Diabetic Foot Wound

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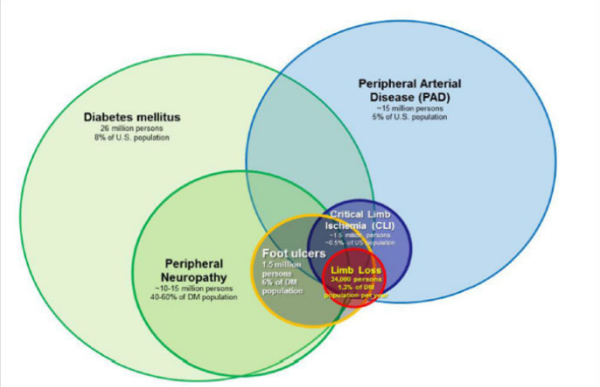
"Diabetic foot" variety of pathological conditions that might affect the feet in patients with diabetes (Boulton 2002)

Team Approach

- Expedited referral and care
- Madagin program proven to decrease amputations 82%
  - Driver et al. Diabetes Care 2005
- Swedish study decreased amputations 71% over 11 years
  - Wennberg et al Diabetes research 2019
- UK study 40% reduction and 62% reduction in major amputations



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

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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.

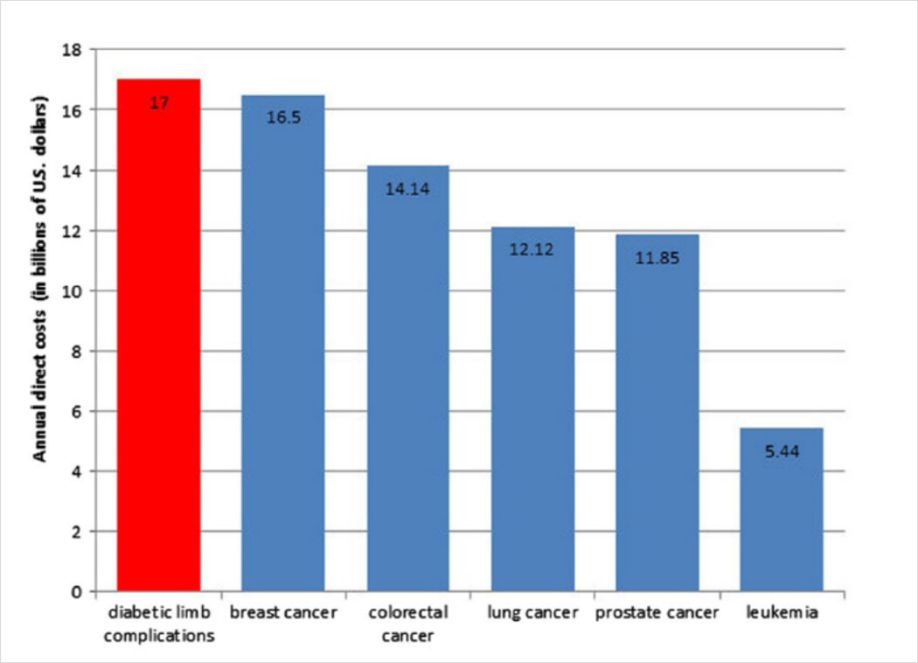
Results: Although we identified only limited high-quality evidence for many of the critical questions, we used the best available evidence and considered the patients' values and preferences and the clinical context to develop these guidelines. We include preventive recommendations such as those for 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.)

- 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*

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

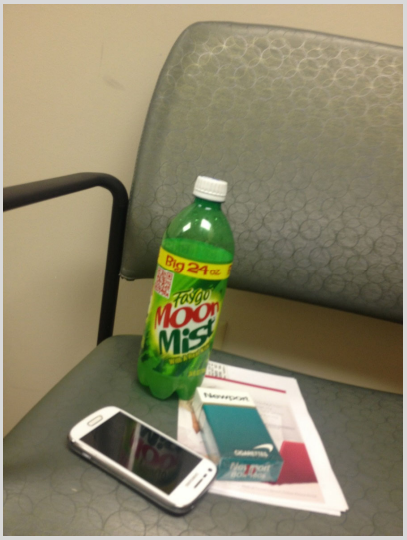
Guidance for Industry
Chronic Cutaneous Ulcer and Burn Wounds — Developing Products for Treatment

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

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

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

Orthopaedic Wound Care

Management of osteomyelitis and bone infection

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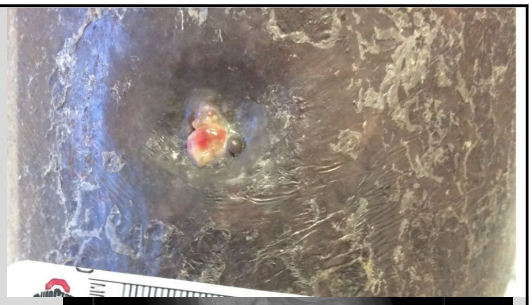
Why Orthopaedic Wound care?



- Things may not be as they appear…..
- Bone Expertise provides a margin for safety
- Bone Debridement without Expertise
  - May Compromise Structural integrity
  - May Fail to Eradicate infection
- Bone Debridement without Coverage
  - Exposes previously Protected area to Environment
  - May Promote Deeper Infection
- Biopsy techniques Must Avoid Contaminating deeper bone – Metaphyseal or Medullary bone.
- **Red flag: Persistent Draining Wound despite Meticulous care**
- What Lies Beneath……
  - As many as 64% Diabetic Foot infections involve Bone
  - Foreign material and Necrotic bone harbor Biofilm
  - Granulation tissue Obscures, does Not Protect underlying Structures from Environment
  - Proper use of Imaging/X-rays is Essential

Osteomyelitis
= Infection involving bone

- Timing: acute or chronic
- Organisms: Staphylococcus aureus
  - Most common, can be any organism
- Causes/ examples: (may be acute or chronic)
  - Direct contamination – bone contacts environment—
    - Open Fracture
    - Penetrating Trauma
    - Stage 4 ulcer
    - Animal or Human bite
  - Contiguous spread –from Local wound or abscess,
    - Diabetic Foot wound, Pressure ulcer, Paronychia, Injection Related abscess
    - Infected Fixation Hardware or Prosthetic Joint Infection (PJI)
  - Hematogenous seeding from Remote source
    - Endocarditis, Pyelonephritis,
    - Infections related to Injected Drug use

Osteomyelitis
Cierny- Mader Classification/ Factors (1980's)

- **Location of infection in Bone:**
  - 1. Medullary
  - 2. Superficial
  - 3. Localized
  - 4. Diffuse

- **Type of Host:**
  - **"A": Healthy Host**
    normal healing potential
  - **"B": Compromised Host**
    Systemic or Local Factors
    +/- Correctable ??
  - **"C": Debilitated host:**
    Treatment is worse than Disease

Cierny G, Mader JT, Pennick H. A clinical staging system of adult osteomyelitis. Contemp Orthop1985; 10:17 – 37

Mader JT, Shirtliff M, Calhoun JH. Staging and Staging Application in Osteomyelitis. *Clinical Infectious Diseases*. 1997;25:1303–1309.

- **Systemic (s):**
  - **Organ failure (renal, hepatic)**
  - **Malnutrition,**
  - **Diabetes Mellitus**
  - **Chronic Hypoxia**
  - **Extremes of Age**
  - **Immune disease**
  - **Immune compromise**
  - **Malignancy**

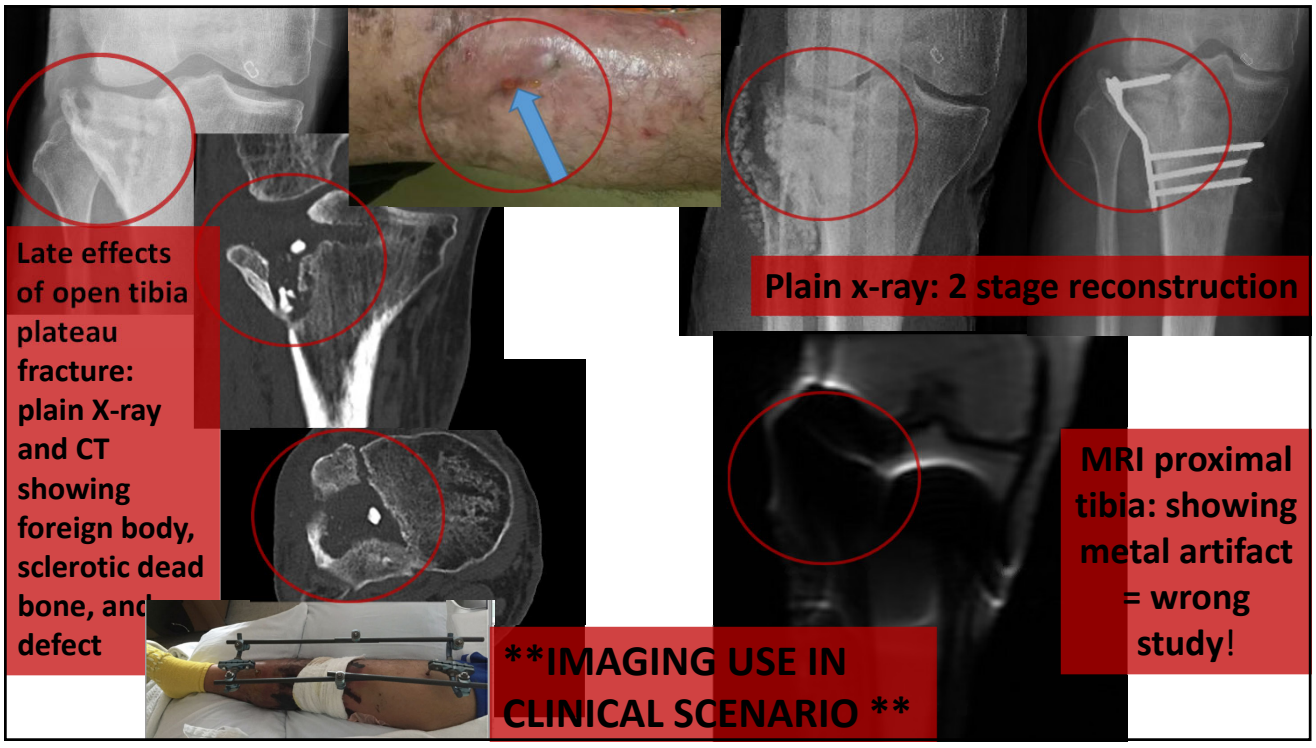
*** 2021***
Substance Abuse, Noncompliance

- **Local (l):**
  - **Vascular disease, stasis, lymphedema**
  - **Scarring, radiation fibrosis**
  - **Neuropathy**
  - **Small vessel disease**
  - **Tobacco abuse**

Treatment Strategies:

Wound Closure efforts may require any or all to succeed

- Recognize Source and remove Bioburden
  - Assessment, Imaging, Irrigation, Debridement, Bone Resection
- Protect bone
  - Avoid Further and Repeat contamination
  - Maintain or Restore Structural integrity of bone, joint, tendon, ligament
    - **May Require Advanced Orthopaedic Reconstruction**
  - Antibiotics: IV, Oral, Local delivery (beads), Antimicrobial dressings
  - Avoid spread: Coverage/ closure, Blood supply, Dressings, Control pathogens
- Optimize healing potential--Improve host
  - Oxygen, Nutritional resources for Healing,
  - Decrease Size of wound–, Negative pressure, Bone resection, Flap/Graft
  - Address Soft tissue Issues
  - Control Medical Factors (optimization)
  - **No Tobacco**



Late effects of open tibia plateau fracture: plain X-ray and CT showing foreign body, sclerotic dead bone, and defect

Plain x-ray: 2 stage reconstruction

MRI proximal tibia: showing metal artifact = wrong study!

**IMAGING USE IN CLINICAL SCENARIO **

General Surgery and Wound Care

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General Surgery and Wound Care

- Typically, General Surgery deals with the abdomen, so this is what we deal with in Wound Care as well
- Most of what I am seeing in wound care is chronic abdominal wounds
- This often has to do with infected prosthetics such as hernia mesh that are involved in patient care in the past
- Also help with colostomy creation for help in healing sacral wounds

Laparoscopic Loop Colostomy

- Diverts stool to the abdominal wall through a stoma
- Helps clean up perineum, allows for complex wound closure of sacral wounds
- Can be temporary, or permanent, depending on patient preference

Wound Care

- With a team approach, we can offer our patients a full breadth of options for wound care
- Having Plastic Surgery, Orthopedics, and General Surgery gives patients the best chance of healing their wounds
- Our nursing staff is very experienced, and helps get patients ready for surgery if it is indicated.

Case Presentations on Various Wound Etiologies

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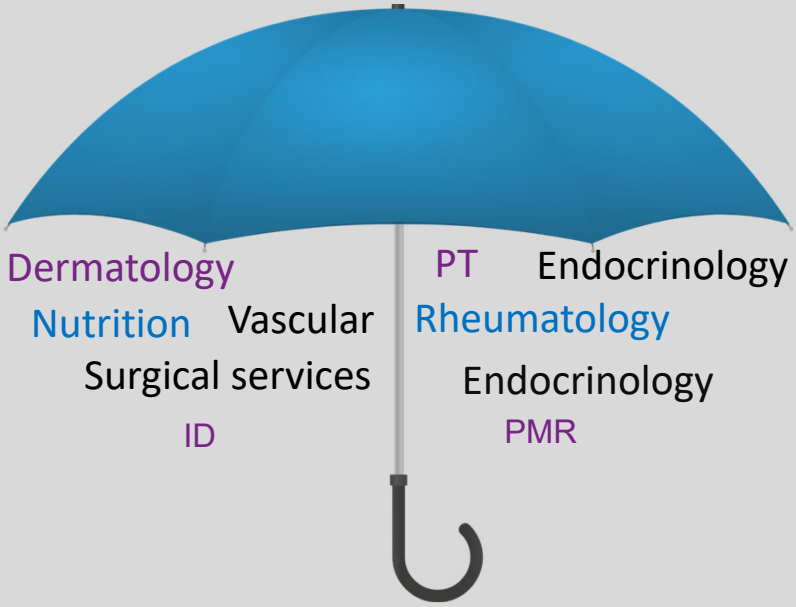
Wound Center Provider

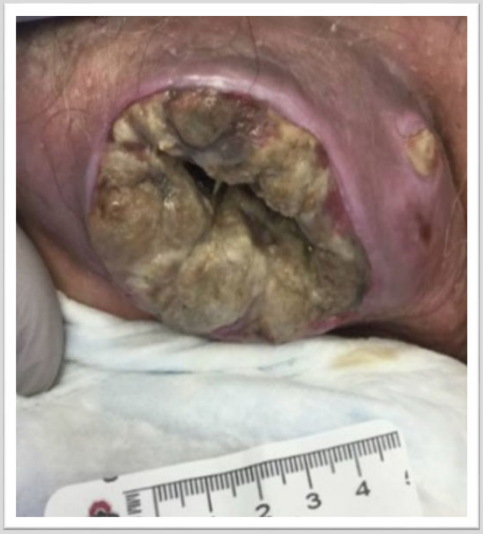


Pyoderma

Stage 4 Pressure Injury

Arterial Wound

Malignant Melanoma



Advanced Wound Care at the New OSU Wound Center

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Disclosures

I have no disclosures

New OSU Wound Center
What is Advanced Wound Care

Wound care professionals should select the appropriate wound management system based on:

1) Published clinical evidence ;
2) Contribution to providing the best outcomes at the total lowest cost of care, and
3) Comprehensive multidisciplinary care model with highly specialized care.

We offer the most advanced treatment for nonhealing and hard-to-heal wounds, including hyperbaric oxygen therapy, surgical and microsurgical reconstruction, advanced use of biologics and new emerging technology

Referral to Wound Center

Good Wound Care	Advanced Wound Care
History	Hyperbaric Medicine
Assessment	Growth Factors
Debridement	Bioengineered Tissues
Warm, Moist Environment	Negative Pressure Therapy
Offloading	Biologic Dressings
Topical Care	Active Topicals
	Plastic Surgery
	Curative Surgery

Wound Care Documentation

DESCRIBE WHAT YOU SEE!

Note the percentages

Is there odor, is there pus, is there drainage?

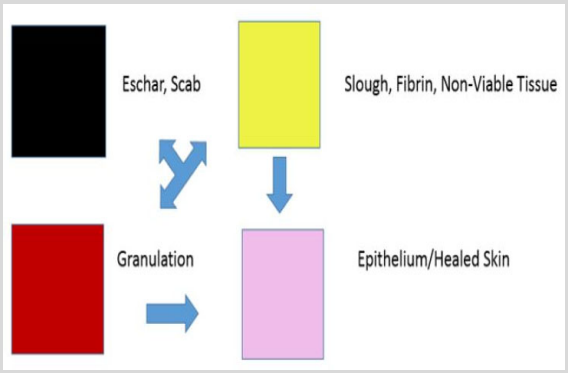
Describe the periwound

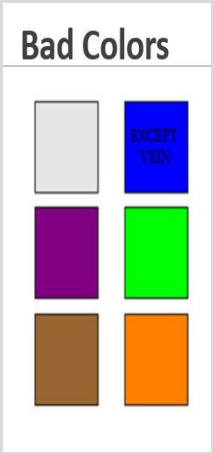
- Bleeding, moist, intact, red, hot, swollen, dry, cracked

Note your intervention

- What did you put on the wound?

Color Coding Wounds



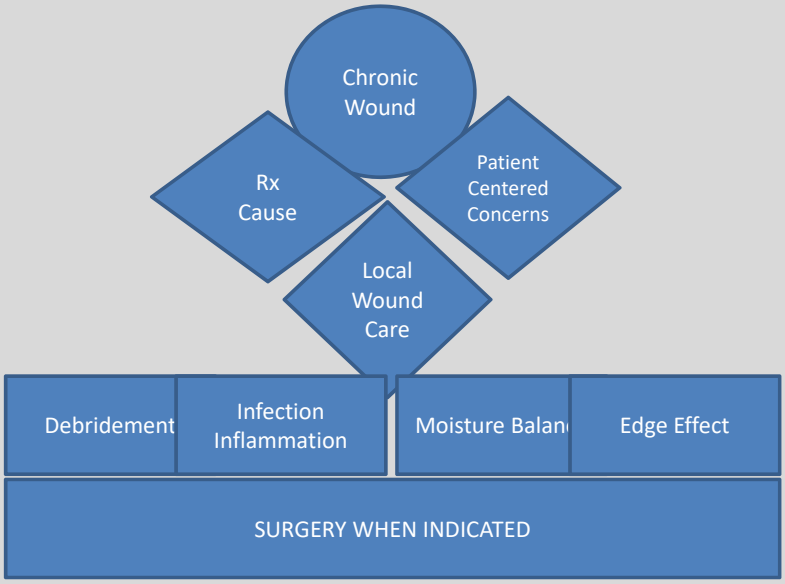


New OSU wound care center

Principles of Advanced Wound Care

- Differentiate between acute wounds and the development of chronic wounds.
- Identify risk factors for chronic wound development.
- Identify the four most common type of chronic wounds: pressure injury and venous, arterial, and diabetic ulcers.
- Discuss the development of biofilm and the role it plays in wound chronicity.
- Apply the concepts of DIME+S
  - Debridement, Inflammation Control, Moisture management, Edge effect AND Surgery (when indicated)

New OSU wound care center
Wound Preparation Model



DEBRIDEMENT
Why is it necessary?

Necessary to convert a chronic wound into an acute wound

Keeps the wound in the active phases of healing

Removes nonviable/infected tissue and bioburden

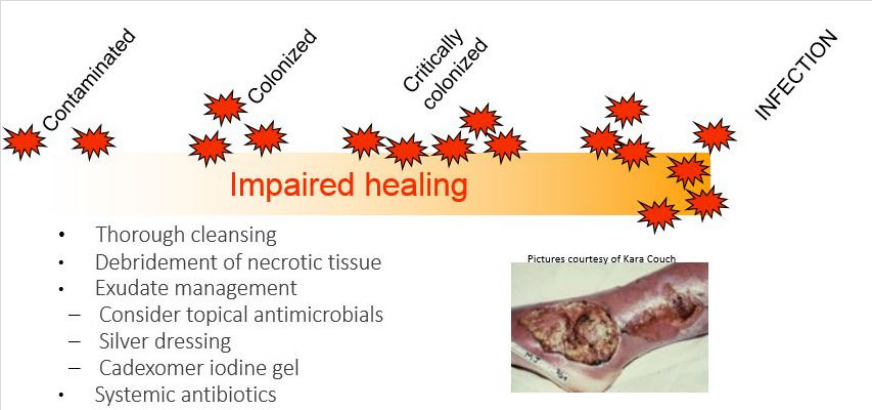
Types of debridement: autolytic, enzymatic, sharp, mechanical

DEBRIDEMENT
Why is it necessary?

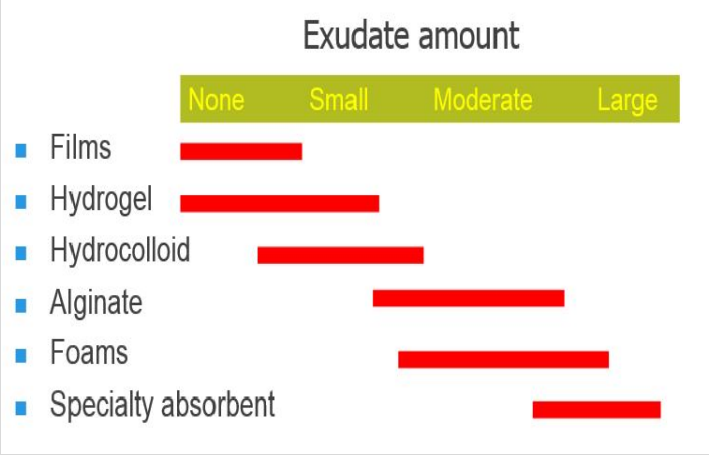
Inflammation and Infection Control
What Does it Do?

	Critically colonized	Deep wound infection	Systemic infection
	Nonhealing	Size bigger	Fever
	Exudative	Temperature increased	Rigors
	Red and bleeding	Os (probes to or exposed bone)	Chills
	Debris	New areas of breakdown	Hypotension
	Smell	Exudate, Erythema,	Multiple organ failure
		Edema	
		Smells	
TX:	Topical	Systemic	Systemic

Infection – shades of grey



Management of Moisture Tips and Tricks

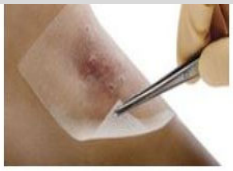


Edge Effect:
The Benefits of a Contact Layer

Non-adherent, atraumatic

Porous mesh structure

Can stay on wound for many days, changing secondary dressing over contact layer



Edge Effect:
Choosing the Right Dressings

	Hydrogel	Honey	Foam	Alginate	Contact Layer
Epithelial	■	■	■		■
Granulated	■	■	■	■	■
Exudative		■	■	■	
Fibrin	■	■		■	
Slough	■	■			
Eschar	■	■	■		
Depth	■	■		■	

***Silver can be added into hydrogel, foam, alginate, and contact layer as needed.
***Bordered foams can be used over hydrogels, honey, silver, alginate, contact layers.

Overall Cost-Awareness

Complicated by many factors:

- Insurance coverage
- Quality of life
- Economic constraints
- Rising health care costs - labor and materials

Cheaper wound management does not necessarily = cost savings

- For example, if the dressing costs more but reduces time to wound healing, decreases length of stay, reduces the frequency of dressing changes, and/or decreases the need for analgesia with dressing changes, then it may actually mean overall cost savings

Surgical Closure

Pre-op Evaluation

- History:
  - Cardiac, pulmonary, endocrine, oncologic
- Location :
  - Depth, volume
  - Involvement of adjacent structures
    - Bone, Joint, sinus
- Quality:
  - Vascularity
  - Presence of scarring
  - Extent of infection
    - Cellulitis, Heavy bacterial count, C/S

Pre-op Evaluation

- Nutritional status
  - Cachexia, anemia
- Musculoskeletal status
  - Spasms, fixed contractures
- Distant infection
  - Urinary, pulmonary, other
- General status
  - Neurologic/ psychiatric
    - Coma, disorientation
    - Schizophrenia, depression
    - Social support system

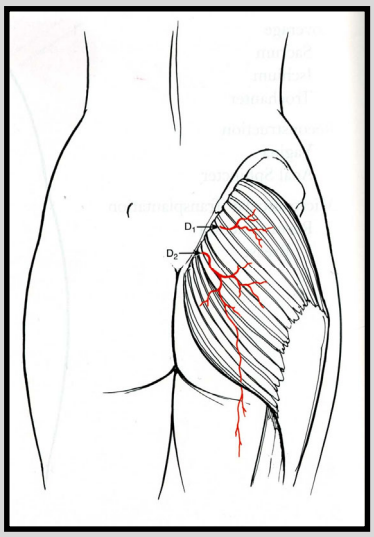
Methods of Surgical Closure

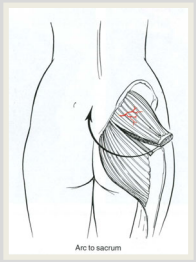
- Primary closure
- Skin graft
- Pedicle flap: muscle, musculocutaneous, fasciocutaneous
- Free tissue transfer

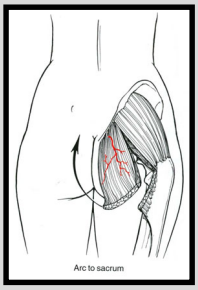
Sacral Ulcer Closure

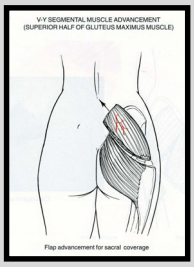
- primary closure
- **superior gluteus muscle**
- gluteal fasciocutaneous
- gluteal turnover
- reverse dermal graft
- V-Y advancement
- paraspinous based perforator flap

Gluteus maximus



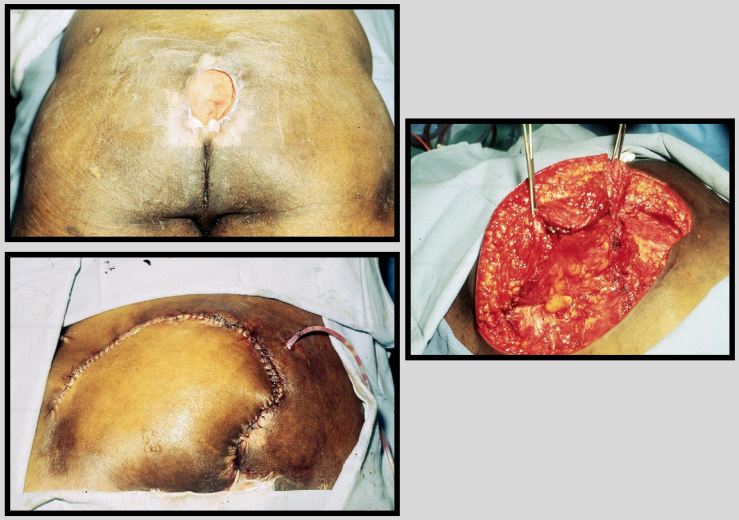




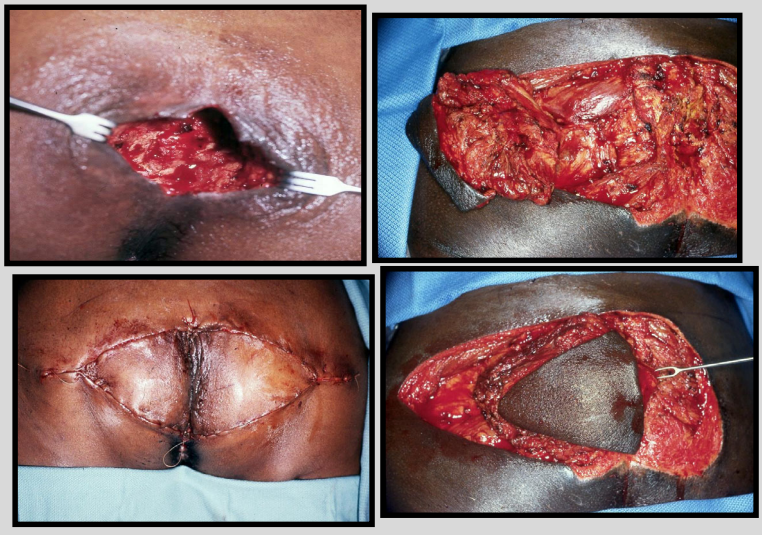


Sacral Ulcer

Sacral Ulcer



Sacral Ulcer



Ischial Ulcer Closure

- primary closure
- **posterior thigh**
- inf. gluteal muscle
- gracilis
- biceps femoris & skin
- hamstring
- **tensor fascia lata** & vastus lateralis
- lateral thigh
- rectus abdominus

Ischial Ulcer

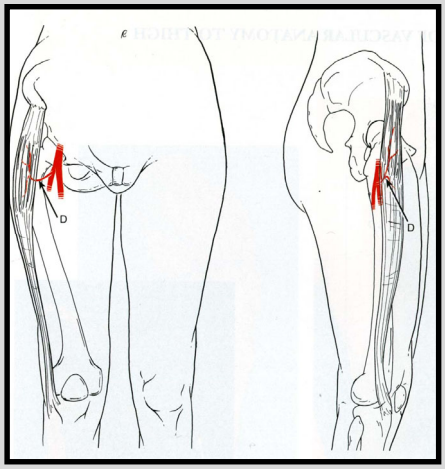
Ischial Ulcer

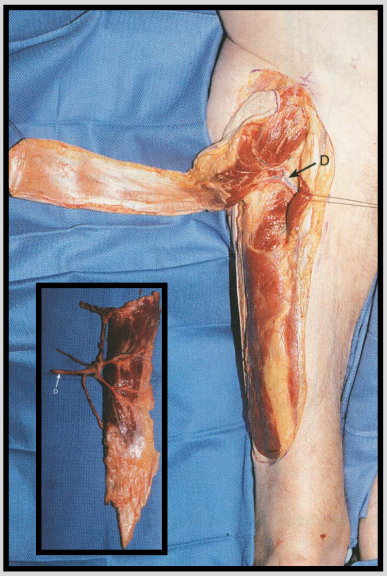

Ischial Ulcer


Trochanteric Ulcer Closure

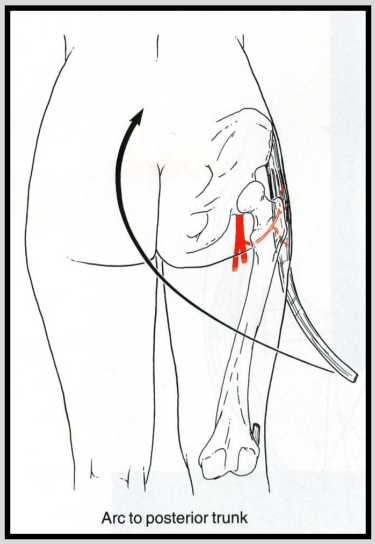
- random fasciocutaneous
- **TFL**
- TFL V-Y
- sensate TFL
- TFL w/ skin island
- gluteus medius & TFL
- vastus lateralis
- gluteus maximus, distally based
- gluteal thigh flap
- expansive gluteus max.

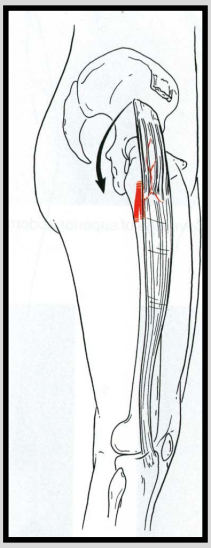
Tensor Fascia Lata (TFL)



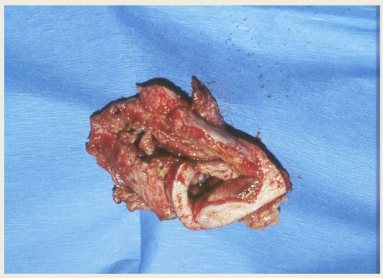
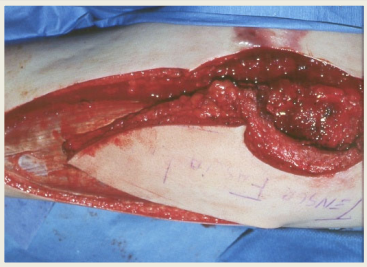


Tensor Fascia Lata (TFL)

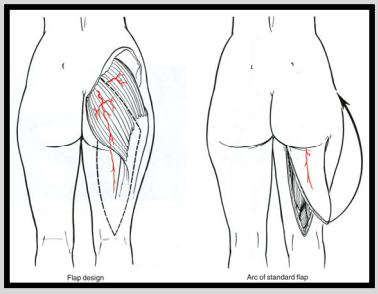




Trochanteric Ulcer


Posterior thigh flap






Fillet (Leg Amputation) Flap

- Hip disarticulation & fillet flap
- High complication rate - OR blood loss, infection, sinus tract, dehiscence, femoral stump rotation
- Hemicorporectomy: For extensive infection, very morbid

Fillet (Leg Amputation) Flap

What does 'FUNCTIONAL RESTORATION' mean?

Functional Restoration
The FIVE CARDINAL QUESTIONS

Can the patient ambulate easily?

Can she/he resume their original work? If not can they find new work suitable to their 'NEW' limb function?

Is the reconstruction robust enough for continued wear and tear?

Are recurrence rates of diabetic foot wounds lowered?

Is the patient able to manage his diabetic target organ disease?

Functional Restoration
The FIVE ESSENTIAL TOOLS

Accurate functional preoperative assessment

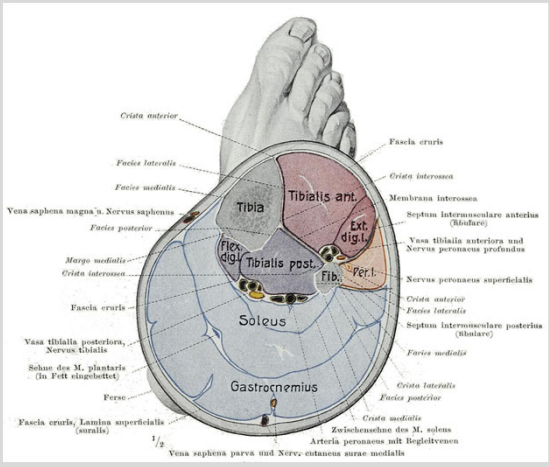
Diabetic (and other comorbids) control

System Structures: *The Iceberg Metaphor*

Well-defined Surgical Plan

Acute Postoperative Management

SURGICAL PLAN: Reconstructive Choices Are A Plenty



11 muscles, abundant adipofascia, three blood vessels, multiple perforators, superficial, deep and venae comitantes, one expendable bone.
Coupled with great orthotics, and the ability to supercharge

Functionalized Reverse Sural Fasciocutaneous Flap

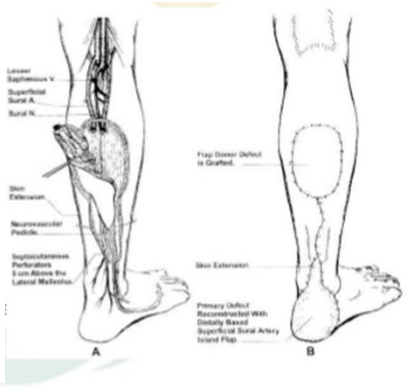
Reverse Sural FascioCutaneous Flap

Sural And
Saphenous Vessels

Vasanervosum and
Vasovasorum may play a role
(controversial)

Deep fascia is included

Great for Achilles Repair
coverage



Funtionalized Reverse Sural Fasciocutaneous Flap

Funtionalized Reverse Sural Fasciocutaneous Flap

Funtionalized Reverse Sural Fasciocutaneous Flap - Transfer

Funtionalized Reverse Sural Fasciocutaneous Flap - Inset



Funtionalized Reverse Sural Fasciocutaneous Flap

Funtionalized Reverse Sural Fasciocutaneous Flap

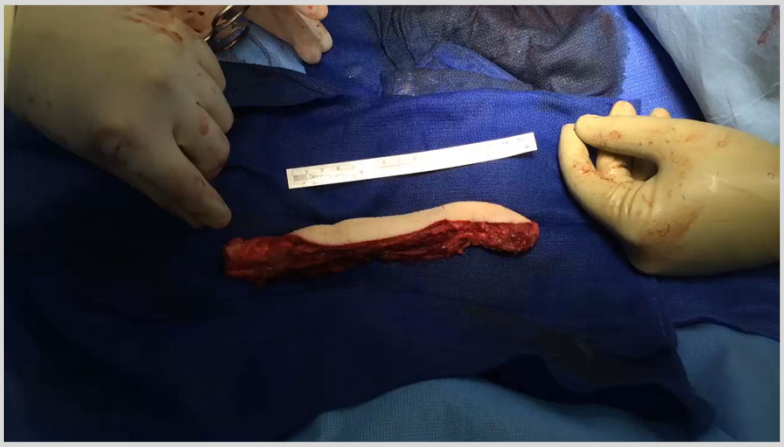
Currently, this patient walks without support, drives, and has resumed her job as a school teacher

Calcaneal reconstruction with microvascular double/single barrel fibula osteocutaneus flap

Background

Calcaneal destruction commonly occurs in diabetics - usually necessitates a below-knee amputation since the central weight-bearing mechanism is lost and reconstructive choices are limited.

Here we present two cases of calcaneal reconstruction, using double/single-barreled fibular osteocutaneous free flaps.



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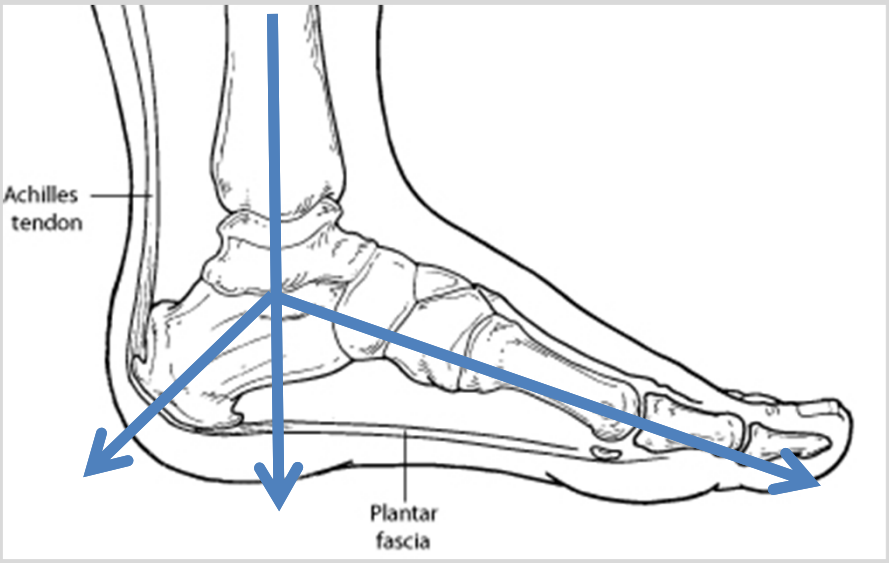
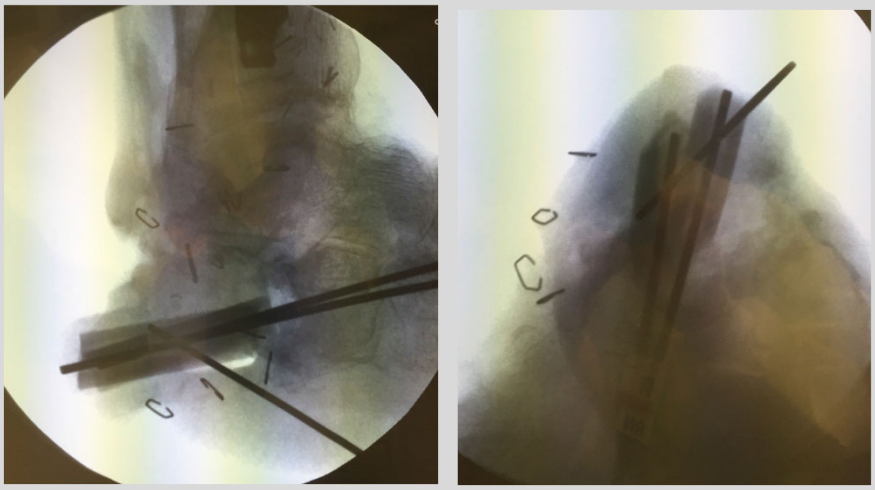
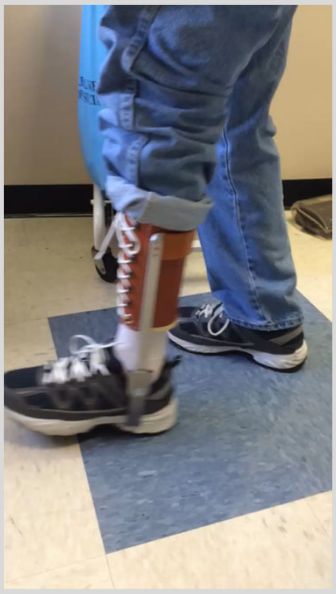

Achilles
tendon
Plantar
fascia

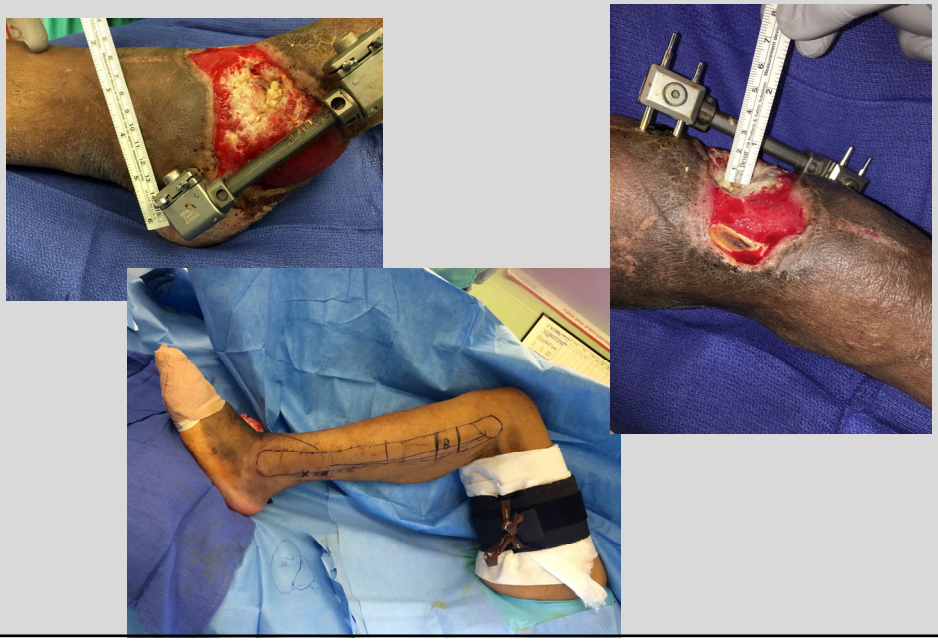




Currently, this patient walks without support and has resumed his job as a supervisor in a tree-cutting agency

Currently, this patient walks without support and has resumed his job as a short-distance truck driver.
He even takes his Harley out, once in a while!

Reverse Peroneus Brevis Flap



Reverse Peroneus Brevis Flap

New OSU wound care center

- Strong commitment by the members of the multidisciplinary team
- Physical space and financial support from the sponsoring institution
- Performance metrics, Quality measures
- Data Management and Support
- Technology
- Partnership with an OutPatient Community
- Actionable Knowledge
- CoMarket Expansion
- Defined Drivers of Care and Patient Volumes