production Methods

The medial oblique shell incline is a modification designed for use in patients demonstrating a medially deviated subtalar joint axis. This may be assessed by the assumption that the axis passes directly through the center of the talar neck.¹⁵⁻¹⁹ In the relaxed bipedal stance, the central anterior aspect of the talus should be pointing to the approximate area of the first metatarsophalangeal joint. If the talus is placed medial to the first metatarsophalangeal joint, the axis may be classed as medially deviated.^{6, 20}

Prescription Choices

When prescribing the medial oblique shell incline modification, the podiatric physician needs to

stipulate the amount of frontal plane incline and transverse plane angulation. The frontal plane incline is best prescribed in 5° increments depending on the number of supination moments to be applied to the subtalar joint. For example, a 20° medial oblique shell incline may be prescribed to apply a larger supination moment or a 5° medial oblique shell incline to apply a lesser moment.

The transverse plane angulation is the podiatric physician's set angle at which the incline is to be applied depending on the position of the subtalar joint axis. This is best marked on the negative cast, or another impression system, by approximating the progression of the axis through the talar head to the medial aspect of the foot.

Medial Oblique Shell Incline Cast Modification

The negative cast or other impression system is filled as normal, and the marked position of the subtalar joint axis is transposed onto the positive cast. A line is drawn from this point to a measured two-thirds lateral posterior aspect of the heel (Fig. 8). Other routine cast modifications, such as intrinsic forefoot posting, are made as required, and a large lateral expansion is added to prevent excessive narrowing of the heel cup with later plaster reduction. A large lateral heel expansion has been presented elsewhere,²¹ and as a heel cup modification has itself linked to greater degrees of foot control.

A forefoot wedge is then placed under the cast to the lateral aspect of the forefoot at the required frontal plane incline (eg, 15°). This incline tilts the rearfoot to allow for frontal plane plaster removal.



Figure 8. The subtalar joint axis is transposed onto the positive cast.

The cast is then positioned with the transverse plane line on the cast pointing perpendicular to the person holding the cast. Using an abrasive base, the required amount of plaster can be removed by moving the cast forward and back (Fig. 9). This will remove plaster at the required transverse axis. Approximately two-thirds of the total area of the heel should be removed.

Figures 10 and 11 show photographic views of posterior and plantar aspects of the medial heel skive and medial oblique shell incline modifications as they would appear on positive casts. The medial

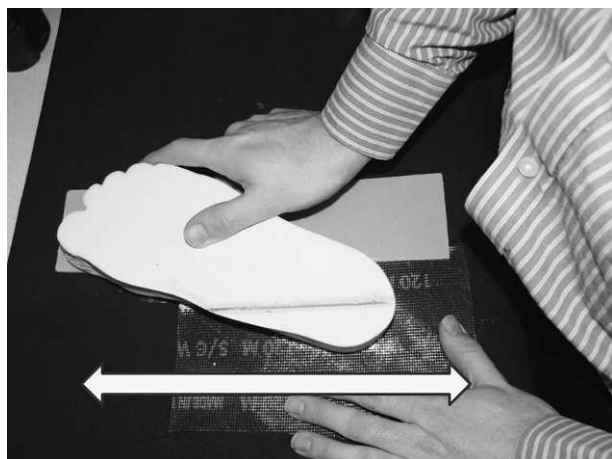
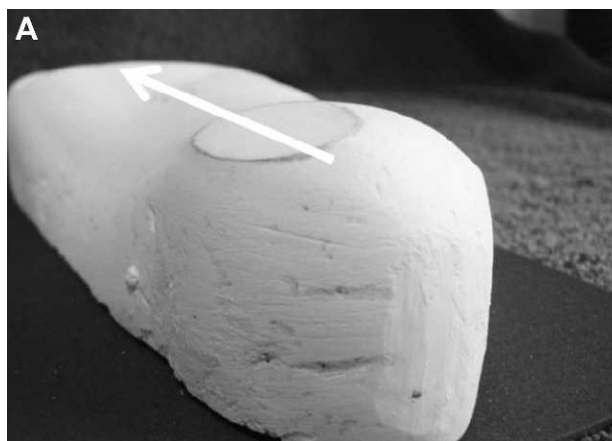


Figure 9. The cast is positioned with the transverse plane line pointing perpendicular to the person holding the cast. The required frontal plane angulation is placed on the lateral aspect to the forefoot. The cast can then be moved back and forth in this position until approximately two-thirds of the medial heel has been removed.



heel skive is shown to allow comparison with the manufacturer with this previous cast modification. The oblique angle of the incline and lateral expansion is visible and highlighted via the white arrows.

The choice of shell material can then be pressed to the cast in the regular manner, the result of which is shown from the posterior and dorsal aspects in Figures 12 and 13, respectively. The oblique application of the incline is highlighted in Figure 13 via the white arrow and can be compared with the medial heel skive. Any extrinsic shell modifications, such as extrinsic rearfoot posting, can then be added (Fig. 14).

Possible Contraindications

As with all aspects of podiatric medicine, care must be taken to minimize the possibility of harm to the patient. By increasing the supination moment placed on the subtalar joint axis, it may be possible to “oversupinate” a foot and cause adverse effects, such as inversion injuries and peroneal overuse injuries.

The medial oblique shell incline should also be used only in feet demonstrating a medial subtalar joint axis. In a nonmedial subtalar joint axis it would be of less benefit than would a medial heel skive or rearfoot post because its angle of application would be less parallel to the axis.

In addition, the talocrural joint lies approximately 8° from the transverse plane (or 82° from the sagittal plane) and 20° to 30° from the frontal plane.²² This means that by aligning the frontal plane inclination of the heel section of the orthosis in a more medial

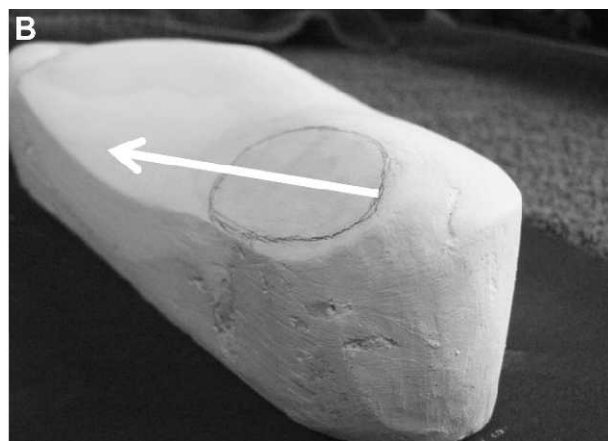


Figure 10. Posterior views of positive casts with the medial heel skive modification (A) and the medial oblique shell incline modification (B). The white arrows demonstrate the different angle of application of the incline between the two cast modifications.

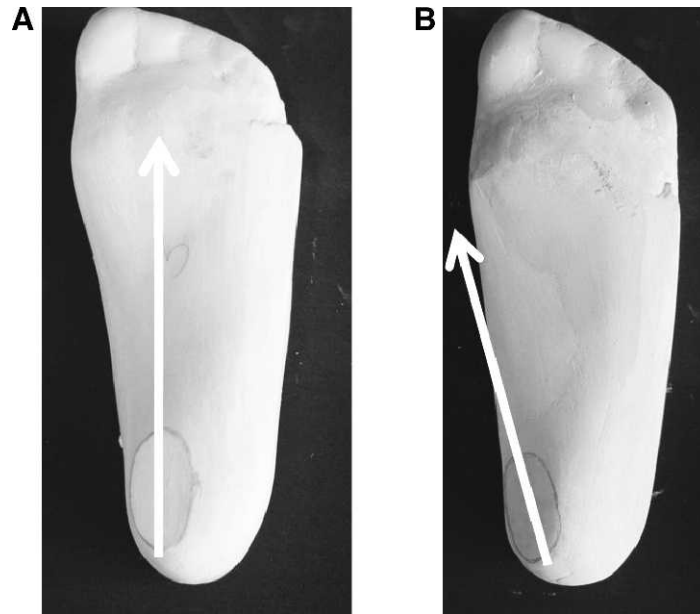


Figure 11. Plantar views of positive casts with the medial heel skive modification (A) and the medial oblique shell incline (MOSI) modification (B). The white arrows demonstrate the different angle of application of the incline between the two cast modifications.

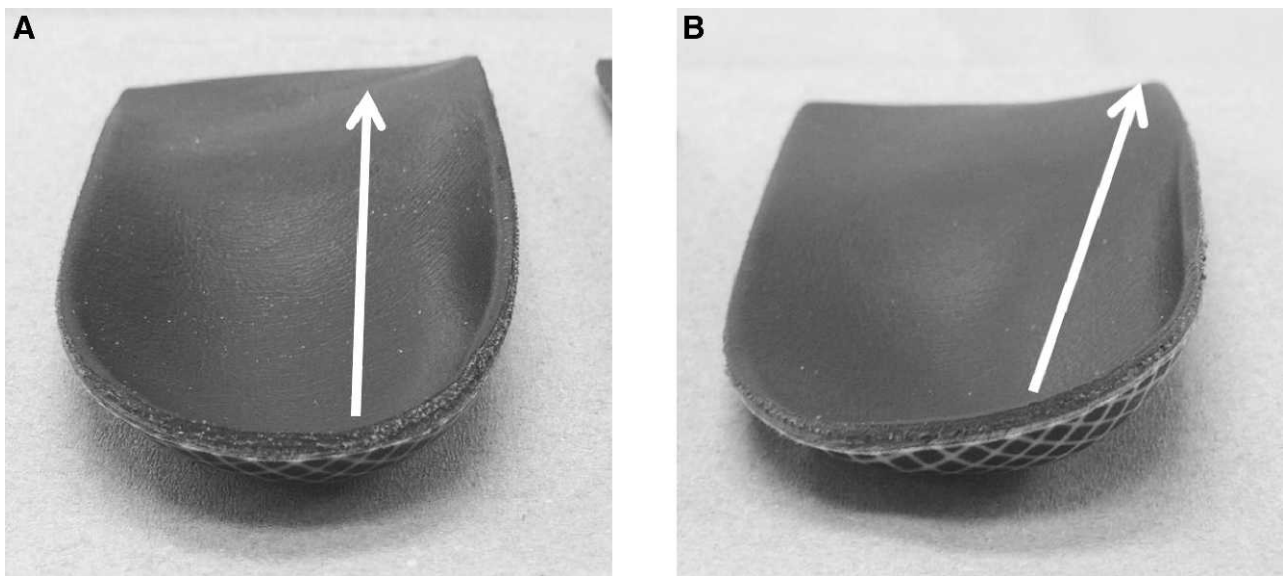


Figure 12. Posterior aspect comparison of the shell pressed from the medial heel skive (A) and the medial oblique shell incline (B). The oblique application of the incline is highlighted via the white arrow and can be compared with the medial heel skive.

orientation, the orthosis reaction force is applied more perpendicular to the talocrural joint axis. Theoretically, this can also increase the moment plantarflexing the foot at the ankle. This modification, therefore, may not be suitable for patients exhibiting weak anterior tibial components or anterior compartment syndrome or patients possi-

bly at risk for such injuries due to chosen activities, eg, hill or mountain running.

Conclusions

The medial oblique shell incline is an orthosis shell modification that can be used to reduce pronation

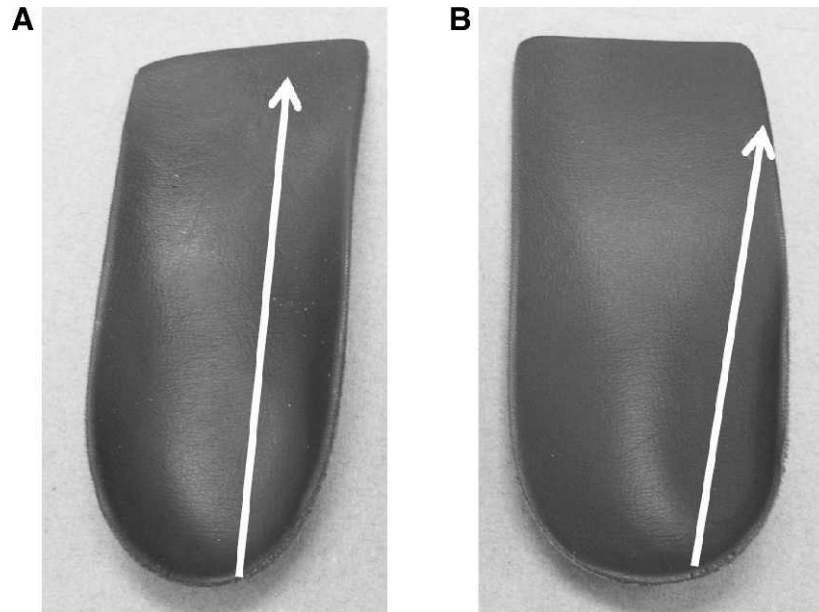


Figure 13. Dorsal aspect comparison of the shell pressed from the medial heel skive (A) and the medial oblique shell incline (B). The oblique application of the incline is highlighted via the white arrow and can be compared with the medial heel skive.

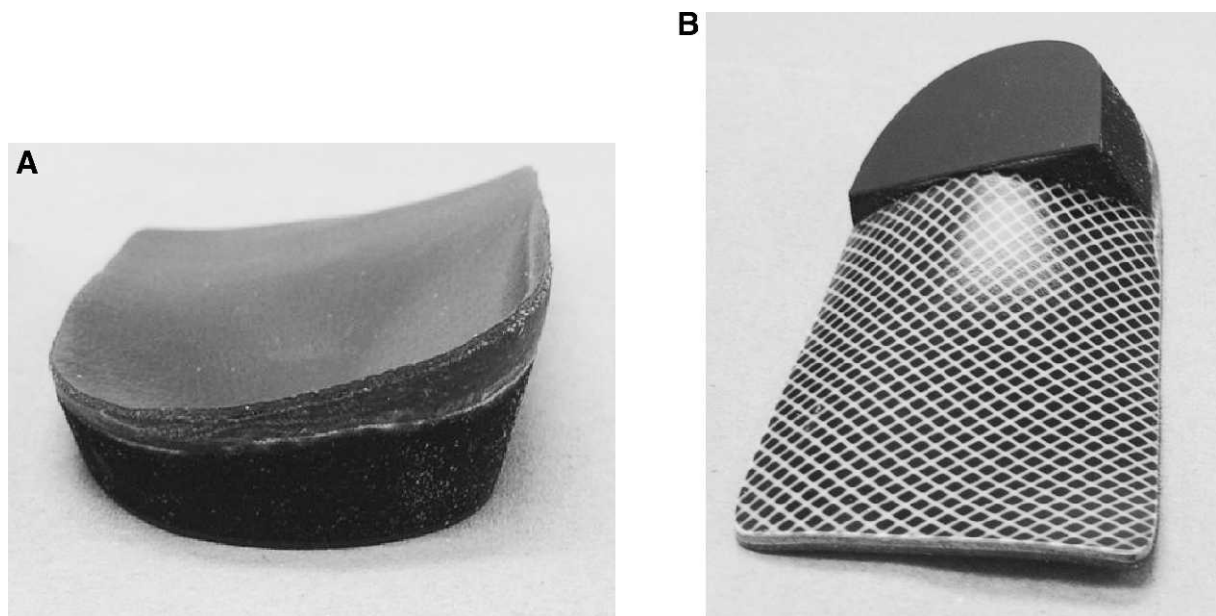


Figure 14. Posterior (A) and plantar (B) aspects of the medial oblique shell incline modification with an extrinsic rearfoot post.

moments in patients with a medially deviated subtalar joint axis. The theoretical benefit from its prescription has been presented, and its construction method introduced. It is requisite that further investigation into best use and the possibility of adverse effects is undertaken.

Acknowledgment: Phil Rees from Langer UK Ltd for his assistance with casts and orthoses for photography.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

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