Orthotic and Pedorthic Treatment in the Diabetic Foot

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Diabetic Foot

- Foot ulcers develop in approximately 15% of patients with diabetes
- 85% of all amputations are preceded by foot ulcers
- Most of foot ulcers occur from repetitive trauma resulting from weight bearing or ill-fitted footwear
- Strategies aimed at preventing foot ulcers are cost effective and can even be cost-saving if increased education and effort are focused on those patients with recognized risk factors for foot problems
## Risk Categorization - Pedorthic Aspect -

<table>
<thead>
<tr>
<th>Category</th>
<th>Loss of Protective Sensation</th>
<th>Deformity, Callus, Weakness</th>
<th>History of Ulceration or Ischemia</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Annually</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>6 Months</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>3-4 Months</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>1-2 Months</td>
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Treatment Recommendations

- Category 0
  - patient education to include proper shoe style selection
- Category 1
  - review all footwear the patient wear, add soft insoles
- Category 2
  - custom-molded foot orthoses, prescription footwear
- Category 3
  - custom-molded foot orthoses, prescription shoes
General Principles of Footwear Prescription

- Shoe should match the shape of the foot
- 1/2 to 5/8 inch longer than the longest toe
- Roomy and in-depth shoes (+1/4 – 3/8”)
- Triple depth-inlay (removable insole)
- Minimizing shear/friction: high instep, non-leather insole
- Heel heights: < 2 inches
- Shoes should be fitted at the end of the day
General Principles of Footwear Prescription

The role of therapeutic footwear in diabetic patients is mainly prevention of initial or recurrent ulceration rather than actual healing of ulcers.
In-depth shoes

- Blucher-style oxford or athletic shoe
  - Increased ease of donning and doffing
  - Allows for more adjustability and space
- Additional ¼ to ½ inch of depth throughout the shoe
  - Provides the extra volume needed to accommodate both the foot and a TCO
- Light-weight, shock-absorbing soles
- Strong counters
- Upper materials
  - Moldable, stretchable and breathable: leather
  - Soft, seam-free interior linings: plastazote, supple leather
- Charcot foot
  - Shaped wider in the midfoot area to accommodate deformity
Shoe Inserts

✔ Redistribute plantar forces
  1. Pressure under one part of the foot can be relieved by increasing the pressure on an adjacent part
  2. Exactly molding an insole to the plantar shape
  3. Soft material take time to compress

✔ Insole design
  - lamination of different materials
  - a single firm material

✔ Softer component next to the skin for shear relief and firmer materials underneath for structural support
Effects of Different Types of Cushioning

Dynamic Phase

Quasi-static Phase
### Percent Loss in Performance During Dynamic Compression of Dual-Density Insole

<table>
<thead>
<tr>
<th>Number of Cycles</th>
<th>Materials</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
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</thead>
<tbody>
<tr>
<td>1000</td>
<td>a. Poron + Plastazote #2</td>
<td>7%</td>
<td>13%</td>
<td>8%</td>
<td>4%</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>b. Spenco + Microcel Puff Lite</td>
<td>12%</td>
<td>22%</td>
<td>27%</td>
<td>36%</td>
<td>50%</td>
</tr>
<tr>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100,000</td>
<td>c. Plastazote #1 + Poron</td>
<td>26%</td>
<td>25%</td>
<td>36%</td>
<td>49%</td>
<td>61%</td>
</tr>
<tr>
<td></td>
<td>d. Plastazote #1 + Poron + Microcel Puff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Plastazote #1 and Plastazote #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Foto JG & Birke JA, 1998
Upper

- Limit the amount of shear strain that the tissue on the plantar aspect

Appropriate insole
+ Well-fitting upper
↓
Reduce plantar injury
The Easiest Way to Reduce Shear Force

- The shoe size and shape are appropriate for the foot
- lubricate the surfaces moving against one another
  - shear-reducing socks: acrylic blend fabric
    (traditional cotton socks have a relatively high COF)
  - keeping the feet and sock dry
  - double socks
Shoe Sole Modifications

- Rigid rocker sole
- Extended steel shank
- Stabilization: Flare, Stabilizer
- Cushion heel
- Wedge
Rigid Rocker Sole

As much as 50% of the pressure can be reduced by use of a rigid rocker sole

✔ Rigid shoe sole
  - reduce shear stress on the foot
  - limit the damage to toes: limited motion at MTP joint

✔ Rocker sole
  - restoring lost motion in the foot, ankle, or both
    → overall improvement of gait
  - relieving pressure of a specific area of the plantar surface
Midstance and Apex of Rocker Sole

- **Midstance**
  - contact with the floor when in a standing position

- **Apex**
  - located at the distal end of the midstance
  - must be placed behind any area for which pressure relief is desired
  - reducing MTH pressure: 55%-60%
  - reducing toe pressure: 65%
Six Types of Rocker Soles

A. **Mild**: the most widely used, relieve mild metatarsal pressure, assist in gait

B. **Heel-to-Toe**: ankle or subtalar joint fusion, fixed claw or hammer toe deformity

C. **Toe-only**: forefoot ulcerations with stability or proprioception problems

D. **Severe Angle**: extreme relief of MTH or toe-tip ulcerations

E. **Negative Heel**: accommodate a foot fixed in dorsiflexion, relieve forefoot pr.

F. **Double Rocker**: midfoot pathology
Extended Steel Shank

- Strip of spring steel or carbon graphite composite inserted between the layers of the sole, extending from the heel to the toe of the shoe
- Most commonly used in combination with a rocker sole and helps maintain the shape and effectiveness of the rocker sole
- Prevent the shoe from bending
- Limit toe and midfoot motion
- Propulsion on toe-off
Flares

✓ ¼-inch-wide medial or lateral extensions or the sole or heel
✓ Acts as an outrigger
✓ Provides a wider base of support for the foot
✓ Partial foot amputation
  Fixed varus or valgus ankle deformity
  Unstable foot or ankle
Temporary Pressure Relief Methods

- Total Contact Cast
- Fiberglass Cast with a Metal Stirrup
- Scotch Cast
- Forefoot Relief Shoe
- Heel Relief Shoe
- Felted Pads
Orthoses

✓ In patients whose foot problems have already advanced to foot ulceration or Charcot joint, orthosis play an important role.

✓ Orthosis provide
   - stability
   - restrict unnecessary joint motion
   - control deformity
   - off-loading
Physical Properties of Orthoses Material

✓ **Soft / flexible**
  - low-temperature polyethylene foams
    : Plastazote, Pelite, Aliplast
  - Others
    : ethylene vinyl acetate(EVA), Poron, PPT

✓ **Semirigid**
  - graphite laminates
  - polypropylene
  - polyethylene

✓ **Rigid**
  - acrylic plastics
  - acrylic plastic and carbon fiber-mesh composite
Prefabricated Removable Walking Braces

- Rigid rocker sole
- Padded with a protective insole
  - Plastazote or PPT®
- May be removed for bathing, skin checks, and dressing changes

- CAM Walker
- Pneumatic Walker
- Diabetic Conformer
Removable Walking Brace

✓ Pressure reduction similar to those of TCC
  *New Engl J Med 2004;351:48-55*

✓ Lower healing rates
  - Walking brace: 65% (mean time: 50 days)
  - TCC: 90% (mean time: 34 days)
  *Diabetes Care 2001;24:1019-1022*

✓ The removable walking brace was not as effective as the TCC simply because patients were not compliant with wearing a removable device
Irremovable Cast Walker

- Identical to a removable walking brace
- "irremovable" by wrapping it with a layer of cohesive or plaster bandage or fiberglass tape
- Healing rates – In a 12-week follow-up
  - irremovable cast walker: 80% - 83%
  - TCC: 74%
  - removable walking brace: 53%
- Irremovable cast walker took less time to apply and remove and cost less than TCC

*Diabetes Care* 2005;28:551-554
*Diabetes Care* 2005;28:555-559
PTB (Patellar Tendon-Bearing) Orthosis

- PTB brace with custom-molded footwear
- Saltzman et al. at the Mayo Clinic (Foot Ankle. 1992;13:14-21)
  - Reduce the mean vertical peak force by only 15% compared with vertical force in a shoe
  - Adding extra padding to the brace may decrease mean vertical peak force by only 32% compared with shoe
    → limited benefit in the acute stage
      helpful adjunct for management of the stage of consolidation
- Tapering PTB brace may be considered after 6 to 24 months in the foot remains stable
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F-Scan Study of PTB Brace

Peak Pressure vs. Frames

Darco  PTB-Ant-Ext  PTB-Ant-Int
Arizona Brace
Calf Corset Brace
CROW
(Charcot Restraint Orthotic Walker)

☑ Some similarity to a bivalved TCC
  - better hygiene and comfort

☑ Custom, bivalved, total-contact, full-foot enclosure
  AFO consisting of a polypropylene outer shell, rocker sole, and well-padded inner lining

☑ Benefit
  - edema control
  - effective ankle and foot immobilization
  - near normal ambulation
  - excellent patient satisfaction

☑ Disadvantage
  - high costs of fabrication and maintenance
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Alignment Control Strap

Arch Phys Med Rehabil 2007;88:120-123
The key to avoiding diabetic foot infections is to prevent the opening of a portal of entry for infection to occur (eg, pressure ulcerations or minor traumatic skin wounds).

Proper footwear recommendation according to different categories.

General principles of footwear prescription.

In-depth shoes with laminated insole.

The way to reduce shear force:
- acrylic socks vs. cotton socks, double socks

Off-loading methods for fixed deformity:
- Walking braces, PTB orthosis.
Thank You for Your Attention!