Plantar First Metatarsal Head Blisters Orthotic Prescription Variables

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In this article, I'm going to explain the relevant structural and functional factors causing blisters under the first metatarsal head and the orthotic prescription variables that should be under consideration for preventing them. This is a bit technical and aimed more towards my podiatry colleagues.

Plantar first metatarsal head blisters

A quick refresher on skin shear

Blisters are the acute manifestation of excessive shear forces (callouses are the chronic manifestation). Skin shear can be pictured as the skin being stretched back and forth with every step we take.

"Shear forces are applied to the human foot during walking and running because of the mechanics of foot alignment during contact and propulsion. The foot approaches the ground at a tangential angle (not a purely vertical angle) and then pushes off in a similar tangential direction. The foot must skid to a stop and then push into the ground to propel forward." *Richie, 2010*

So what goes into creating the conditions resulting in skin shear? The answer is three-fold.

Firstly

There needs to be a combination of **high pressure** and **high friction levels** (ie: high coefficient of friction). This keeps the internal shoe surface adhered to the sock, and the sock adhered to the skin. These are exactly the pressure and friction conditions we see in-shoe during exercise - high weightbearing and shoe contact forces, high temperatures and high humidity levels with low evaporation.

Secondly

The **bones move relative to the skin**. The foot and all of its components are not like a rigid block of cement. As Richie stated above, "The foot must skid to a stop and then push into the ground to propel forward." Richie is referring to the skidding between skin and bone (not between the shoe and the ground). This skidding is the stretching or skin shear.

Thirdly

There needs to be sufficient shear **repetitions**. The longer the activity duration (walking, running, sporting activity), the more likely the blister threshold will be reached for that individual.

The blister injury

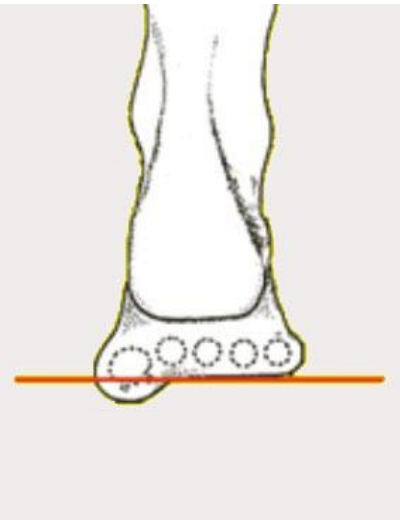
Skin shear is entirely normal, and our skin can put up with a lot of it. Some more than others. There is a large individual variation in blister resistance with some people being more towards the blister prone end of the continuum. When shear occurs to excess, in magnitude or repetition, a tear occurs within the stratum spinosum of the epidermis. This tear is the initial blister injury. Within two hours, fluid fills the injury site, this makes the skin bubble up and this is what is familiar to us all as a blister.

More blisters under the first metatarsal head

Blisters under the first metatarsal head

In considering the skin under the first metatarsal head, let's focus on the anatomical entity of a plantarflexed first ray. A plantarflexed first ray shows the first metatarsal head on a lower plane compared to the other metatarsal heads. It can be stiff (rigid)

or compliant (flexible), or somewhere in between. Let's simplify this and make the distinction between stiff and compliant.



Plantarflexed first ray - image credit

Stiff versus compliant plantarflexed first ray

The difference between a stiff and compliant plantarflexed first ray is:

- A stiff plantarflexed first ray sees the head of the first metatarsal bear weight sooner and for longer. Peak pressures under the first metatarsal head are relatively high. *The predominant blister-causing force is pressure.*

- A compliant plantarflexed first ray sees the first metatarsal dorsiflex upon weightbearing pressure. In doing so, the first metatarsal head slides distally, culminating in the medial longitudinal arch flattening. *The predominant blister-causing force is bone movement.*

With all other factors being equal

With all other factors of the in-shoe conditions and the activity being equal (ie: friction levels, the number of shear repetitions), the predominant blister-causing forces under the first metatarsal head for each condition are:

- Stiff plantarflexed first ray: Pressure
- Compliant plantarflexed first ray: Bone movement

Orthotic prescription variables in preventing blisters under the first metatarsal head

There are numerous orthotic prescription variables a podiatrist can use when designing an orthotic. With a knowledge of foot function and tissue stress, a podiatrist can choose the relevant prescription variables to design the best orthotic to minimise the damaging forces on injured tissues. In this case, the skin under the first metatarsal head.

Most of this I learned from Craig Payne through his resources at LaTrobe University, at his Biomechanics Bootcamps and at Running Research Junkie; and Kevin Kirby's Precision Intricast Newsletter books.

a) Stiff plantarflexed first ray – With pressure being the predominant blister-causing force, pressure reduction could come about with:

- Metatarsal dome - increases weightbearing pressure to the second, third and fourth metatarsal heads, thereby reducing pressure under the first (and fifth).
- Lateral forefoot padding 2-5 – reduces peak pressure under first metatarsophalangeal joint.
- Heel lift – if limited ankle joint dorsiflexion, a heel lift keeps rearfoot loaded for longer.
- Heel height differential / avoid zero drop – for same reason as above.
- Calf stretches & tib/fib mobilisations – for same reason as above.

b) Compliant plantarflexed first ray – With bone movement being the predominant blister-causing force, reducing dorsiflexion of the first metatarsal could come about with anything to facilitate the windlass mechanism, either to initiate windlass mechanism sooner or reduce the force required to initiate it:

- Heel lift – initiates windlass mechanism sooner.
- Heel height differential – initiates windlass mechanism sooner.

- Calf stretches & tib/fib mobilisations – if limited ankle joint dorsiflexion as it reduces first metatarsal dorsiflexion.
- Invert the rearfoot / inverted orthotic – inverting the rearfoot lowers the force required to activate windlass mechanism.
- Cluffy wedge – initiates windlass mechanism sooner as it preloads the hallux.
- Lateral forefoot extension padding – everting the forefoot lowers the force required to activate windlass mechanism.
- Plantarfascial groove - lowers the force required to activate windlass mechanism.
- First ray wipe / first met head cutout – reduces dorsiflexion of the first metatarsal.

Reality

In reality, foot structure is not so black and white. There is still weightbearing pressure under the first metatarsal head of a compliant plantarflexed first ray. The first metatarsal can still dorsiflex and the arch flatten a little with a stiff plantarflexed first ray. Plus, there are coexisting biomechanical factors that may impact on the orthotic prescription variables used. The task for your podiatrist is to determine which factors are most relevant and to prescribe an orthotic device (pre-made, customised or custom-made) with the appropriate prescription variables for your foot structure, function and activity.

Don’t forget repetitions and friction levels

Look back at the quick refresher on skin shear. We’ve dealt with pressure and bone movement in the discussion so far. But we’ve assumed the number of shear repetitions and friction levels have remained unchanged. Certainly, you can choose to reduce the number of shear repetitions. But it would mean walking or running shorter distances or less game time. Friction levels are easy to reduce with moisture-management methods, Engo patches, lubricants or powders. There are two further blister prevention strategies your podiatrist may implement. These are: shear absorption, such as with a Spenco orthotic cover; and shear distribution with skin taping techniques.

Wrapping up

When it comes to blisters under the first metatarsal head, a plantarflexed first ray can be significant in different ways. Consider the forces imparted to the overlying skin when the first ray is stiff and compliant.