CASE STUDY:

Diabetic Foot

By Dr. Timothy Kalla, DPM

History and Presentation

A 65-year old male presented to the clinic with long-standing diabetes and an ulcer inferior to the right third metatarsal head. Previous treatments had included off weighting with accommodative inserts, heel lifts, an off–weighting walker cast boot, home-nursing, and regular debridement. The ulcer waxes and wanes but never completely heals.

Figure 1: Right, sub-third metatarsal head ulceration.

Examination Findings

A complete physical examination revealed:

- Pedal pulses were palpable,
- Insensate to vibratory sensation, sharp/dull sensation and 5.07 nylon filament,
- Skin temperature via infrared thermometer are 2° Celsius warmer over the right forefoot,
- Intrinsic arch muscle atrophy with prominent metatarsal heads,
- Hyperkeratotic uleration inferior to the right third metatarsal head without tracking to bone (Figure 1),
- No clinical signs of infection,
- Marked bilateral gastroc/soleus equinus to -10°,
- Bilateral hallux limitus,
- Plain X-rays negative for osteomyelitis,
- Erythrocyte sedimentation rate and C-Reactive Protein were normal, and
- Hamoglobin A1c less than 8.5.

Diagnosis

The diagnosis was of a non-healing, sub–right third metatarsal head neuropathic ulceration without osteomyelitis.

This patient failed to respond to off–weighting and local wound care. The ulcer etiology was chronic overload of the third right metatarsal head secondary to lateral weight transfer from the hallux limitus as well as increased plantar forefoot weight bearing pressure secondary to equinus. The foot resembles a teeter-totter that moves over the ankle joint. If the heel chord is tight it will pull the back of the teeter-totter up and drop the front down which leads to increased plantar forefoot weight bearing.

Treatment

This patient's treatment plan included the following:

- Percutaneous heel chord lengthening so that neutral to 5° of ankle joint dorsiflexion was achieved,
- Postoperatively, he was ambulatory in a cast boot for 4-6 weeks followed by a return to therapeutic professionally fitted shoes and Diabetic Tridensity custom foot orthoses (Figure 2A),
- The footwear of choice was an Apex Ambulator with a modified stiff midsole (Figure 2B), and
- The ulcer was dressed with hydrogel and gauze cover dressing.

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EDITOR:
Christopher L. MacLean
Ph.D. (Candidate)
Director of Biomechanics
Paris Orthotics Ltd.
3630 East 1st Avenue
Vancouver, BC V5M 1C3
1-800-848-0838
e-mail:
cmaclean@parisorthotics.com

Paris

CASE STUDY:

Diabetic Foot (cont'd)

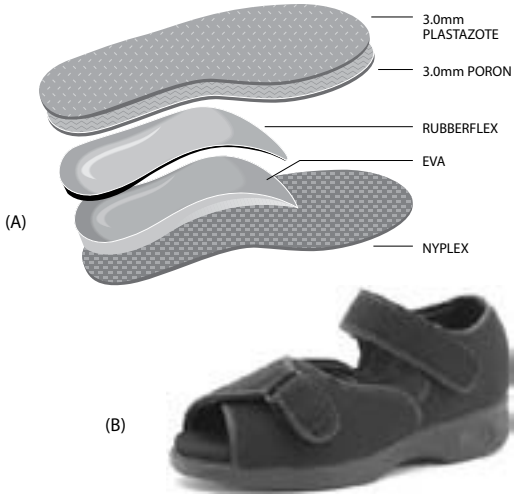

Figure 2: (A) Diabetic Tridensity Custom Foot Orthoses, and (B) Apex Ambulator® Footwear.

Outcome

The ulcer healed unremarkably by 4 weeks and has not recurred (Figure 3).

Figure 3: Outcome after 4 weeks.

Discussion

Conservative therapy failed because it was not possible to overcome the increased plantar forefoot weight-bearing pressures. Isolated third metatarsal head resection or elevational osteotomy was almost certain to result in transfer ulceration especially in light of the ankle equinus.

On examination, there was only a 2° Celsius skin temperature difference. The temperature difference was minimal and reflective of the mild hyperemia associated with the ulcer. Temperature differences greater than 5° Celsius with an ulcer are suggestive of infection. Without an ulcer those same temperature differences are suggestive of a Charcot process.

Figure 4: Hyper-dorsiflexion secondary to over-lengthening of the heel chord (lateral view).

One has to be careful not to over lengthen the heel chord because this can tip the teeter-totter in the other direction leading to hyper-dorsiflexion (Figure 4) and result in a heel ulcer (Figure 5). For this reason, heel chord lengthening is preferred to heel chord sectioning.

Figure 5: Heel ulcer secondary to hyper-dorsiflexion mechanism.

CLINICAL BIOMECHANICS:

The Importance of Sagittal Plane Dynamics

By Christopher MacLean, Ph.D. (Candidate)

Introduction

The Case Study presented in the current Industry Bulletin demonstrates the importance of sagittal plane dynamics in the primary prevention, management and secondary prevention (recurrence) of diabetic neuropathic ulcers. There are many etiological factors associated with the increased plantar pressure that can result in the development of neuropathic ulcers.

The current Clinical Biomechanics will review some of the anatomical and biomechanical etiological factors associated with increased plantar pressures in the diabetic patient. In addition, the dynamical influence of footwear and custom orthotic interventions will be discussed.

Etiological Factors

The etiological factors that have been associated with increased plantar pressures have been well documented by Cavanagh et al. (2000). Of special interest to the Biomechanist are those that relate to anatomical and biomechanical issues that increase plantar pressures. Cavanagh et al. (2000) have classified these as intrinsic, extrinsic and behavioral factors. Among the intrinsic factors that are associated with increased plantar pressures is limited joint mobility.

Limited joint mobility in the major joints of the foot and ankle has been widely documented in patients with diabetes (Payne, 1998). Decreases in joint mobility are likely attributed to nonenzymatic glycosylation of collagen due to hyperglycemia. Nonenzymatic glycosylation involves a stiffening of joint ligaments and capsules. It has been suggested that this affects the subtalar joint (Delbridge et al., 1988), the 1st MTPJ (Flynn et al., 1996) and the talocrural joint (Cavanagh et al., 2000). Subjects exhibiting such decreases in joint range of motion have been shown to exhibit increased plantar pressures (Fernando et al., 1991).

Further complicating matters, is the possibility that glycosylation might alter the mechanical properties of the skin leading to increased callus formation. Callosity acts as a foreign body under the foot and can increase plantar pressure significantly (Cavanagh et al., 1996).

The notion that excessive subtalar joint pronation is deleterious has often overshadowed the important role that pronation plays in the attenuation of forces and adaptation to changes in terrain. It has been shown that plantar pressures increase when subtalar joint pronation decreases as a result of glycosylation. Interventions that can enhance subtalar joint (STJ) motion have rarely been investigated however, there is some evidence to suggest that ongoing manipulative therapy (Dijs et al., 2000) can improve STJ range-of-motion.

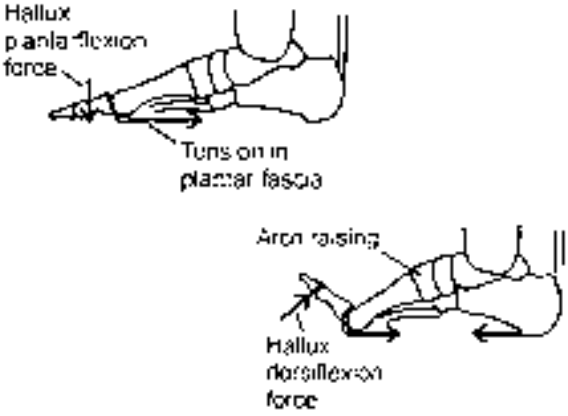

Figure 1: Windlass Mechanism (from Kirby, 2002)

Sagittal plane dynamics of the foot and ankle have received the greatest attention in the literature. Of particular interest are the complications associated with hallux limitus and ankle equinus. The 1st metatarsophalangeal joint (MTPJ) has received the most attention. The autosupportive mechanisms necessary for efficient sagittal plane function can be disrupted by hallux limitus (functional or structural) and rigidus. Limited 1st MTPJ range of motion could hypothetically inhibit the: 1) windlass mechanism (Figure 1), 2) close-packing of the calcaneocuboid joint, and 3)

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