Orthoses to Prevent Diabetic Ulceration: Management of Friction and Pressure

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Disclosure: ProLab Orthotics

Lecture Guide

- Concepts of pressure management
- Validity of these concepts
- Concepts of friction management
- Orthotic prescription

What is our current knowledge (evidence) about pressure and ulcers?

Pressure and Ulcers

"Dynamic foot pressures are diagnostic and a predictive aid for plantar ulcerations"

A. Bolton, 1983
Diabetic Care

Pressure and Ulcers

"Loads and vertical forces impose a higher risk for ulcers in patients with peripheral neuropathy"

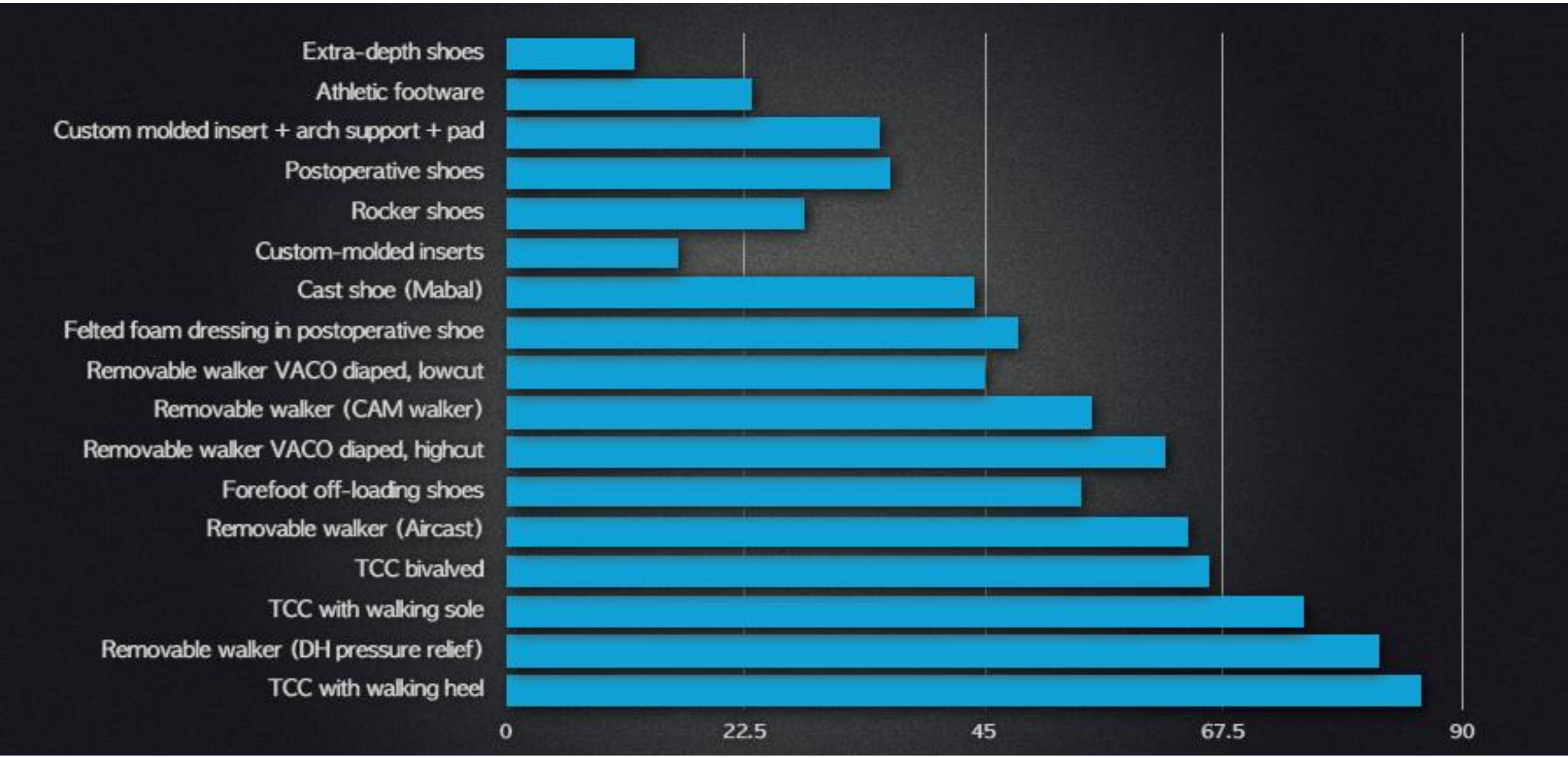
R.G. Frykberg, 1998
Diabetic Care

Pressure and Ulcers

"Retrospective and prospective studies have shown that elevated plantar pressure is a causative factor in the development of many plantar ulcers"

P. Cavanaugh,2010
JAPMA

Does altering these “vertical loads” help?



Off loading devices heal ulcers from 20-80% of the time - 37 studies

P. Cavanaugh, 2010 JAPMA

Pressure Management for the Foot

- PURPOSE: Determine the effect of a **Total Contact Insert** and an **Metatarsal Pad** on metatarsal head peak plantar pressures and pressure-time integrals.
- CONCLUSION: **The TCI and the MP caused substantial and additive reductions of pressures under the metatarsal heads.**
  - The TCI reduces excessive pressures at the metatarsal heads by increasing the contact area of weight-bearing forces.
  - The MP acts by compressing the soft tissues proximal to the metatarsal heads and relieving compression at the metatarsal heads.

Hastings, Mueller, 2006
Physical Therapy

Metatarsal Pad Placement

- Peak plantar pressure measured on 20 diabetic patients
  - With total contact insert only
  - With TCI and proximal met pad
  - With TCI and distal met pad
- CT scans determined the relationship of pad to 2nd met head
- Met pads placed between 6.1mm and 10.6mm prox to met head resulted in significant peak plantar pressure reduction compared to wearing TCI only.
  - Some distal placements resulted in plantar pressure increases

Hastings, Mueller, 2003
Clinical Biomechanics

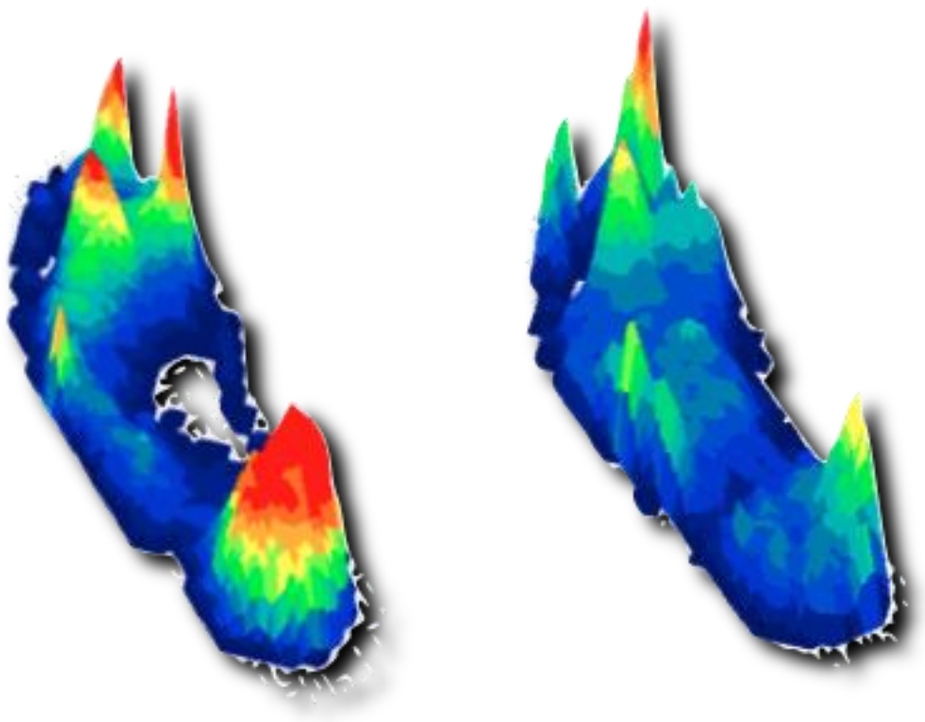
Is Pressure the Primary Cause of Ulcers?

"Pressures are not as specific in producing ulcers as we had hoped" Lavery, 2003

"Patients can and will ulcerate in areas of normal pressure and may not ulcerate in areas of high pressure" Ledoux, 2005

"Ulcers appeared at high pressure area only 38% of the time" Veves, 1992

Patients with areas of normal plantar pressure values may still ulcerate and patients with elevated plantar pressure may not! Hsi, 1993



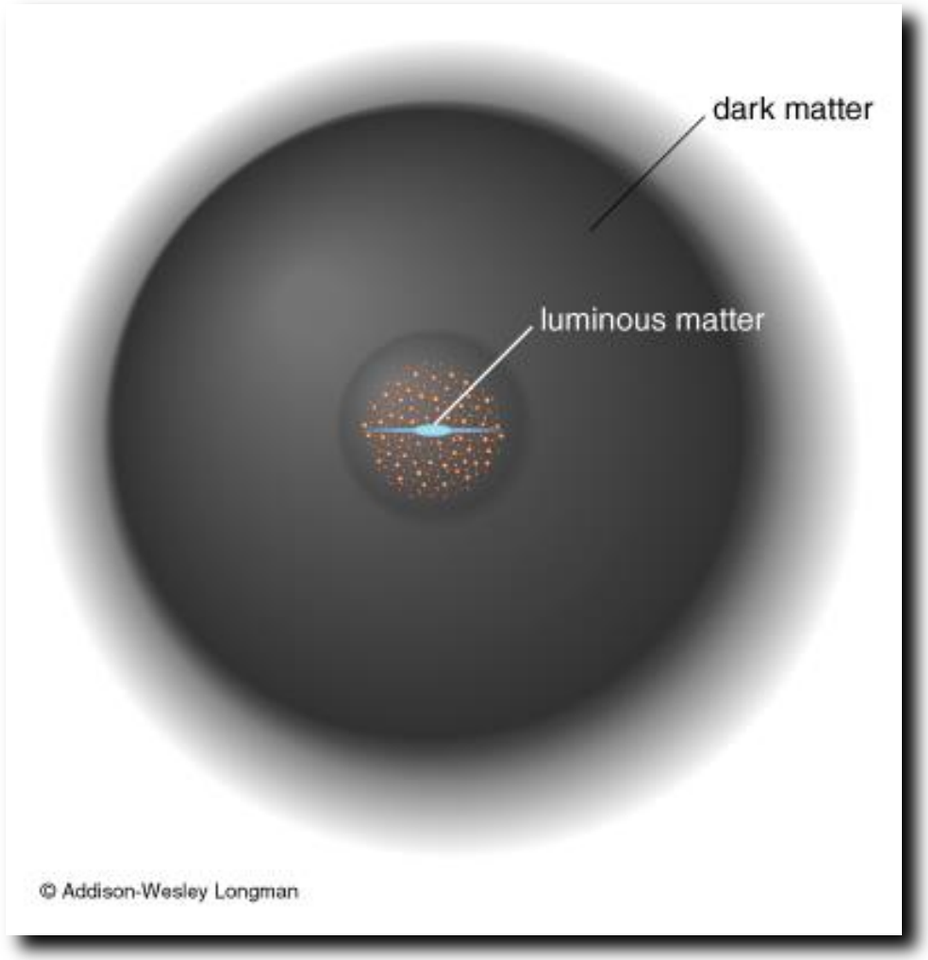
- Pressure studies demonstrate there is much more pressure on the heel of insensate patients ... but we see much more ulcers on the forefoot

M. Mueller, 2003; JBJS

- Where are the pressure peaks vs.
- Where are the ulcers

- If increased plantar pressures (pressure peaks) cause ulcers why do ulcers occur in other areas 62% of the time?

M. Veves,1992
Diabetologia



- Something other than just pressure is contributing to calluses, blisters and ulcers

“Podiatric Dark Matter”

David Armstrong, D.P.M., PhD.,
University of Arizona

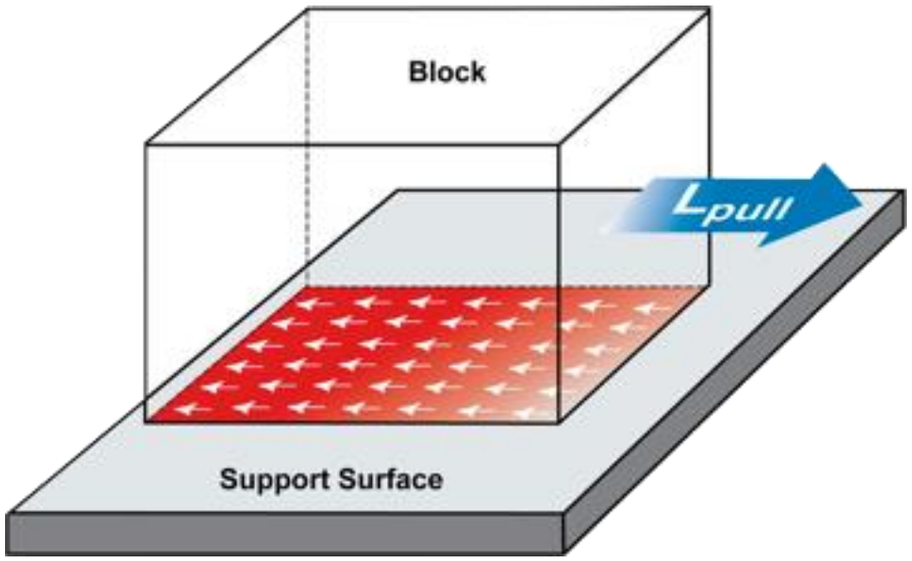
There are two types of force which occur on the sole of the foot —

one is vertical load which causes direct pressure on the tissue.

The other is horizontal load which is parallel and leads to shear (friction).

Of the two forces shear (friction) is likely more damaging than pressure.

Friction



Friction is the force which develops at an interface resisting sliding of one surface relative to the other

Friction = restriction to motion = rubbing

- Perpendicular Load = pressure
- Parallel Load = friction

Coefficient of Friction

- Friction
  - restriction to motion
- Coefficient of Friction (COF)
  - Scale of friction between two objects
  - Lower COF
    - Easier to slide
    - Less load on skin

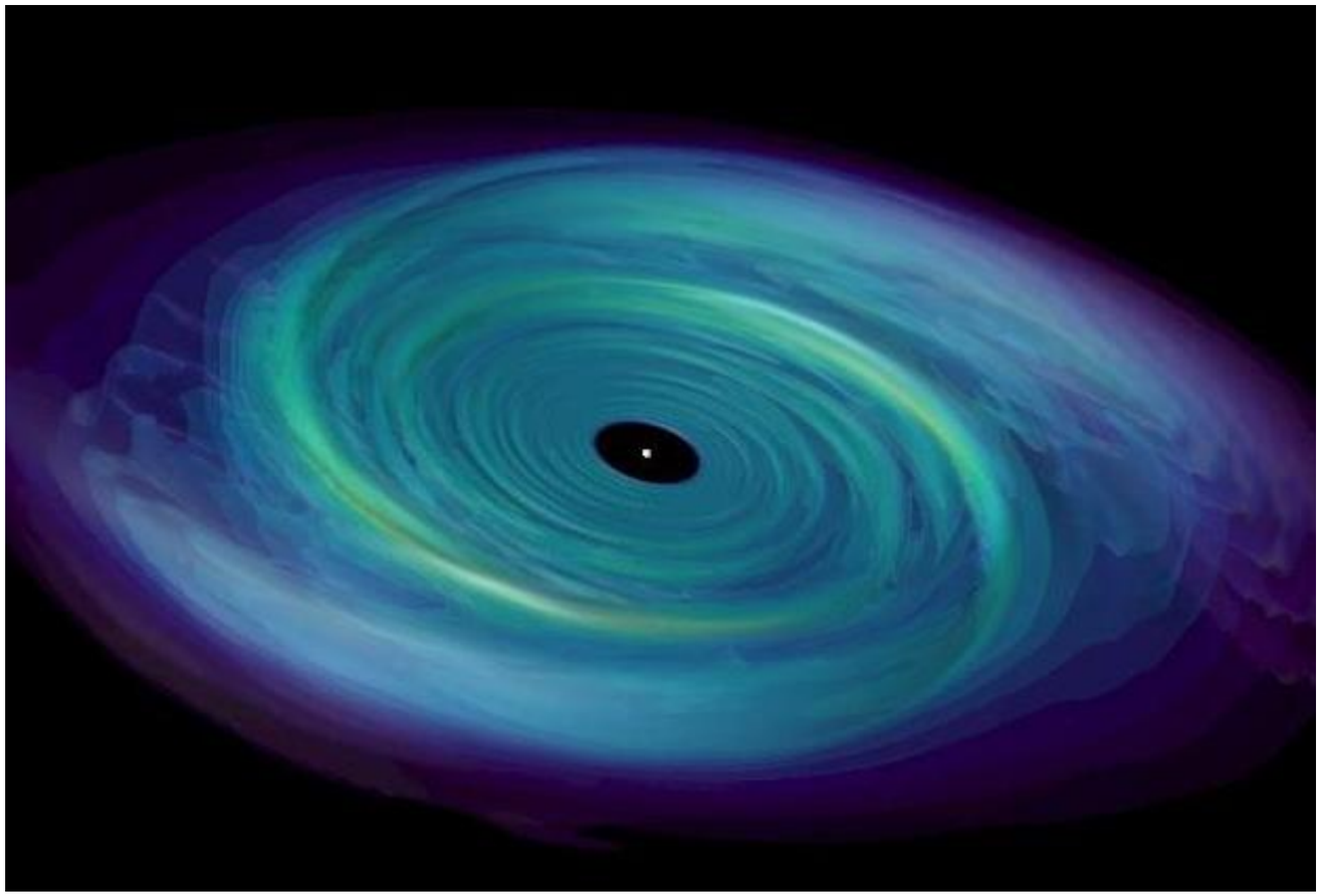
Friction and Skin

Studies quantifiably demonstrated that higher friction loads could produce blisters in normal skin. Naylor, 1955

A 30% reduction in the COF would approximately triple the number of load cycles (steps) needed to produce an abrasion. Naylor, 1955

Shear, not pressure may precipitate plantar ulcer formation” Pollard, 1983

Can we apply biomechanics and new materials to treating this friction even though we can't measure it?



Friction Management for the Foot

- Current Status
  - We can’t easily measure friction so it is often ignored in treatment
  - Crushing materials (eg. soft Plastazote) do not absorb friction -they only create contours
  - Topcover materials have increased COF when wet
  - Cutouts in topcover increase pressure around lesion site and require extra thickness for covers
  - Plantar skin has less mobility than other skin and healed skin has even less

Friction Management for the Foot

- Solution
  - Use material to substitute for the loss of internal skin mobility for greater skin-surface mobility
  - Use material that does not increase the COF when wet

- Polytetrafluoroethylene (PTFE)

What is Polytetrafluoroethylene (PTFE)?

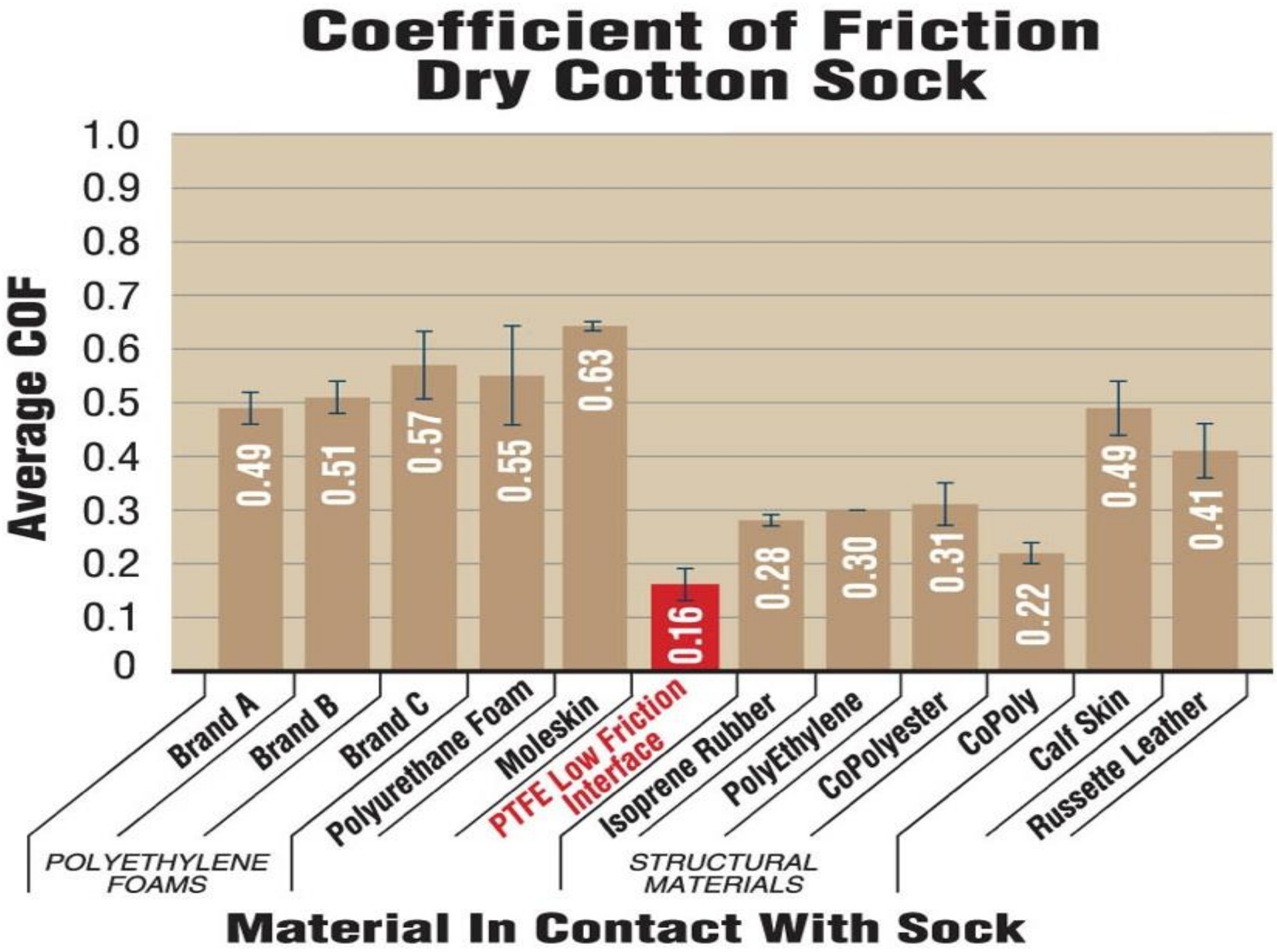
PTFE is a synthetic with the lowest COF

Most commonly known as Teflon (non-medically)

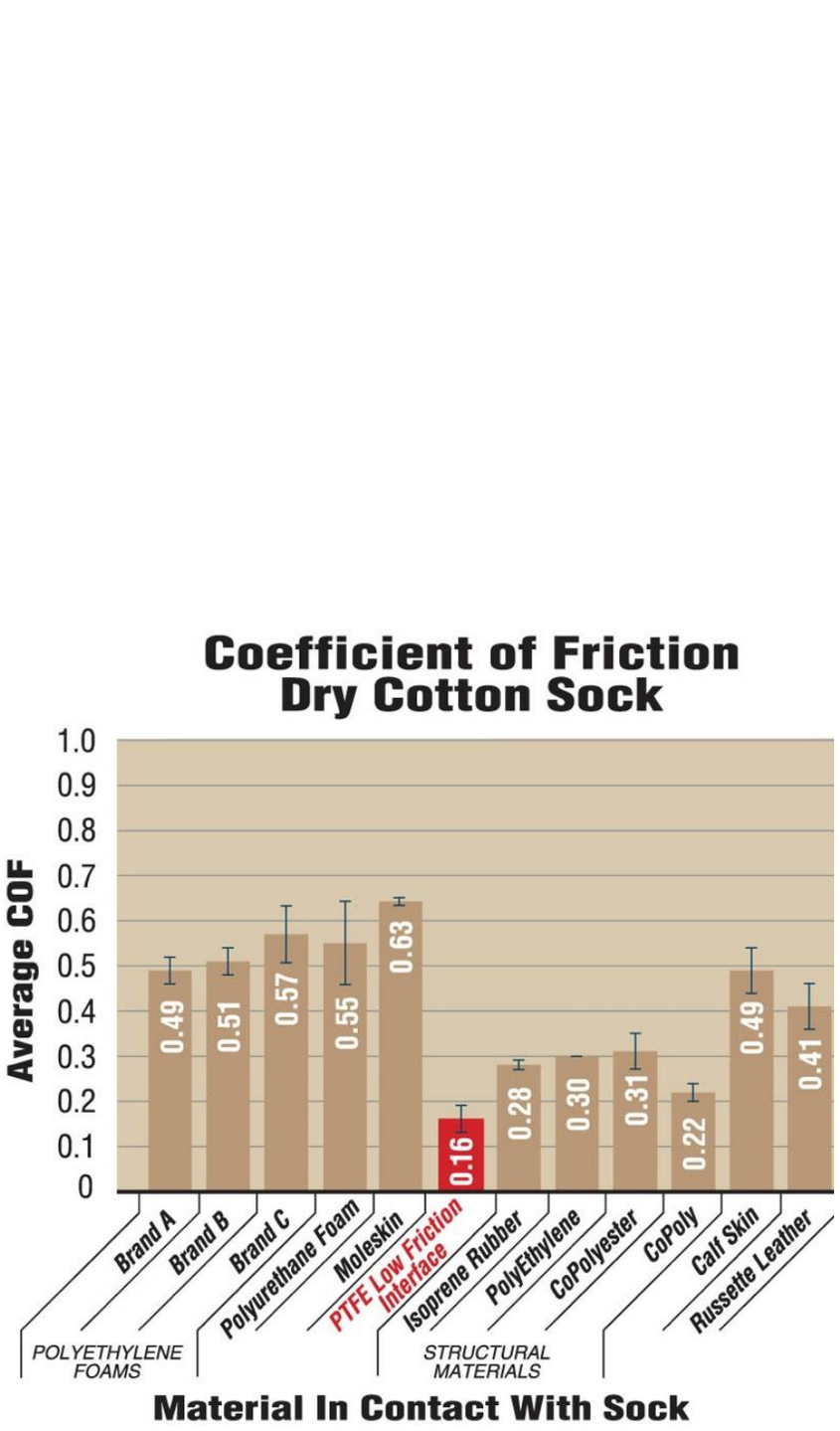
- Medical uses include:
  - Neurologic and vascular suture
  - Vascular graft
  - Orthotic accessory
    - Class 1 medial device (FDA)

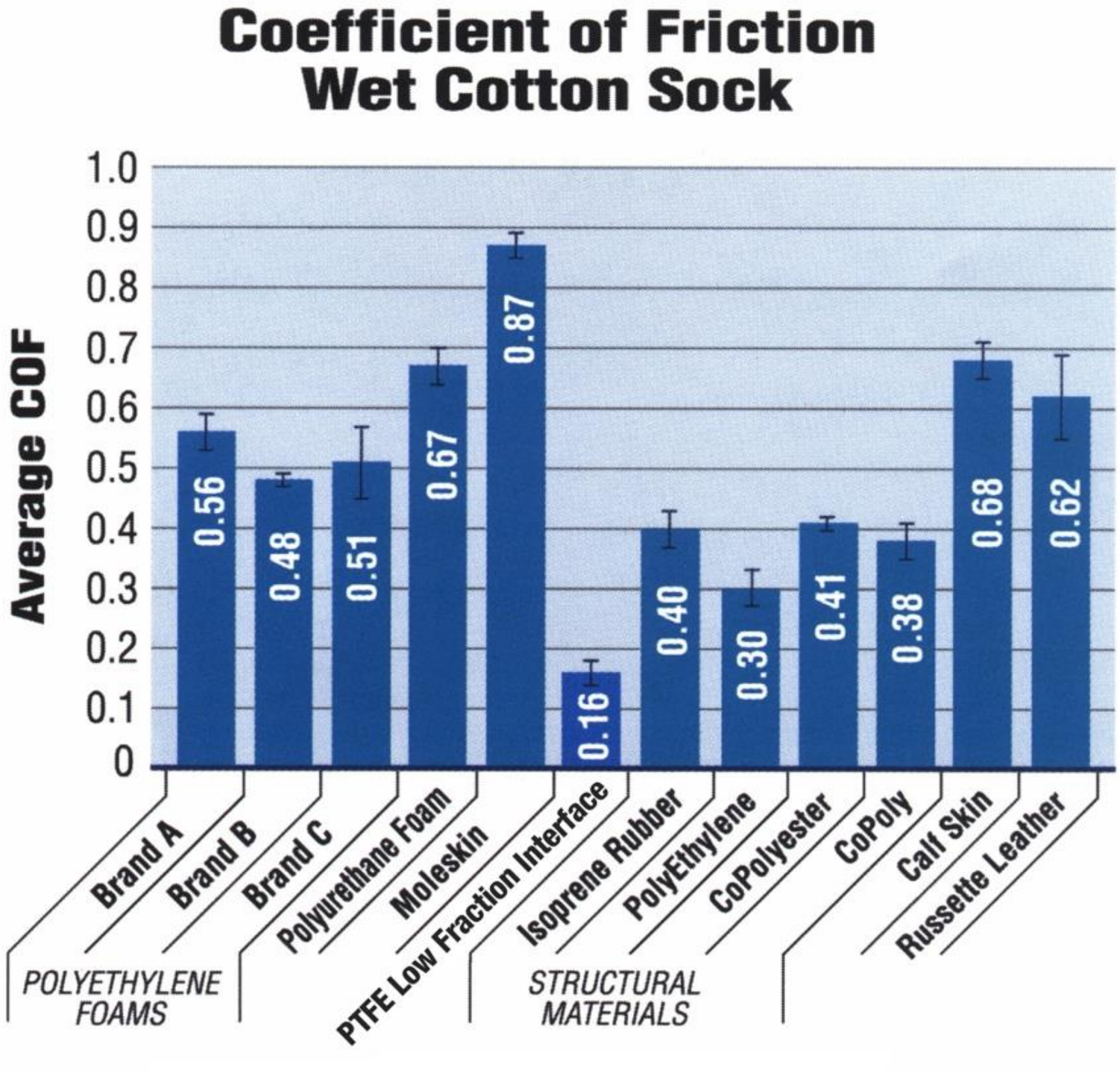
Coefficient of Friction:

PTFE vs Common Orthotic Materials



What Happens if These Materials Get Wet?

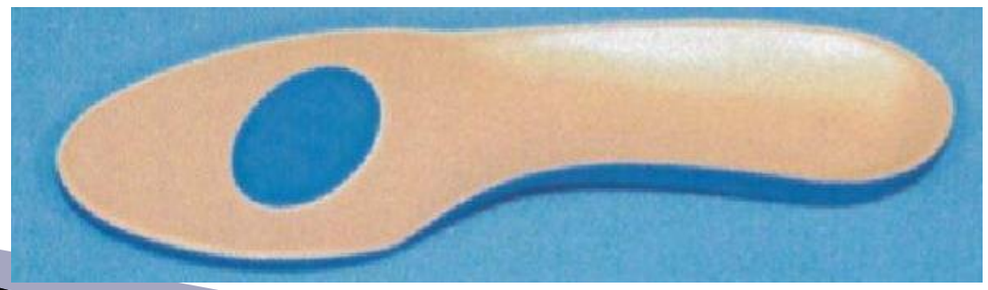




PTFE in Shoes

Sock - Plastazote → Wet → Increased COF

Sock - **PTFE-** Plastizote → Wet → No Change



Will PTFE Work for Diabetics?

299 subjects two groups

A. Orthotic device with PTFE

B. Same device with no PTFE

C. 18 months

L.A. Lavery, 2005
Diabetes Technology Therapy

Will PTFE Work for Diabetics?

Results

- 3 ulcers with PTFE
- 10 ulcers without PTFE
- PTFE is 3.5 times more effective in preventing ulcers

L.A. Lavery, 2005
Diabetes Technology Therapy

Will this work on:

Calluses?

Blisters?

Callus formation precedes ulcer formation in over 82% of patients with diabetic foot ulcers

R.A. Sage, 2001
JAPMA

Orthotic Prescription

Orthotic Goals:
Diabetic Ulcer Prevention

- Reduce forefoot pressure
- Reduce forefoot friction

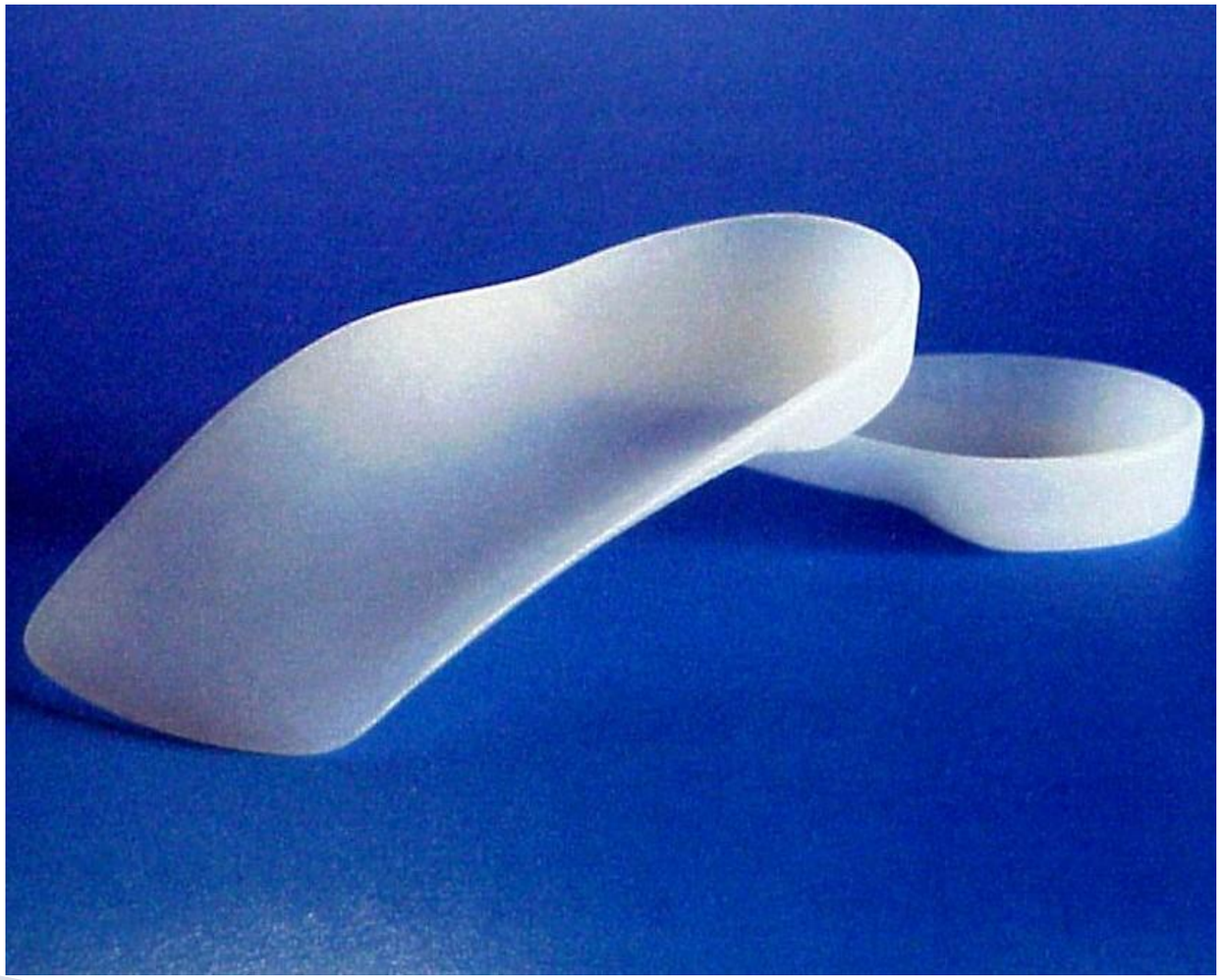
Reducing Forefoot Pressure

1. Use Non-deforming materials

- Non-deforming materials improve pressure redistribution
  - Polypropylene
  - Firm plastizote

Semi-rigid orthoses had significant effect on pressure reduction. Soft orthoses did not.

Chalmers, 2000



2. Conform Close to Arch

Total contact insert reduces excessive pressures at the metatarsal heads by increasing the contact area of forces.

Mueller 2006

Mueller MJ.: Efficacy and mechanism of orthotic devices to unload metatarsal heads in people with diabetes and a history of plantar ulcers, Phys Ther, 2006

2. Conform Close to Arch

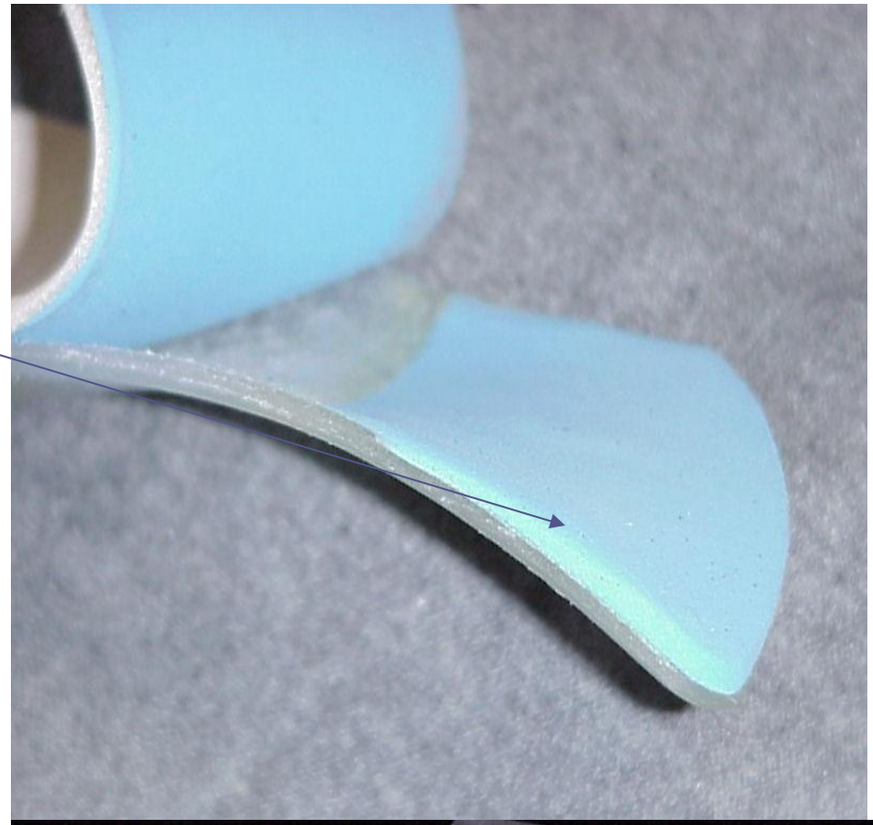
- Proper casting position
  - Non-weightbearing
  - STJ neutral / MTJ locked
  - Plantarflex 1st ray
- Prescribe minimum fill
  - Ensure that the lab does not overfill the medial arch
  - Excess plaster expansion in the arch reduces effectiveness
- Invert the positive cast

3. Use Metatarsal Pads and Bars

- Metatarsal Bar
- Metatarsal Pad

Met pads placed between 6.1mm and 10.6mm prox to met head resulted in significant peak plantar pressure reduction compared to wearing TCI only.

Mueller, Hastings, 2003



4. Glue Topcover Posterior Only

- Metatarsal pad and bar positioning is patient specific and may require adjustment
- Recommend adding in office

5. Use Forefoot Cushioning

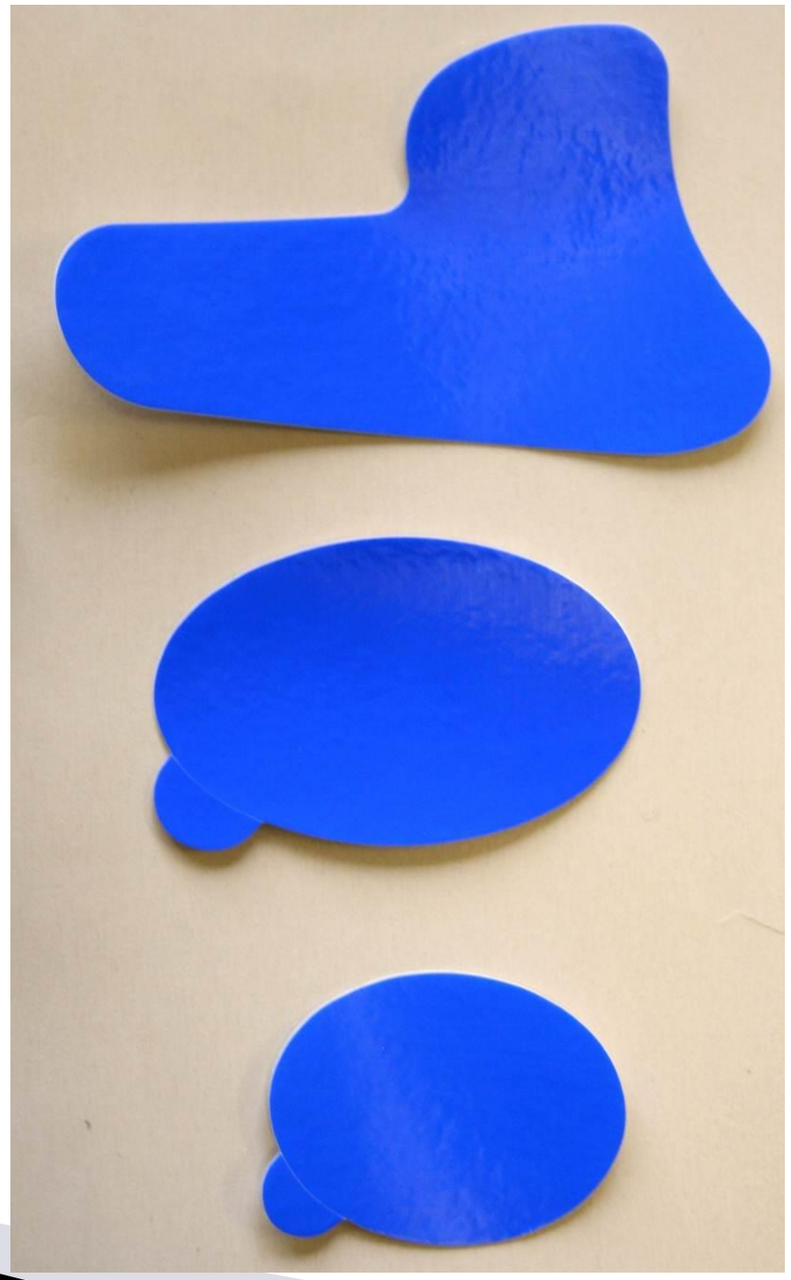
- Cushioning decreases force by decreasing velocity
- Poron extension to sulcus or toes

Reducing Friction

Decrease Friction: PTFE Patch

- For at-risk areas: callus, blister, ulcer

- Have available in office for application to shoes and orthoses



Summary

- Both vertical and horizontal loads appear to play a role in ulcer development
- Ulcers, blisters and calluses do not necessarily occur at highest pressure peaks
- Horizontal loads are just as damaging if not more so than vertical loads
- Optimum orthotic outcomes can be achieved by controlling both pressure and friction

Thank You

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Resources

- **Books**
  - Recent Advances in Orthotic Therapy; Paul R. Scherer, DPM
  - Foot and LE Biomechanics: Kevin Kirby, DPM
- www.ProlabOrthotics.com
  - Search within site by pathology
  - Webinars
  - eJournal
  - Articles
  - Videos
    - Adjusting orthotic flex
    - Casting
- ProLab Medical Consultants available for clients