FOOT CARE AND DIABETIC FOOT ULCER

** ADDENDUM **

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Anatomy 101

Joints

Lateral view

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**Common causes of foot pain**

- Achilles Tendinitis
- Bursitis
- Calluses
- Claw Toes
- Corns
- Hammer Toes
- Inflamed Bunion
- Heel Spurs
- Ingrown Toenails
- Mascot Toes
- Metatarsalgia
- Morton's Neuroma
- Mortons Toe
- Overlapping Toes
- Over Pronation
- Plantar Fasciitis
- Pododigital Tendinitis
- Sesamoids

**Morton’s neuroma**

- A neuroma is a thickening of nerve tissue
- Morton’s neuroma occurs as the nerve passes under the ligament connecting the metatarsals in the forefoot (sometimes referred to as an intermetatarsal neuroma).
- Morton’s neuroma most frequently develops between the third and fourth toes, usually in response to irritation, trauma or excessive pressure.

**Morton’s neuroma: assessment and treatment**

**Assessment**

- Normally, there are no outward signs, such as a lump, because this is not really a tumor.
- Burning pain in the ball of the foot that may radiate into the toes. The pain generally intensifies with activity or wearing shoes. Night pain is rare.
- There may also be numbness in the toes, or an unpleasant feeling in the toes.

**Treatment**

- Changes in footwear: Avoid high heels or tight shoes, and wear wider shoes with lower heels and a soft sole. This enables the bones to spread out and may reduce pressure on the nerve, giving it time to heal.
- Orthoses: Custom shoe inserts and pads also help relieve irritation by lifting and separating the bones, reducing the pressure on the nerve.
- Injection.
Hallux valgus (bunion)

- Medial deviation of the first metatarsal and lateral deviation and/or rotation of the hallux, with or without medial soft-tissue enlargement of the first metatarsal head. This condition can lead to painful motion of the joint or difficulty with footwear.
- Related to gout, arthritis, CMT

Heel spur

**Risk factors**

- Walking gait abnormalities, which place excessive stress on the heel bone, ligaments, and nerves near the heel
- Running or jogging, especially on hard surfaces
- Poorly fitted or badly worn shoes, especially those lacking appropriate arch support
- Excess weight and obesity

**Treatment**

- Exercise
- Custom-made orthotics
- Anti-inflammatory medications, and cortisone injections.
- If conservative treatments fail, surgery may be necessary.

Bursitis

- Aging.
- Trauma, such as a sports injury.
- Too much repetitive motion of the joints
- A sudden twisting or rapid joint movement.
- Overusing a joint, such as going up and down stairs too often.

What causes TTS

- Anything that creates pressure in the Tarsal Tunnel can cause TTS. This would include benign tumors or cysts, bone spurs, inflammation of the tendon sheath, nerve ganglions, or swelling from a broken or sprained ankle, varicose veins, flat foot.
- Patients with TTS typically complain of numbness in the foot radiating to the big toe and the first 3 toes, pain, burning, electrical sensations, and tingling over the base of the foot and the heel.

Common Causes of Heel Pain: History, Physical Examination Findings, and Treatment Options

<table>
<thead>
<tr>
<th>CLINICAL ENTITY*</th>
<th>HISTORY</th>
<th>PHYSICAL EXAMINATION</th>
<th>CONSERVATIVE TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantar fasciitis</td>
<td>Morning pain or pain on standing after prolonged sitting</td>
<td>Tenderness over calcaneus Increased pain with passive dorsiflexion of toes</td>
<td>Analgesics, stretching, exercise, orthotics, night splint</td>
</tr>
<tr>
<td>Achilles tendonitis</td>
<td>Pain with running, jumping, or making quick turns</td>
<td>Pain and tenderness over insertion of Achilles tendon on calcaneus Pain may increase with dorsiflexion</td>
<td>Rest, analgesics, stretching, and strengthening exercises</td>
</tr>
<tr>
<td>Retrocalcaneal bursitis</td>
<td>Stiff posterior shoe edge</td>
<td>Pain and tenderness at posterior calcaneus</td>
<td>Analgesics, proper shoes with Achilles notch and padding over posterior heel</td>
</tr>
<tr>
<td>Tarsal tunnel syndrome</td>
<td>Pain or numbness in heel radiating to the sole and toes</td>
<td>Reproduction of symptoms with percussion of tarsal tunnel or dorsiflexion and eversion of foot</td>
<td>Analgesics, correcting foot posture with orthotics</td>
</tr>
</tbody>
</table>

Exercises

- **Towel Stretch**
- **Step Stretch:** Stand with your toes on a step, your heels off the edge. Slowly lower your heels down, hold for 10 to 15 seconds, then lift your heels to starting position. Repeat five to 10 times.
- **Toe Stretch**
- **Foot Roll:** Take a golf ball, and roll it back and forth from your toes to your heels.
Charcot-Marie-Tooth disease

- Charcot-Marie-Tooth disease (CMT) is one of the most common inherited neurological disorders:
  - demyelination, leading to uniform slowing of conduction velocity
  - peripheral neuropathy through direct axonal death
- A typical feature includes weakness of the foot and lower leg muscles, which may result in foot drop and a high-stepped gait with frequent tripping or falls.

Diabetic foot syndrome

- 2–3% PWD develop a foot ulcer/year
- 25% lifetime risk of developing a foot ulcer
- Foot ulcers precede 84 percent of all nontraumatic lower limb amputations in PWD
- Diabetic associated lower-extremity ulcers are responsible for 92,000 amputations annually

Hyperglycaemia and physiological changes

- Polyol pathway: Increased fructose
- Hexosamine pathway: Increased glucosamine
- Advanced glycation end product (AGE) precursors: glyoxal (GO) and methylglyoxal (MGO)
- Diacylglycerol pathway: Increased PKC
- Increased oxidative stress
- Pro-inflammatory gene expression
- Altered protein functions
- Endothelial damages
- Platelet activation

Comprehensive care for persons with Diabetes

A. Hemoglobin A1C
B. Blood Pressure
C. Cholesterol
D. Diet – Body weight
E. Exercise
F. Foot care
S. Smoking

DFU and amputation

- Nerve damage
- Skin ulceration
- Bacteria infection
- Amputation

Wound-healing: HbA1c of 5.6% (a – d) and HbA1c of 11.1% (e – i).

Foot check

- 25% life time risk of foot ulcers
- Ulcers can lead to amputation
- Ulcers are preventable
- How often do you check your patients’ feet?
  - Not enough time.
  - More work for me.
  - Not sure what to do?

![Graph showing how often family physicians check patients’ feet]

Audit of leg and foot ulcer in an Ontario community care access centre

SENSORY NEUROPATHY: LOSS OF PROTECTIVE SENSATION

Neuropathy:

- Autonomic
- Sensory
- Motor
- Neuropathy

![Diagram showing sites for identifying neuropathy]

Natural Moisturizing factor

![Diagram showing stratum corneum structure with corneocytes and intercellular lipids]

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NMF

- The Natural Moisturizing Factor (NMF) is a natural skin protector against dehydration; it also plays a major role in the physical properties of the outermost layer of skin, the horny layer. Good moisturizing of this layer is essential for skin smoothness.

### Composition of NMF

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acids</td>
<td>40</td>
</tr>
<tr>
<td>Ammoniac, uric acid and other organic acids</td>
<td>1.5</td>
</tr>
<tr>
<td>Pyrrolidone carboxylic acid (PCA)</td>
<td>12</td>
</tr>
<tr>
<td>Ions ($Na^+, K^+, Ca^{2+}, Mg^{2+}, PO_4^{3-}, Cl^-$)</td>
<td>18.5</td>
</tr>
<tr>
<td>Urea</td>
<td>7</td>
</tr>
<tr>
<td>Lactate</td>
<td>12</td>
</tr>
<tr>
<td>Citrate</td>
<td>0.5</td>
</tr>
<tr>
<td>Sugar, organic acids, peptides</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Moisturizers

**Lubricants**
- External cover:
- Petrolatum
- Dimethicone

**Humectants**
- Increase skin surface moisture content
- Urea
- Lactic acid

IWGDF Guidance on footwear and offloading interventions to prevent and heal foot ulcers in patients with diabetes

- Casting and prefabricated healing devices
- To heal a neuropathic plantar forefoot ulcer without ischemia or uncontrolled infection in a patient with diabetes, offload with a non-removable knee-high device with an appropriate foot-device interface. (GRADE recommendation: strong based on 2 meta-analyses, Quality of evidence: high)
- When a knee-high device is contraindicated or cannot be tolerated by the patient, consider offloading with a forefoot offloading shoe, cast shoe, or custom-made temporary shoe to heal a neuropathic plantar forefoot ulcer in a patient with diabetes, but only and when the patient can be expected to be adherent to wearing the shoe. (Weak; Low)
- Instruct an at-risk patient with diabetes not to walk barefoot, in socks, or in thin-soled standard slippers, whether at home or when outside (Strong; Low).
- Surgical: Consider Achilles tendon lengthening, joint arthroplasty, single or pan metatarsal head resection, or osteotomy to prevent a recurrent foot ulcer when conservative treatment fails in a high-risk patient with diabetes and a plantar foot ulcer. (Weak; Low)

Preventative foot care sought for diabetics

Amputations cost $700s

BY ANTONELLA ARTUSO, QUEENS PARK BUREAU CHIEF
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TORONTO - Around 1,700 diabetic Ontarians each year lose foot amputations due to a lack of regular foot assessments and a $100 medical device, two health groups say.

The Registered Nurses Association of Ontario (RNAAO) and the Canadian Association of Wound Care (CAWC) estimate that about 85% of the 2,000 foot amputations performed annually — at a cost of “terrible suffering” for patients and a $71,000 per-removal bill to the health-care system — would be unnecessary with proper preventative care.

Both groups were joined by other health professionals at Queen’s Park Tuesday to urge the Ontario government to fund universal preventative foot care and “off-loading” devices for all diabetics.

RNAAO Doris Grinnon said premiers across the country promised three years ago that they would fund best practices for diabetic foot care, but said most have
Appropriate footwear

Is your shoe right for you?

Stand on a piece of paper
Trace the outline of your foot
Place your shoe on top of the tracing

COMMON DERMATOLOGICAL ISSUES

Treatment

- Stronger peeling medicine (salicylic acid)
- Cryotherapy
- Trichloroacetic acid (TCA).
- Immune therapy: imiquimod (Aldara, Zyclara).
- Electrodesiccation and curettage).
- Vaccine. Human papillomavirus (HPV) vaccine has been used with success to treat warts.
- Duct tape.

Necrobiosis lipoidica diabeticorum

- Necrobiosis lipoidica is a disorder of collagen degeneration with a granulomatous response, thickening of blood vessel walls, and fat deposition.
- The main complication of the disease is ulceration, usually occurring after trauma.
- More common in women.
- They are slightly raised shiny red-brown patches. The centers are often yellowish.

Acanthosis Nigricans

- Velvety, light-brown-to-black markings
- It is frequently found in people with diabetes or a tendency towards diabetes and is most common among people of African descent.
- It also can occur as a result of obesity or an endocrine (glandular) disorder.
**Cholesterol embolism**

Cholesterol Embolism

Symptoms of Cholesterol Embolism or Purple Toe Syndrome
- Fever
- Muscle pains
- Loss of weight
- Nausea

**Treatment**
- Statin
- Antiplatelet agents
- Benefits of thrombolytic and anticoagulant therapy is not clear

**Vasculitis Lesions**
- Persistent erythema
- Urticaria
- Hemorrhagic blisters
- Palpable purpura
- Livedo Reticularis
- Necrosis
- Nodules
- Ulcers

**Onychogryphosis**
- Onychogryphosis is the enlargement and thickening of the nail
- The nail keratin distally bends around and eventually curves under the toe. This appearance is eloquently described as Ram's horn or oyster like. nail plate

**Ingrown nails or onychocryptosis**
- Possible causes of ingrown toenails include improperly trimmed nails, hyperhidrosis, poorly fitting footwear, trauma, subungual neoplasms, obesity, or excessive external pressure.
### Ingrown nails or onychocryptosis

- pincer nail (overcurvature of the nail plate that may be genetic with an adult onset), subcutaneous ingrown toenail, and hypertrophy of the lateral nail fold.

### Treatment

- Warm water soaks
- Taping
- Packing: Cotton-wick insertion in the lateral groove corner
- Debridement (debulking) of the lateral nail groove
- Silver nitrate cautery to the hypertrophied lateral nail tissue
- Complete nail avulsion
- Partial nail avulsion: Phenol matricectomy
- Wedge resection of the distal nail edge

### Tinea unguium and onychomycosis

- Tinea unguium is used to describe dermatophyte infections of the fingernails or toenails.
- Onychomycosis is a less specific term used to describe fungal disease of the nails.
- Dermatophytes are fungi that require keratin for growth.
- Approximately half of all patients with onychomycosis experience pain or discomfort.
- Infected nails may serve as a reservoir of fungi with a potential for spread to the feet, hands and groin.

### Why treat onychomycosis?

- Onychomycosis can result in disruption of integrity of the skin, providing an entry point for bacteria leading to the development of foot ulcers, osteomyelitis, cellulitis and gangrene in diabetic patients.
- Chronic paronychia: a soft tissue infection around a fingernail that begins as cellulitis but that may progress to a definite abscess
- Sensitizing fungal/dermatophytic antigens in the nail plate may predispose to other clinical conditions such as asthma/sensitization of the respiratory tract, and skin conditions including atopic dermatitis, urticaria and erythema nodosum.
- Socks and stockings may frequently be damaged, due to the constant friction with sharp, dystrophic diseased nails in patients with onychomycosis.

### Tinea Investigations

- Scruping or nail clipping for culture and sensitivity
  - Scruping from the edge of the lesion
  - Clipping should include the subungal debris
- About 20% falsely negative
- Reasonable to perform 3 cultures before classed as negative
- Can order 1% Hydrocortisone powder in Clotrimazole cream when waiting for the results

### Onychomycosis: topical treatment

- The hard keratin and compact structure of the dorsal nail plate act as a barrier to topical drug diffusion into and through the nail plate.
- The concentration of topically applied drug can drop by 1000 times from the outer to inner surface.
- The hydrophilic nature of the nail plate also precludes absorption of most lipophilic molecules with high molecular weights.
The normal triphasic Doppler arterial wave has an initial steep peak, representing the high flow of systole. The second portion, dipping down, indicates the reverse flow in early diastole. The third segment of the wave, a small peak, signifies the forward flow of late diastole.

### Test Range Evidence Comments

| Pedal pulse | 80mmHg | Absent or reduced pedal pulses increase the likelihood of PAD (LR, 4.70, 95% CI, 2.20–9.90) | PPP can be affected by edema. |
| ABPI | >0.5 <1.4 | Using imaging techniques as reference test, ABI is able to detect PAD with sensitivity =15-79%; specificity =83.3-99%. Audible signals: sensitivity of 42.8%, a specificity of | False elevation in patients with calcified vessels. Cuff inflation can be painful. |
| TcPO2 | >55mmHg | TcPO2 had a sensitivity of 77% and specificity of 100% in detecting the presence of arterial disease at rest; both sensitivity and specificity improved to 100% after exercise. | *Affected by edema, dry flaky skin, maceration, calloused or plantar skin, and cellulitis. *Does not measure oxygen tension within the wound. |
| TBI | <0.6-0.75 | Sensitivity of 90-100%; specificity of 65-100%; PPV of 47-100%; and NPV of 96-100% | *Small caliber without a fully developed adventitial layer. *Cannot be calibrated with previous toe amputation. |

### Waveforms

#### Biphasic waveform

#### Monophasic waveform

### Diagnostic criteria to determine vascular supply for healing

<table>
<thead>
<tr>
<th>Assessment methods</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankle brachial pressure index</td>
<td>&gt;0.5</td>
</tr>
<tr>
<td>Transcutaneous oxygen tension</td>
<td>&gt;30 mmHg</td>
</tr>
<tr>
<td>Toe pressure</td>
<td>&gt;55 mmHg</td>
</tr>
</tbody>
</table>

### 60 Second foot screen

#### Inspect
Examine for callus, colour, toenails and structure

#### Touch
Palpate foot for pulses & range of motion

#### Check
Check sensory perceptions

#### Ask
Are your feet... Numb, tingling, burning, insects crawling?
**DFU classification system**

<table>
<thead>
<tr>
<th>Classification system</th>
<th>Key points</th>
<th>Pros/cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wagner</td>
<td>Assesses ulcer depth along with presence of gangrene and loss of perfusion using six grades (0-5)</td>
<td>Well established&lt;sup&gt;26&lt;/sup&gt; Does not fully address infection and ischaemia</td>
</tr>
<tr>
<td>University of Texas (Armstrong)</td>
<td>Assesses ulcer depth, presence of infection and presence of signs of lower-extremity ischaemia using a matrix of four grades combined with four stages</td>
<td>Well established&lt;sup&gt;26&lt;/sup&gt; Describes the presence of infection and ischaemia better than Wagner and may help in predicting the outcome of the DFU</td>
</tr>
<tr>
<td>PEDIS</td>
<td>Assesses Perfusion, Extent (size), Depth (Tissue loss), Infection and Sensation (neuropathy) using four grades (1-4)</td>
<td>Developed by IWGDF User-friendly (clear definitions, few categories) for practitioners with a lower level of experience with diabetic foot management</td>
</tr>
<tr>
<td>SINBAD</td>
<td>Assesses Site, Ischaemia, Neuropathy, Bacterial infection and Depth Uses a scoring system to help predict outcomes and enable comparisons between different settings and countries</td>
<td>Simplified version of the S(AID)/SAD classification system&lt;sup&gt;25&lt;/sup&gt; Includes ulcer site as data suggests this might be an important determinant of outcome&lt;sup&gt;25&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**INCREASED BACTERIAL BURDEN IN THE UPPER COMPARTMENT**

- **U-unhealthy tissue**
  - Presence of >50% of debris, red friable tissue or abnormal discoloration of granulation tissue

- **P-poor healing**
  - Changes in wound size of less than 10% in last 7 days

- **P-pain**
  - Sudden emergence of increase in pain

- **E-exudate**
  - Moderate to heavy amount of exudate

- **R-reek**
  - Presence of foul odor

**Increased bacterial burden in the lower**

- **L-Larger in size**
  - Increase in wound size or new areas of satellite breakdown

- **O-osseous tissue**
  - Wound that probes to bone

- **W-warmth**
  - Increased periwound temperature of more than 20°F compared to temperature on contralateral limb

- **E-edema**
  - Mild to moderate edema

- **R-redness**
  - Redness of >2 cm beyond wound margin

**Culture**

- Send a specimen for culture that is from deep tissue, obtained by biopsy or curettage after the wound has been cleansed and debrided.
- Avoiding swab specimens, especially of inadequately debrided wounds, as they provide less accurate results.
Probe to bone test

- Efficacy: Diabetes Mellitus pedal ulcers
- Test Sensitivity: 66%
- Test Specificity: 85%
- Positive Predictive Value: 57-89%
- Negative Predictive Value: 56%

Diagnostics

- Plain x-rays can help to confirm the diagnosis, but they have a relatively low sensitivity (early in the infection) and specificity (late in the course of infection) for osteomyelitis.
- If MRI is contraindicated or unavailable, white blood cell scanning combined with a radionuclide bone scan may be performed instead.
- The most definitive way to diagnose osteomyelitis is by the combined findings of culture and histology from a bone specimen. Bone may be obtained during deep debridement or by biopsy.

Biofilm identified in 60% of biopsies in chronic wounds but only 4% in acute wounds

Debridement

- Removal of devitalized tissue
- Eschar (leathery tissue)
- Slough (yellow or tan colored)
- Devitalized tissue causes a pro-inflammatory effect
- Culture media for bacterial proliferation
- Removal of biofilm (protective layer for bacteria)
Biofilms and their management: from concept to clinical reality

- **Challenge**
- **Regrowth**
- **Re-challenge**

No. of viable cells

- **Persister cells**

Time

Chronic wound

Static healing, moderate improvement with repeated rounds of oral antibiotics

- Suspected biofilm
- Reduce biofilm burden → debridement/vigorous cleansing
- Prevent recontamination with microorganisms → barrier dressing
- AND
- Suppress biofilm reformation → sequential topical antimicrobials
- Reasses healing
- **Healed**

Antimicrobial toolkit

**Upper compartment:** Increased bio-

**Lower compartment:** Systemic WOUND INFECTION CONTROL

Drug/Dose/Duration/De-escalation

- Silver
- Honey
- GVMB
- PHMB
- Iodine

Dakin’s solution: past, present, and future
Acid and wound healing

- It has been proven that the surface pH of a wound plays an important role in wound healing as it helps control infection and increase antimicrobial activity, oxygen release, angiogenesis, protease activity, and bacterial toxicity.
- Increase the antimicrobial activity of topical antimicrobials such as iodine and silver that are incorporated into wound dressings: increase metal ion solubility.
- Reduce the activity of proteases (more active in alkaline conditions) and their end products are toxic to wound tissues.
- Lead to the Bohr-effect (ie, an increase of the amount of available oxygen of cells).
  - A lowering of pH by 0.6 units releases 50% more oxygen and a shift of pH by 0.9 units causes 5-fold increase in release of oxygen.
  - Oxygen is required for oxidant-radical production (ie, for killing bacteria), collagen synthesis and epithelization.
- Reduce the toxicity of bacterial end products such as ammonia, which is liberated from urea by the action of the enzyme urease.
  - Ammonia is toxic to wound tissue.
- Boost fibroblastic growth and neovascularization.
- Enhances the destruction of abnormal collagen in the ulcer bed, increases macrophage and fibroblast activity, and controls activities of various enzymes participating in the wound healing process.

Acetic acid

- Acetic Acid is a synthetic carboxylic acid, also known as ethanoic acid, with antibacterial and antifungal properties.
- Acetic acid, as a weak acid, can inhibit carbohydrate metabolism resulting in subsequent death of the organism.
- Acetic acid is frequently used in wounds as a 0.25-percent or 0.5-percent solution. It is bactericidal against many Gram-positive and Gram-negative organisms, especially Pseudomonas aeruginosa.
- Acetic acid, citric acid (comic acid, ascorbic acid)

THANK YOU!!