The Diabetic Foot

Michael Anthony, DPM
Assistant Professor - Clinical
Department of Orthopaedics
The Ohio State University Wexner Medical Center

Prevalence of Diabetes

- **422 million diabetic – 2016**
  - **382 million -2013**
  - **8.5% adult population**
  - **90% Type II**

Prevalence of Diabetes United States

- **CDC**
- **29.1 million diabetic – 2014**
  - **¼ undiagnosed**
- **86 million prediabetic**
  - **15-30% developing diabetes within 5 years**

Symptoms

- **Increased thirst**
- **Frequent urination**
- **Extreme hunger**
- **Unexplained weight loss**
- **Fatigue**
- **Irritability**
- **Blurred vision**
- **Slow-healing sores**
- **Frequent infections**

Economic Strain

- American Diabetes Association
  - $327 billion in 2017 from $245 billion in 2012
    - Medical cost and lost wages
  - 26% increase

Economic Strain

- $237 billion in direct medical costs
  - hospital inpatient care (30%)
  - prescription medications (30%),
  - diabetes supplies (15%)
  - physician office visits (13%).

Economic Strain

- **$ 90 billion indirectly**
  - **increased absents ($3.3 billion)**
  - **reduced productivity while at work ($29.2 billion)**
  - **inability to work as a result of disease-related disability ($37.5 billion)**
  - **lost productive capacity due to early mortality ($19.9 billion).**

Mortality

- **8th leading cause of death:**
  - **World Health Organization**
  - **1.5 – 5 million deaths a year – 2012**
    - **International Diabetes Federation**
      - **Directly or indirectly**
- **2-fold higher rate for death middle-aged people with diabetes**

Complications of Diabetes

- Cardiovascular disease
- Neuropathy
- Retinopathy
- Nephropathy
- Neuroarthropathy

The diabetic foot

- Cardiovascular disease
  - PAD
    - 1 out of 3 diabteics over the age of 50
  - Risk Factors
    - DM
    - Smoking
    - High blood pressure
    - Abnormal blood cholesterol
    - Overweight
    - Not physically active
    - Over age 50
    - History of heart disease:heart attack or a stroke
    - Family history of heart disease, heart attacks, or strokes

Signs of PAD

- **Absent pedal pulses**
- **Leg pain, walking or exercising, which improves with rest**
- **Numbness, tingling, or coldness**
- **Sores or infections heal slowly**

Diagnosis of PAD

- **ABIs**
- **Ultrasound: Arterial Wave flow**
- **MRI/CTA**
- **Angiogram**

Concern for PAD

- **Impact on healing**

The diabetic foot

- **Neuropathy**
  - **Peripheral Neuropathy**
  - **Autonomic Neuropathy**

Peripheral Neuropathy

- Numbness
  - Do not feel pain or temp changes
- Burning
  - Increased sensitivity:
    - Sensation hot or cold
- Tingling
  - Pins and needles

Peripheral Neuropathy

- Diagnosis
  - Monofilament
  - EMG
  - Tuning fork
  - Biopsy

Peripheral Neuropathy

- **Concern**
  - **ulceration**

Autonomic Neuropathy

- **Affects the nerves that control your body systems**
  - **digestive system**
  - **urinary tract**
  - **sex organs**
  - **heart and blood vessels**
  - **sweat glands**
  - **eyes**

Autonomic Neuropathy

- Impact on feet
  - Integrity of the skin
  - Dry cracking

The diabetic foot

- Retinopathy
  - Visual impairments
    - Issues with proper foot care
    - Issues with visualizing foot concerns

The diabetic foot

- **Nephropathy**
  - **Complications**
    - **Fluid retention, swelling**
    - **Damage to the blood vessels**
    - **Anemia**
    - **Non-enzymatic glycation → structural changes**

Nephropathy

- **Irreversible damage to your kidneys (end-stage kidney disease)**
  - **dialysis**
  - **kidney transplant for survival**
- **Antibiotic usage**

The diabetic foot

- Neuroarthropathy
  - Charcot
    - chronic, progressive, and destructive arthropathy
    - Pathogenesis
      - Multifactorial
        - mechanical and vascular factors
        - peripheral and autonomic neuropathy
        - metabolic abnormalities of bone

Charcot

- Structural changes
  - Increase peak pressure
    - ulcerations

The diabetic foot

- **Preventative care**
  - **Circulation**
  - **Sensation**
  - **Structural changes**
    - **Non-enzymatic glycation → contractures**
    - **increased plantar pressures**
  - **Skin integrety**
  - **Nail Care**

Why

- **Foot complications: leading cause of hospitalization for patients with diabetes**
- **15% to 20%: foot ulcer during their lifetime**

Why

- **Hospitalized diabetic foot ulcer patients can expect a 59% longer length of stay**
- **Patient with diabetes are 15 times more likely to require a major amputation**
  - **14% to 24% DM ulcers will result in an amputation**

Routine examination of the foot in diabetic patients

When to refer to a podiatrist?

Diabetic Foot

Said Atway, DPM. FACFAS
Assistant Professor - Clinical
Department of Orthopaedics
The Ohio State University Wexner Medical Center

“Diabetic foot” variety of pathological conditions that might affect the feet in patients with diabetes (Boulton 2002)

- **Prevalence**
  - **29.1 Million people 9.3% of the US 2012**
    - **CDC**
  - **2.8% Worldwide 2000 (171 million)**
    - **WHO**

Amputations

- **73,000 non-traumatic amputations in diabetics 2010**
  - **CDC**

- **Cost**
  - **$4,595 per ulcer and $28,000 >2years**
  - **$5billion per year annually**
    - ***Clin Ther 1998***
  - **$30-50k amputation according to president**

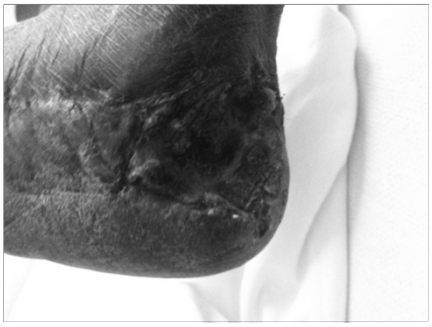
Foot Infections

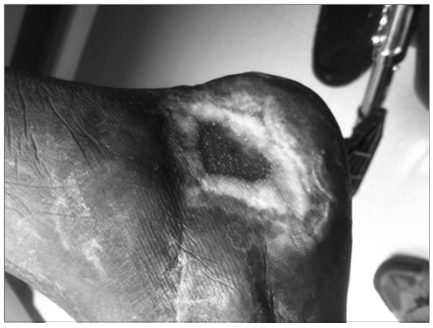
- Any infra-malleolar infection in a person with diabetes
- Common and costly problem
  - DM related amputation cost 3B per year
    - *Diabetes Care 2003*
- Most common reason for a diabetic to be admitted
  - *National Hospital Discharge Data*
- Most common non-traumatic cause of amputation
  - 60% of LEA
  - Most common cause of nontraumatic lower extremity amputation
    - *Lancet 2005*

Importance of Diabetic Wound care

- Diabetic foot ulcers present >4 weeks have a 5 fold higher risk of infection
- Infection in a foot ulcer increases the risk for hospitalization 55.7 times and risk for amputation 155 times
- 5 year mortality after limb amputation is 68%
  - *NIH publication 1995*

Wound Care is Easy





The FDA defines a healed wound as reepithelialized skin without drainage or dressing requirements confirmed at 2 consecutive visits 2 weeks apart.

Guidance for Industry

Chronic Cutaneous Ulcer and Burn Wounds — Developing Products for Treatment

Clinical Practice Guidelines

- **Management of etiologic factors**
  - **Adequate perfusion**
    - **PAD (Twice as common in DM)**
    - **Gregg et al 2004**

    Rarely lead to ulcer directly
    Contributes to 50% of ulcers
    Diabetes Metab 2008
  - **Debridement**
    - **Sharp debridement of infection**
    - **Urgent for gas/necrotizing infection**
  - **Infection Control**
    - **IDSA guidelines**
  - **Pressure Mitigation**
    - **Offloading**
    - **Total contact cast**

The management of diabetic foot: A clinical practice guideline by the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine

Anil Hingorani, MD,[a] Glenn M. LaMuraglia, MD,[b] Peter Henke, MD,[c] Mark H. Meissner, MD,[d] Lorraine Loretz, DPM, MSN, NP,[e] Kathya M. Zinszer, DPM, MPH, FAPWCA,[f] Vickie R. Driver, DPM, MS, FACFAS,[g] Robert Frykberg, DPM, MPH, MAPWCA,[h] Teresa L. Carman, MD, FSVM,[i] William Marston, MD,[j] Joseph L. Mills Sr, MD,[k] and Mohammad Hassan Murad, MD, MPH,[l] *Brooklyn, NY; Boston and Worcester, Mass; Ann Arbor, Mich; Seattle, Wash; Danville, Pa; Providence, RI; Phoenix Ariz; Cleveland, Ohio; Chapel Hill, NC; Houston, Tex; and Rochester, Minn*

Background: **Diabetes mellitus continues to grow in global prevalence and to consume an increasing amount of health care resources. One of the key areas of morbidity associated with diabetes is the diabetic foot. To improve the care of patients with diabetic foot and to provide an evidence-based multidisciplinary management approach, the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine developed this clinical practice guideline.**

Methods: **The committee made specific practice recommendations using the Grades of Recommendation Assessment, Development, and Evaluation system. This was based on five systematic reviews of the literature. Specific areas of focus included (1) prevention of diabetic foot ulceration, (2) off-loading, (3) diagnosis of osteomyelitis, (4) wound care, and (5) peripheral arterial disease.**

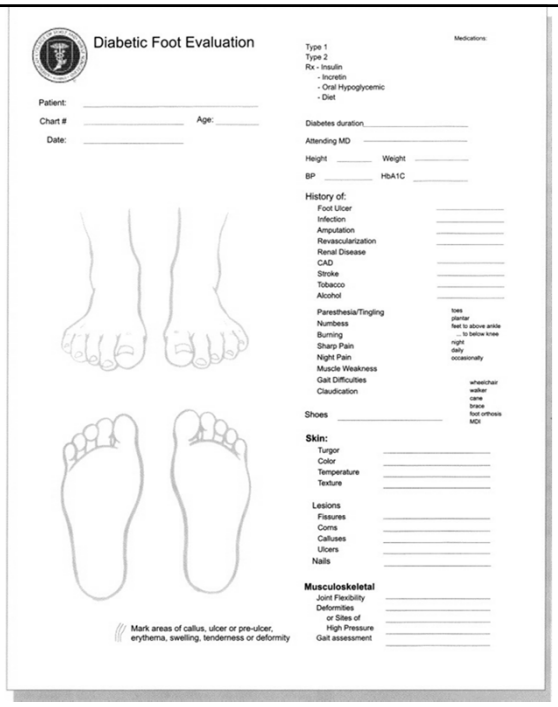
Results: **Although we identified only limited high-quality evidence for many of the critical questions, we used the best available evidence and considered the patients' values and preferences and the clinical context to develop these guidelines. We include preventive recommendations such as those for adequate glycemic control, periodic foot inspection, and patient and family education. We recommend using custom therapeutic footwear in high-risk diabetic patients, including those with significant neuropathy, foot deformities, or previous amputation. In patients with plantar diabetic foot ulcer (DFU), we recommend off-loading with a total contact cast or irremovable fixed ankle walking boot. In patients with a new DFU, we recommend probe to bone test and plain films to be followed by magnetic resonance imaging if a soft tissue abscess or osteomyelitis is suspected. We provide recommendations on comprehensive wound care and various débridement methods. For DFUs that fail to improve (>50% wound area reduction) after a minimum of 4 weeks of standard wound therapy, we recommend adjunctive wound therapy options. In patients with DFU who have peripheral arterial disease, we recommend revascularization by either surgical bypass or endovascular therapy.**

Conclusions: **Whereas these guidelines have addressed five key areas in the care of DFUs, they do not cover all the aspects of this complex condition. Going forward as future evidence accumulates, we plan to update our recommendations accordingly. (J Vasc Surg 2016;63:3S-21S.)**

Frequency

- **Category 0 (Normal Risk)**
  - **Annual**
- **Category 1 (Neuropathy)**
  - **Semiannual**
- **Category 2 (Neuropathy/PAD/Deformity)**
  - **Quarterly**
- **Category 3 (Previous ulcer/amputation)**
  - **Monthly/Quarterly**

The management of diabetic foot: A clinical practice guideline by the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine Anil Hingorani, MD,et al

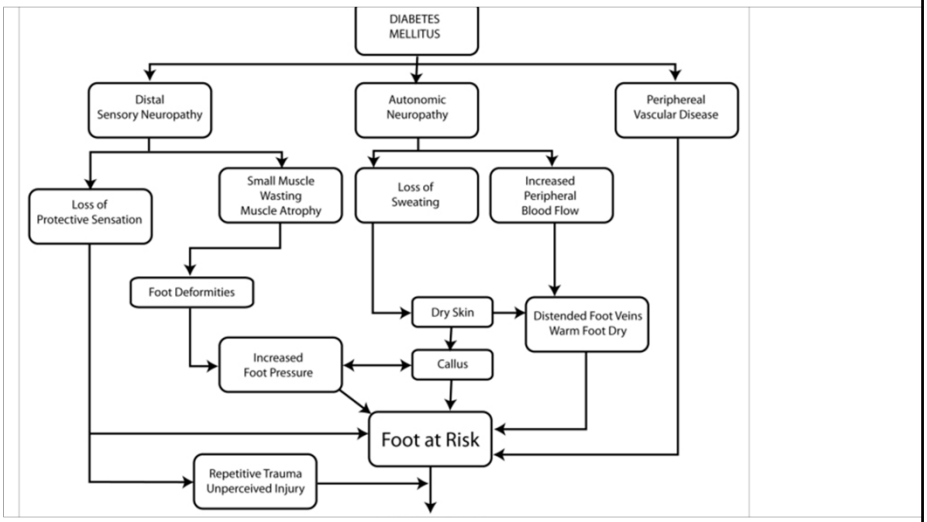


Basic evaluation and treatment of foot diabetic foot ulcers

- Neurologic status
  - Monofilament
  - Vibratory sensation
  - Questionnaire
    - Patient may not realize loss of sensation
- Vascular status
  - Pedal pulses
  - ABI's with waveforms and toe pressures
  - TcO2

Vascular work up

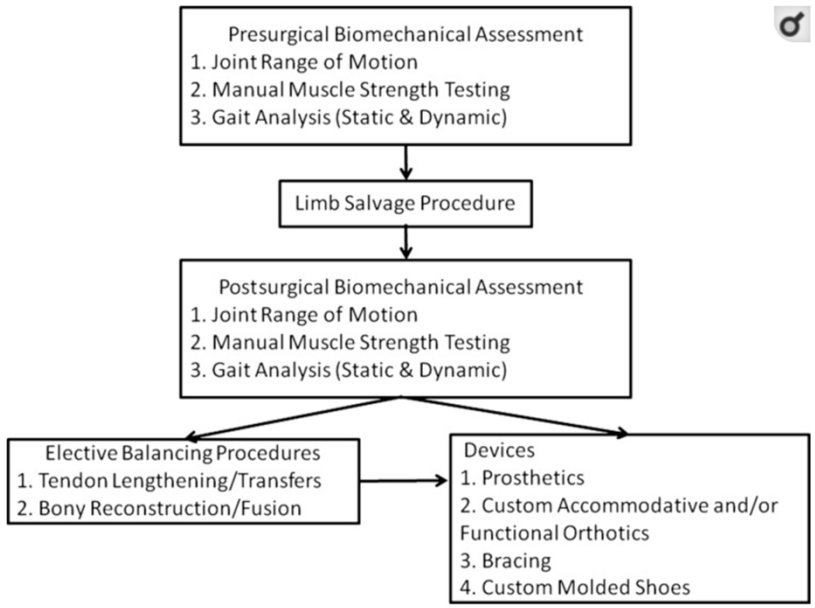
- ADA recommendations:
  - ABI >50y DM
  - <50y with risk factors
    - Smoking
    - HTN
    - Hyperlipidemia
    - >10years DM
  - Anyone with PAD symptoms
- Dependent rubor
- Pallor on elevation
- Absence of hair growth
- Dystrophic nails
- Cool/Dry/Fissured skin
  - ✓ Diabetes Care 2003



Deformity

- **Pathophysiologic mechanism complex**
  - **Neuropathy**
  - **Repetitive trauma**
  - **Focal tissue ischemia**
  - **Tissue Destruction**
- **Foot deformities**
  - **Charcot**
    - **Neuroarthropathy**
- **Limited joint mobility**
  - **Glycosylation of soft tissue**

Figure 1.



General pathway of where the biomechanical examination fits in the environment of limb salvage.

- **"The Majority of foot ulcers appear to result from minor trauma in the presence of sensory neuropathy" McNeely**
- **Critical Triad: (65% of diabetic foot ulcers)**
  - **Neuropathy**
  - **Deformity**
  - **Trauma**

Wound Evaluation

- Size
  - % reduction early predictor of outcome
- Location
  - WB surface
  - Digits
  - Heel
  - Legs
- Shape
  - Margolins
- Depth
  - Deep tissue involvement
- Base
  - Necrotic/Fibrotic/Granular
- Border
  - Abnormal
- Probe
  - 89% Probe to bone
- Xrays
  - Free air/foreign body
- Infection
  - Advanced imaging work up

Diagnostics

- Inflammatory markers
  - Lack specificity
  - Neuropathy/vascular disease mimic/diminish inflammatory findings
- CBC
- Culture
  - All open wounds are colonized
- Bone biopsy
  - Invasive
    - Guide antibiosis
- Imaging
  - Radiographs
    - MRI
      - If abscess or osteomyelitis suspected
  - CT
  - White blood cell scan
  - FDG-PET

Table 1

Wound classification system[11]

Stages	Description
Stage A	No infection or ischemia
Stage B	Infection present
Stage C	Ischemia present
Stage D	Infection and ischemia present
Grading	
Grade 0	Epithelialized wound
Grade 1	Superficial wound
Grade 2	Wound penetrates to tendon or capsule
Grade 3	Wound penetrates to bone or joint

Grade 2 ulcers

Grade 3 D ulcers

Diagnosis and Treatment of Diabetic Foot Infections

Benjamin A. Lipsky,[1,a] Anthony R. Berendt,[2,a] H. Gunner Deery,[3] John M. Embil,[4] Warren S. Joseph,[5] Adolf W. Karchmer,[6] Jack L. LeFrock,[7] Daniel P. Lew,[8] Jon T. Mader,[9,b] Carl Norden,[10] and James S. Tan[11]

[1]Medical Service, Veterans Affairs Puget Sound Health Care System, and Division of General Internal Medicine, Department of Medicine, University of Washington School of Medicine, Seattle, Washington; [2]Bone Infection Unit, Nuffield Orthopaedic Centre, Oxford, United Kingdom; [3]Northern Michigan Infectious Diseases, Petoskey, Michigan; [4]Section of Infectious Diseases, Department of Medicine, University of Manitoba, Winnipeg, Manitoba; [5]Section of Podiatry, Department of Primary Care, Veterans Affairs Medical Center, Coatesville, Pennsylvania; [6]Division of Infectious Diseases, Department of Medicine, Harvard Medical School, and Beth Israel Deaconess Medical Center, Boston, Massachusetts; [7]Dimensional Dosing Systems, Sarasota, Florida; [8]Department of Medicine, Service of Infectious Diseases, University of Geneva Hospitals, Geneva, Switzerland; [9]Department of Internal Medicine, The Marine Biomedical Institute, and Department of Orthopaedics and Rehabilitation, University of Texas Medical Branch, Galveston, Texas; [10]Department of Medicine, New Jersey School of Medicine and Dentistry, and Cooper Hospital, Camden, New Jersey; and [11]Department of Internal Medicine, Summa Health System, and Northeastern Ohio Universities College of Medicine, Akron, Ohio

EXECUTIVE SUMMARY

1. Foot infections in patients with diabetes cause substantial morbidity and frequent visits to health care professionals and may lead to amputation of a lower extremity.

2. Diabetic foot infections require attention to local (foot) and systemic (metabolic) issues and coordinated management, preferably by a multidisciplinary foot-care team (A-II) (table 1). The team managing these infections should include, or have ready access to, an infectious diseases specialist or a medical microbiologist (B-II).

3. The major predisposing factor to these infections is foot ulceration, which is usually related to peripheral neuropathy. Peripheral vascular disease and various immunological disturbances play a secondary role.

4. Aerobic gram-positive cocci (especially *Staphylococcus aureus*) are the predominant pathogens in diabetic foot infections. Patients who have chronic wounds or who have recently received antibiotic therapy may also be infected with gram-negative rods, and those with foot ischemia or gangrene may have obligate anaerobic pathogens.

5. Wound infections must be diagnosed clinically on the basis of local (and occasionally systemic) signs and symptoms of inflammation. Laboratory (including microbiological) investigations are of limited use for diagnosing infection, except in cases of osteomyelitis (B-II).

6. Send appropriately obtained specimens for culture prior to starting empirical antibiotic therapy in all cases of infection, except perhaps those that are mild and previously untreated (B-III). Tissue specimens obtained by biopsy, ulcer curettage, or aspiration are preferable to wound swab specimens (A-I).

7. Imaging studies may help diagnose or better define deep, soft-tissue purulent collections and are usually needed to detect pathological findings in bone. Plain radiography may be adequate in many cases, but MRI (in preference to isotope scanning) is more sensitive and specific, especially for detection of soft-tissue lesions (A-I).

8. Infections should be categorized by their severity on the basis of readily assessable clinical and laboratory features (B-II). Most important among these are the specific tissues involved, the adequacy of arterial perfusion, and the presence of systemic toxicity or metabolic instability. Categorization helps determine the degree of risk to the patient and the limb and, thus, the urgency and venue of management.

Received 2 July 2004; accepted 2 July 2004; electronically published 10 September 2004.

These guidelines were developed and issued on behalf of the Infectious Diseases Society of America.

[a] B.A.L. served as the chairman and A.R.B. served as the vice chairman of the Infectious Diseases Society of America Guidelines Committee on Diabetic Foot Infections.

[b] Deceased.

Reprints or correspondence: Dr. Benjamin A. Lipsky, Veterans Affairs Puget Sound Health Care System, S-111-GIMC, 1660 S. Columbian Way, Seattle, WA 98108-5804 (Benjamin.Lipsky@med.va.gov).

Clinical Infectious Diseases 2004; 39:885–910

Osteomyelitis

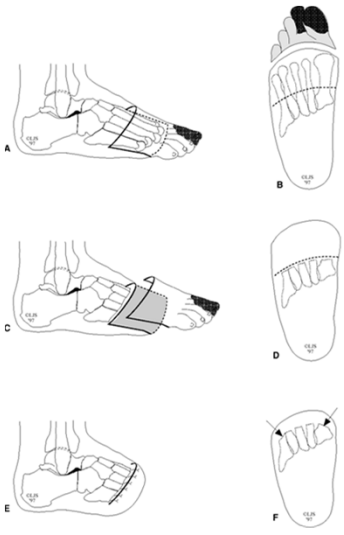
- Hindfoot and leg osteomyelitis is often met with few options for salvage
- Often move into a major amputation – BKA/AKA
- Limb preservation often not an option but should be examined in each case
- Mortality after non-traumatic BKA/AKA (4+ comorbidities)
  - 30 day: 16%
  - 1 year: 25/43(37)%
  - 5 year: 66/83(70)%

Kristensen, Morten T., Gitte Holm, Michael Krasheninnikoff, Pia S. Jensen, and Peter Gebuhr. "An Enhanced Treatment Program with Markedly Reduced Mortality after a Transtibial or Higher Non-traumatic Lower Extremity Amputation." *Acta Orthopaedica* 87.3 (2016): 306-11
Gök, Ü., Ö. Selek, A. Selek, A. Güdük, and M. Ç. Güner. "Survival Evaluation of the Patients with Diabetic Major Lower-extremity Amputations."*Musculoskelet Surg MUSCULOSKELETAL SURGERY* (2016)

- Osteomyelitis – a challenge met by all those treating the foot and ankle
- Osteomyelitis secondary to diabetic foot ulceration is an unfortunate complication that may require
  - Long term intravenous antibiotics
  - Operative debridement
  - Amputation, and commonly a combination of these.
- Debridement/complete excision of infected bone
  - Soft tissue coverage
  - Compliance of patients

Antoniou D, Conner AN. Osteomyelitis of the calcaneus and talus. J Bone Joint Surg Am 1974;56:338–45.

Amputation Healing



- **Transfer Lesion**
- **Abnormal tendon pull**
- **Rotation in various planes**
- **Dehiscence**
- **Optimal healing**
- **Shoe filler**

Amputation Recovery

- Amputation
- Appropriate Orthoses
- Instability

Plantigrade foot

History of ulcer

Amputation

- Hallux
- Digit amputation
- Metatarsal Amputation
- Transmetatarsal
- Lisfranc Amputation
- Chopart Amputation
- Syme's Amputation

Grade 3D

Charcot Neuroarthropathy/Abnormal pressure

Thank You