Heel Pain and the Functional Anatomy of the Plantar Calcaneal Fat Pad

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Primary Functions

- Absorb shock at heel strike (ability to reduce size of impact force)
- Energy Dissipation
- Load bearing
- Pursuance of these however produces other important functions
- Venous heel pump/superficial venous drainage
- Grip
- Insulation

70-100% of body weight in 0.05 secs

Rome et al. 1998 - stat. significant mean difference in thickness = 8.4mm (95% CI 7.68-9.13mm)

Plantar heel fat pad construction – general features

• Approx. 18mm of thickness inferior to calcaneal tubercles (can hypertrophy to 26mm)
• Loaded surface area of between 9-19 sq. cm
• Contains micro and macro-chambers, superficial to deep
• Reticular arrangement of collagen/elastin septral walls containing lipocyte

Plantar heel construction

- **Micro-chambers**
  - ≈ 3.5mm thick unloaded and 3.3mm loaded

- **Macro-chambers**
  - ≈10mm thick unloaded and 5.5mm loaded


Jahss et. al. 1992
Plantar heel construction

- Superficial micro-chambers immediately inferior to the dermis - held together by septral walls of dense irregular collagenous connective tissue
- Superficial layer is highly vascular (contained blanching on pressure)
- Separated from macro-chambers by ligamentous tissue in the shape of a cup, the internal cup

- Vascular supply – 2 posterior branches and calcaneal branch of the peroneal artery and anastomoses of the posterior tibial artery
Plantar heel construction

- Internal cup attached to the calcaneal periosteum via vertical bands of septa forming the **macro-chambers** which thicken at the point of insertion


**Macro-chambers** septral walls arranged in a reticular ‘honeycombed’ fashion with no interconnection between the ‘units’ in a closed cell structure.

Plantar heel construction

• Both macro and micro-chambers contain a combination of different fatty acids with a greater ratio of unsaturated (palmitoleate, oleate, vaccenate, and linoleate) to saturated (myristate, palmitate, and stearate) in order that viscosity is maintained in temperatures lower than body heat.

Afferent nerve endings/mechanoreceptors

- High concentration of Vater-Pacinian corpuscles in the fat chambers superior to the calcaneus. These corpuscles sense high frequency shocks and tissue displacement

Afferent nerve endings/mechanoreceptors

- High concentration of Meissner’s corpuscles in the heel dermis sensing touch
- Contribute to balance during the stance phase via phasic muscle activation?
Under Compression

• Perry calculated that the impact load on the medial tuberosity of the calcaneus was approximately 5kg/cm² with a frequency of 1160 impacts per mile, in a normal walking subject.

• Perry J. Anatomy and Biomechanics of the Hindfoot. Clinics in Orthopaedics 1983;177:9-15
Under Compression

1. The chambers expand dissipating collision forces (primarily lateral expansion because the medialcalcaneal retinaculum reduces medial expansion)


2. The calcaneal tubercles ‘sink’ into the chambers further adding to the shock absorption effect

Lateral expansion confinement

• Jorgensen and Bojsen-Moller (1989) compared the ability of traumatised cadaver heel fat pads to non traumatised cadaver heel fat pads (n=10).

• Shock absorbency was reduced by a mean of 24%; confining the heel fat pad increased shock absorbency by 49% in traumatised heels and ~ 30% in non traumatised heels

Under Compression

• The micro chamber layer has a high degree of stiffness in response to loading and the septral walls are composed of predominately elastic fibres

• The macro chambers (approximately equal amounts of elastic and collagenous fibres) respond with a proportionately larger degree of deformation and corresponds with overall heel pad stiffness

Heel Pad Paradox

• Non traumatised pad – efficient ‘damper’
• Large difference in energy dissipation between *in vivo* (~95%) samples and *in vitro* (~30%) samples and a pronounced hysteresis only in the *in vivo* samples
• (Aerts, Ker, De Clercq et al. 1995) – explained this paradox noting the presence of the whole lower limb *in vivo*

Venous damping

- The combined stroke volume emitted from plantar sole and heel compression is ≈ 20-30ml.
- Impact energy is used for antigravity propulsion of this venous blood contributing to a shock dampening effect.
- Weijers et al. (2005) confirmed this damping effect recently in further research
Mechanical Dashpot

(Adapted from Bojsen-Moller and Jorgenson 1991)

As the ‘piston’ (calcaneus) descends the fluid (fatty acids) in the cylinder (reticular septral cells) is compressed.

This compression forces venous blood transversely into the superficial medial and lateral marginal veins and thereon to the large and small saphenous veins.
Hysteresis - Damping

- Energy dissipated during the impact of the calcaneus within the fat pad is then probably due in part to the propulsion of venous blood from the heel fat pad.
- Level of hysteresis prevents ‘bounce’ and allows grip.
Diabetes and the heel pad

- Collagen septa in the heel fat pad is thought to thicken in the diabetic patient.
- The micro and macro chambers are also believed to decrease in size.
- The consequence of these factors is impaired fat pad function i.e. reduced compressibility.