Preventing Foot Problems in Individuals with Diabetes

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Faculty

Ace Anglin, MS, DPM
Lister Hill Health Center
Montgomery, Alabama

Michelle Jeffcoat, MS, RD
SESNI Nutrition, Inc.

Terry Treadwell, MD, FACS
Institute for Advanced Wound Care
Montgomery, Alabama

Program Objectives

- To review at least three foot care guidelines for people with diabetes.
- To identify at least 5 treatment options in caring for wounds of the foot of individuals with diabetes.
- To discuss 2-3 medical nutrition therapies that impact the healing of wounds in people with diabetes.

Burden of Diabetes, U.S. 20.8 Million has Diabetes

- 130,000 amputations a year, (1/30 Sec) 67% due to Diabetes.
- 50% amputation unnecessary.
- 50% amputees undergo second amputation.
- 50% amputees die 2-5 years after amputation.

Foot Clinics Reduce Amputations by 43-69%

Veterans Administration, CDC

Comprehensive Diabetic Foot Exam

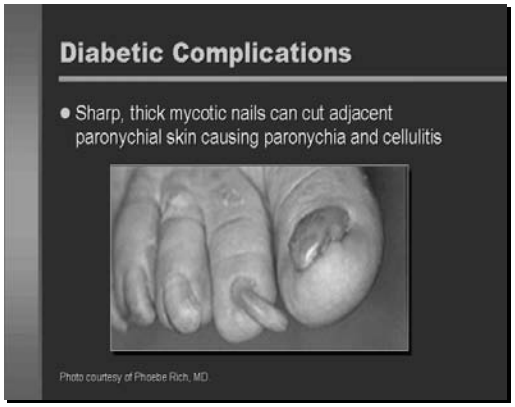
- Determine the presence of diabetes complications.
- Review current history to see if patient is experiencing diabetes complications.
- Perform a foot exam.

Comprehensive Diabetic Foot Exam

- Determine condition of the skin, hair and toenails.
- Measure, draw in and label the patient's skin condition on the foot exam form.
- Look for musculoskeletal deformities.
- Check pedal pulses.
- Perform a sensory exam.

Visual Foot Exam

- Inspect between toes for calluses, blisters, fissures, ulcers and excessively dry or cracked skin.
- Look for signs of decreased vascular skin.
- Assess temperature of the feet: too hot or cold.
- Remove any nail polish. Check for thick, ingrown or fungal nails.



Potential Consequences of Untreated Toenail Onychomycosis

Association between dermatomycosis fo the foot (tinea pedis and/or onychomycosis) and bacterial cellulitis of the leg (erysipelas)

Diabetic Neuropathy

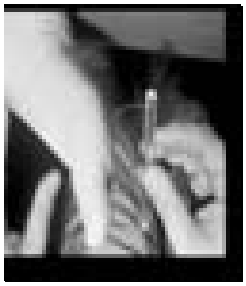
- Damage to the nerve protective coating caused by high blood sugar, which may lead to a loss of pain sensation.
- "The multitude of books is making us ignorant." Voltaire.

Sensory Neuropathy Symptoms

- Burning
- Tingling
- Numbness
- Electrical Shocks
- Aches

Semmes-Weinstein Monofilament

Most cost effective tool for assessment of LOPS



Autonomic Neuropathy

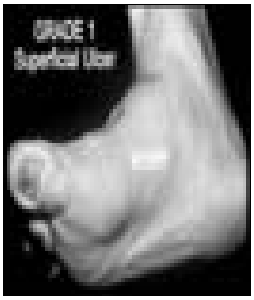
- **Lack of perspiration result in dry skin with cracking.**
- **Cracking creates an entry point for bacteria.**
- **Increased blood flow = bone breakdown; Charcot Joint.**
- **Avoid area callus.**

Bio-Mechanical Exam

Motor Neuropathy Causes Weakness Intrinsic Foot Muscles "Pseudo-Cavus Deformity"

Wagner Grade 0

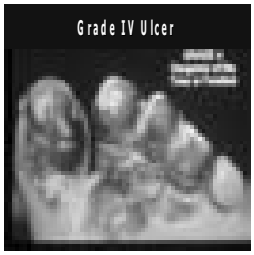
Wagner Grade 1



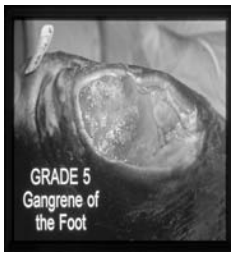
Grade II Ulcer

Wagner Grade III Ulceration Abscess / Osteomyelitis

Wagner Grade IV



Wagner Grade V



Vascular Examination

- Pulses (DP/PT) Popliteal, Femoral
- Capillary fill time <3sec
- Venous fill time <20sec
- Cyanosis, rubor, erythema,
- Edema
- Ischemia, atrophy
- Nail dystrophy
- Absent pedal hair

Diagnosing Ischemia

- Symptoms PAD:
  - Intermittent Claudication
  - Rest pain
  - Night pain
  - Heaviness in legs
  - Ischemic ulceration
- Diagnosing PAD is complicated by Neuropathy
- Signs of PAD:
  - Loss of pulses
  - Loss Subcutaneous fat
  - Loss of hair (feet, legs)
  - Shiny atrophic skin
  - Dystrophic nails
  - Cold feet

Diabetic (Extra Depth Shoes)

Treadsafe (Wal-Mart)
Tom McCann (K-Mart)

Total Contact Casting, Carville, LA

"*Gold Standard*"for Compliant Patients

Multidisciplinary Approach (Team Approach)

Developed by Paul Brand, MD

- Family Medicine
- Internal Medicine
- Nurse, Social Worker
- Cardiology/ Nephrology
- Endocrinologist
- Infectious Disease
- Orthopedic Surgeon
- Podiatric Surgeon
- Vascular Surgeon
- Wound Care Specialist
- Pedorthist
- PT/ OT

Multidisciplinary Approach (Team Approach)

Developed by Paul Brand, MD

"The challenge to any disciplines caring for the diabetic foot is that there can be no turf wars, recognizing instead strengths to achieve success."

Gary Gibbons, MD
Harvard Medical School

Who's at Risk

- **A patient with none of the following is considered low-risk:**
  - **Loss of protective sensation**
  - **Absent pedal pulses**
  - **Foot deformity**
  - **Prior amputation**

Health Services Incorporated Lower Extremity Amputation Prevention (LEAP) Carville LA Approach

- **Provider refer all diabetics for comprehensive foot exam.**
- **Comprehensive exam include vascular, dermatological, biomechanical & neurological testing all diabetics.**

Health Services Incorporated Lower Extremity Amputation Prevention (LEAP) Carville LA Approach

- **Neurological testing on all diabetics to determine risk level.**
- **Foot exam every 2-3 months (high risk patients).**
- **Foot exam every 6-12 months (low risk patients).**

Health Services Incorporated Lower Extremity Amputation Prevention (LEAP) Carville LA Approach

- **Extra depth shoes all low risk patients.**
- **Custom mold shoes or extra depth shoes high risk patient.**
- **Patient education on amputation prevention all diabetics.**
- **Debridement of fungal nails and/or callous.**

"In the 39th year of his reign, King Asa was afflicted with a disease in his feet. Though the disease was severe, even in his illness, he did not seek help from the Lord, but only from the physicians. Then in the 41st year of his reign Asa died and rested with his fathers."

II Chronicles 16:12-14

Compliments of Dr. Wayne Caputo, Belleville, NJ

Treatment of Diabetic Foot Ulcers

- Until 1922 there were essentially NO diabetic foot ulcers.
- Banting, Best, and Macleod discovered insulin in 1922.
- After insulin, treatment was amputation.

Epidemiology of Diabetic Foot Ulcers

- 21 million diabetics in the U.S. today and increasing.
- 15% will develop foot ulcers at some time.
- 6% will require hospitalization for foot problems.

2/3 Major Amputations Due to Diabetic Foot Problems

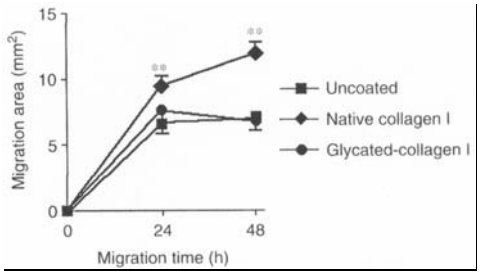
Economic Impact of Diabetic Foot Ulcers

- $300 million per year to treat diabetic foot infections.
- $600 million per year for amputations not counting rehabilitation costs.
- $36,000 to heal a diabetic foot ulcer ($3000 per month).

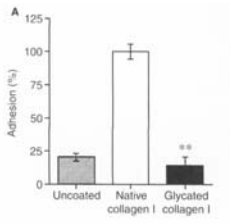
Effect of Hyperglycemia on Cells

- Decreased proliferation and differentiation of keratinocytes.
- Inhibition of fibroblast differentiation.
- Decreased response of cells to growth factors.
- Decreased migration of keratinocytes.

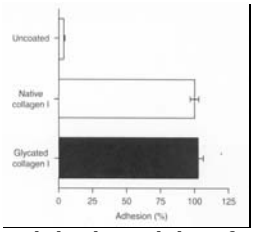
Keratinocyte Migration in the Diabetic



Keratinocyte Migration in the Diabetic



Adhesion of keratinocytes



Biologic activity of keratinocyte integrins

Wound Healing in the Diabetic

Treatment of Diabetic Foot Ulcers With Dermagraft (Clinical Trial)

- Control Patients
- Worsening Hgb A1c – 20.7%
- Decreasing Hgb A1c – 36.3 (p=0.005)

- Dermagraft Treated Patients
- Worsening Hgb A1c – 20.7%
- Decreasing Hgb A1c – 46.7% (p=0.008)

Vascular Disease in Diabetics

- Macrovascular Disease
- Microvascular Disease

Diabetes Mellitus

- Macroangiopathy
  - More diffuse in diabetics
  - Multisegmental involvement
  - Frequently involves collateral vessels
  - More frequently involves infrapopliteal vessels
  - Frequent bilateral involvement (second limb syndrome)

Diabetes Mellitus

Amputation of Opposite Limb After One Amputation

Number of Patients*	1 - 3 years (%)	3-5 years (%)
485	42	56

*** 5 Studies from 1952-1970 adapted: The Diabetes Foot, Ed. Marvin Levin, Lawrence O'Neil p.17, 1988**

Diabetes Mellitus

- Microangiopathy
  - Basement membrane thickening.
  - Mostly seen in muscle, kidney, and retina.
  - Does not occlude vessel lumen.
  - Occurrence in extremity vessels is not more frequent in diabetics.

Wound Environment

- Must be kept moist!
- Air-exposed wounds have increased tissue necrosis and cell death.
- Epithelialization is impaired if eschar or scab remains in place.
- Wet-to-dry dressings do more harm than good!

Necrotic Tissue

- Provides growth medium for bacteria.
- Causes prolonged elevation of pro-inflammatory mediators and cytokines.
- Releases endotoxins which inhibit migration of keratinocytes and fibroblasts into wound.
- Inhibits growth factors.

Debridement of Wound

- Reduces bacterial load of wound.
- Decreases production of inhibitors of growth factors.
- Stimulates the production and release of growth factors from cells.
- Removes unresponsive cells.

Wound Debridement

- Surgically
- Mechanically
- Autolytically
- Enzymatically
- Biosurgically (Maggots)

Ambulation following Amputation

Of patients ambulatory prior to their amputation:

- BKA
  - 16% ambulated independently
  - 19% required walker
  - 65% unable to walk
- AKA
  - 11% ambulated independently
  - 9% required walker
  - 80% unable to walk

Diabetic Foot Infections

- Most cost-effective therapy for non-systemic diabetic foot infection.
  - Surgical debridement.
  - Long course of oral antibiotics.
- Most expensive therapy – immediate amputation.
- Debridement and revascularization, if needed, resulted in long-term salvage of 73% of limbs even those with infection, critical ischemia and/or gangrene.

Neuropathy In The Diabetic Patient

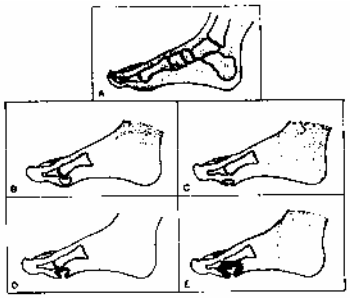
"Neuropathy is the single most important factor leading to ulceration in the diabetic patient."

Bolton AJM. Clinical Presentation and Management of Diabetic Neuropathy and Foot Ulceration. - Diabet Med 1991; 8: S52

Neuropathy in Diabetics

- **Sensory**
- **Autonomic**
- **Motor**

Pathophysiology of Diabetic Foot Ulcers



Diabetes Mellitus infection is always more severe than it appears.

Impaired Resistance to Infection in Diabetics

- **Hyperglycemia (blood sugar > 150).**
- **Peripheral vascular disease.**
- **Neuropathy.**
- **Impaired neutrophil activity (reduced chemotaxis, mobilization, and intracellular destruction of bacteria).**
- **Reduced lymphocyte activity.**

Topical Treatments

- **Neosporin, Bactroban, other topical antibiotics.**
- **Silvadene.**
- **Silverlon, Acticoat, Actisorb, SilverCel and other topical silver products.**

Actions of Silver on Micro-organisms

- Effectively kills >150 different organisms.
- Works by blocking the respiratory enzyme system of bacteria.
- Effect is virtually instantaneously once microbes are reached.
- Microbial resistance has not been reported.

Diabetes Mellitus

- Failure of therapy for infection
  - Undrained pus
  - Incompletely drained pus
  - Inadequate antibiotic coverage
  - Vascular insufficiency

Prepare the Wound for Healing

Wound bed preparation is necessary to correct the cellular imbalances present in chronic wounds allowing the wound to heal or be receptive to our therapy.

Optimal Wound Bed Preparation

- Complete debridement of devitalized and poorly functioning tissue.
- Restoration of bacterial balance.
- Maintenance of optimal moisture balance.

Growth Factor Functions in Wound Healing

- Cell migration to wound site.
- New blood vessel formation.
- Extracellular matrix formation.
- Fibroblast proliferation.
- Protease production.
- Epithelialization.
- Wound remodeling.

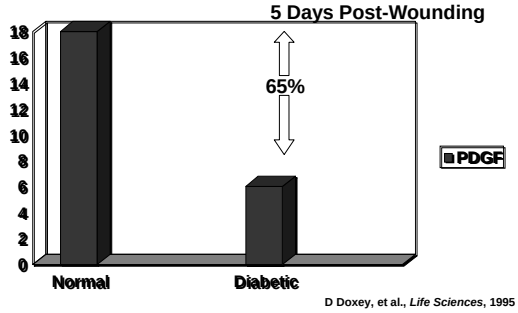
Growth Factors in Chronic Wounds

- Platelet-derived growth factor (PDGF).
- Fibroblast growth factor (FGF).
- Transforming growth factor (TGF-B).
- Epidermal growth factor (EGF).
- Insulin-like growth factor (IGF).
- Vascular endothelial growth factor (VEGF).
- More “to be announced”.

Deficient Growth Factors in Diabetic Ulcers

- Platelet derived growth factor (PDGF).
- Transforming growth factor beta (TGF-B).
- Vascular endothelial growth factor (VEGF).
- Insulin-like growth factor (IGF-1).
- Keratinocyte growth factor (KGF).

PDGF in Diabetic Wounds Compared to Non-diabetic Wounds



D Doxey, et al., *Life Sciences*, 1995

Topically Applied Growth Factors Used in Treatment of Chronic Wounds

- Platelet-derived growth factor (PDGF).
- Fibroblast growth factor (FGF).
- Transforming growth factor (TGF-B).
- Epidermal growth factor (EGF).
- Insulin-like growth factor (IGF).
- Vascular endothelial growth factor (VEGF).
- Keratinocyte growth factor-2.
- Granulocyte macrophage colony stimulating factor.

Growth Factor Therapy

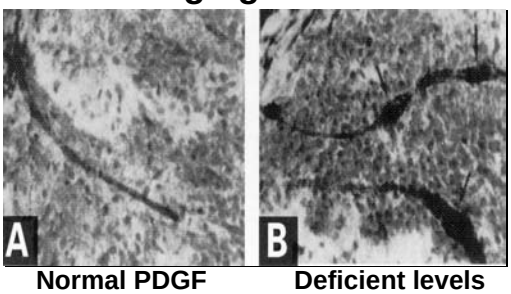
- Rh-PDGF (Regranex)—only FDA approved growth factor therapy for diabetic foot ulcers.
- Activates endothelial cells and fibroblasts.
- Stimulates angiogenesis.
- Stabilizes new vessels.

Effect of PDGF on Angiongenesis

Green - CD31 --- Endothelial cells

Red - Desmin --- Pericytes / smooth muscle cells

Effect of PDGF on Angiogenesis

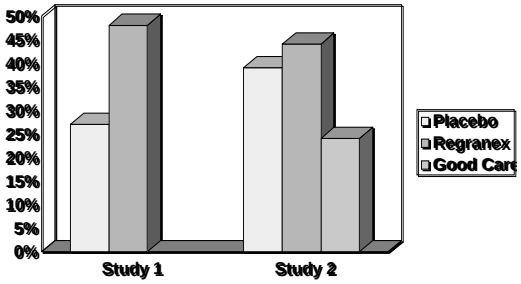


Normal PDGF levels

Deficient levels of PEGF

Diabetic Foot Ulcer Healing with Regranex

(12 weeks of therapy)



Limited Effect of Topical Growth Factor Therapy

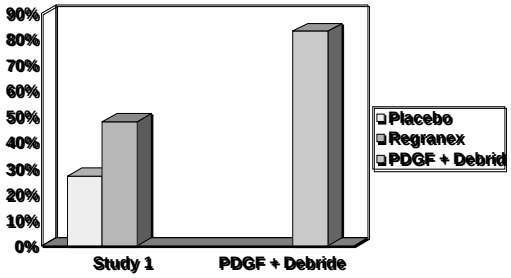
- **Rapid degradation of growth factors due to excess MMPs.** (1)
- **Binding of growth factors in wound base by macromolecules.** (2)
- **Insufficient penetration of growth factors into granulation tissue.** (3)

Effect of Debridement on Diabetic Foot Ulcers

Exposes receptors in tissue so that PDFG can get to them

Wound Healing with Regranex

(12 weeks of therapy)



Need to Protect Regranex and other Growth Factors

- **MMPs are increased in all tissues of diabetic patients.**
- **MMPs are 116 times higher in diabetic foot wounds than in non-diabetic wounds.**
- **Other proteases are 5 – 10 times higher in diabetic foot wounds that in non-diabetic wounds.**

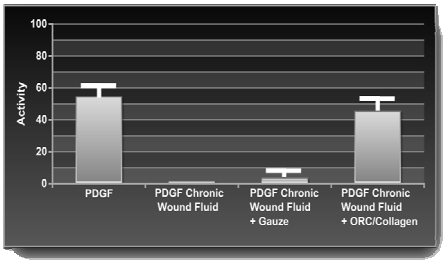
Need to Protect Regranex and Other Growth Factors

- **Inhibiting proteases increases wound angiogenesis.**
- **Can modulate proteases with doxycycline.**
- **Can be done with protease modulating matrix, Promogran.**

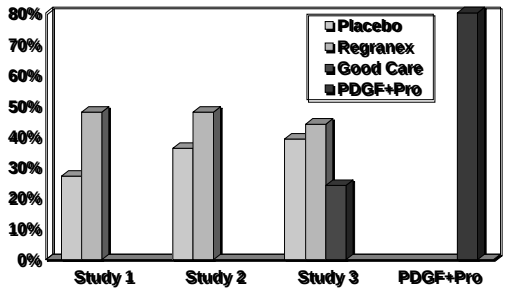
Promogran

- Contains oxidized regenerated cellulose and collagen.
- Protects growth factors by inactivating proteases which are elevated in chronic wound fluid.*
- Decreases production of additional proteases by removing reactive oxygen species (ROS) molecules.

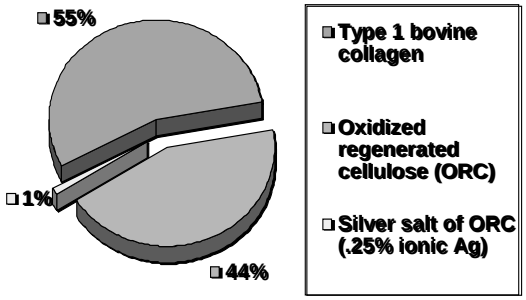
Protection of PDGF in Chronic Wound Fluid by ORC/Collagen



Wound Healing with Regranex
(12 weeks of therapy)



PRISMA Matrix Components



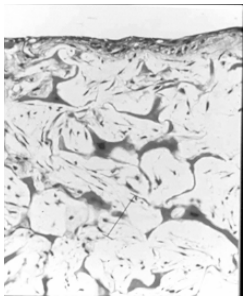
Tissue Engineered Skin Products

- Provide cells responsive to the wound environment.
- Provide a "living factory" producing numerous growth factors, cytokines, and matrix proteins.

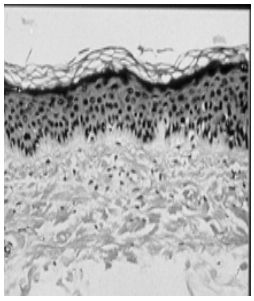
Composite Cultured Skin "OrCel"

OrCel vs Human Skin

Orcel



Human Skin

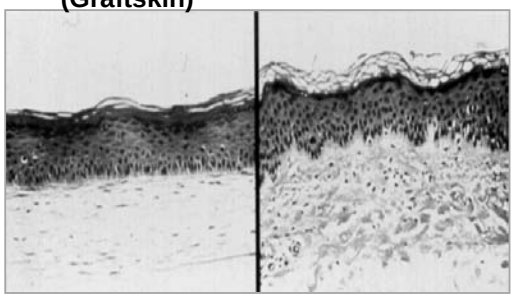


APLIGRAF

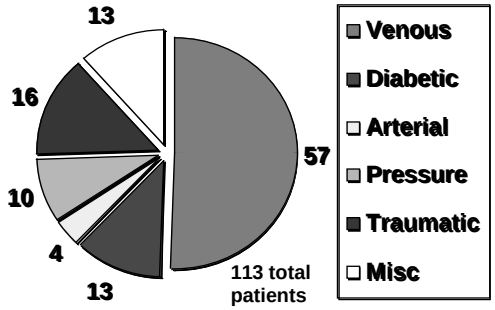
Histologic Comparison

APLIGRAF®
(Graftskin)

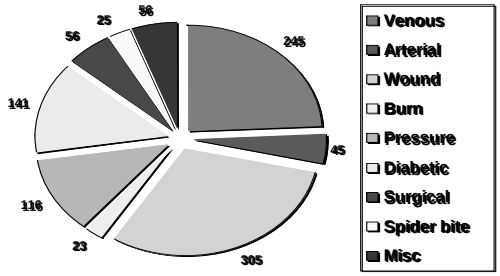
Human Skin



Patients Treated with Bilaydered Cellular Matrix (OrCel)



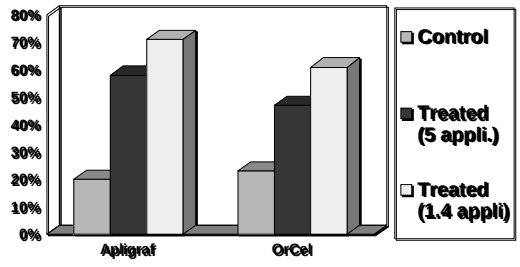
Patients Treated with Bilayered Skin Substitute (Apligraf)



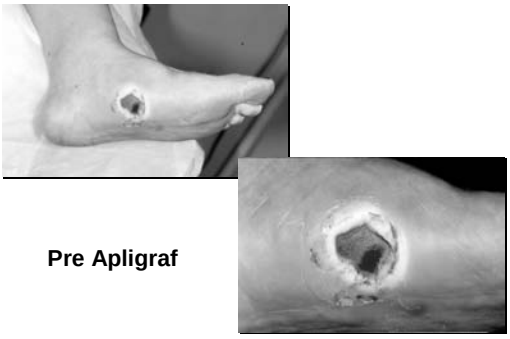
1,011 total patients

Apligraf and OrCel in Diabetic Foot Ulcers

(Patients healed after 12 weeks)



Diabetic Foot Ulcer



Pre Apligraf

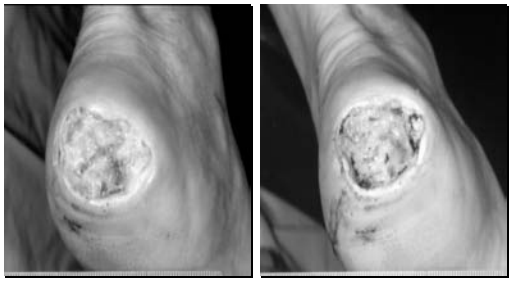
Diabetic Foot Ulcer

3 Months Post Apligraf

Diabetic Heel Ulcer

Heel ulcer before debridement

Heel ulcer after debridement



Diabetic Heel Ulcer

Application of Apligraf

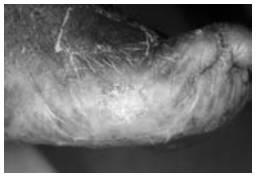
Diabetic Heel Ulcer

16 Weeks Post Apligraf

Diabetic Foot Ulcer

Exposed Bone

Exposed bone in diabetic foot ulcer post debridement



24 weeks post Apligraf

Diabetic Foot Ulcer

Diabetic ulcer post debridement

8 weeks post Apligraf

Diabetic Foot Ulcer

32 Weeks Post Apligraf

If the "fuel" for healing is not provided, the wound will not heal.

Wounds You May Meet

- Venous
- Ischaemic
- Pressure
- Neuropathic
- Mixed

Factors Affecting Wound Healing

- Age
- Nutrition
- Oxygenation
- Smoking
- Drug therapy
- Diabetes mellitus

Conditions Needed for Healing

- Positive well being
- Adequate nutrition
  - Protein, calories, and fluid
- Adequate vascular supply/drainage
- Clean wound
- Minimal trauma
- Moist environment
- Thermal regulation

The Forgotten Factor: Nutritional Status

- State-of-the art wound care may not result in healing.
- Nutritional status is often the overlooked dimension of patient care.
- Screening and assessment forms developed.

Nutrition: Back to Basics

- Nutrition - The science of food and its nutrients and their relationship to human growth, maintenance, and health.
- Nutritional imbalance results when body requirements exceed nutritient intake.
- Six classes of nutrients
  - Carbohydrate, protein, fat,
  - Vitamins, minerals, water

Protein: The Nutritional Cornerstone

- Protein - Aid in reducing inflammation, assists in tissue repair and growth.
- Edema - Inadequate protein intake will result in altered oncotic pressure and diminished oxygen diffusions to tissues making soft tissues more susceptible for breakdown.

Albumin

- Serum albumin concentrations are reliable indicators of patient nutritional status and should be routinely monitored.
- Need for albumin increases as the catabolism of protein continues to accelerate in response to skin injury.
- A plasma protein that decreases during bodily trauma.

Inadequate Protein Intake Consequences

- Increased risk for wounds.
- Prolonged inflammatory response.
- Decreased fibroblast proliferations.
- Decreased collage angiogenesis.
- Increased incidence of infection.

Nutritional Healing from the Inside Out

- Fluids - Aid in hydration of wound site and oxygen perfusion.
  - The body is ~60% water. ↑ Muscle mass = ↑ water mass, as muscle holds more water.
  - Example: A 120# female has ~ 72# of water.

Nutritional Healing from the Inside Out

- Calories - Provide necessary energy of normal tissue defense and wound repair.
- Vitamin A - Required for inflammatory response.
- B vitamins - Required for cross-linking of collagen fibers in rebuilding tissue.

Nutritional Healing from the Inside Out

- Vitamin C - May increase the activation of leukocytes and macrophages to the wound site. Essential co-factor for collagen synthesis; maintains integrity of capillary wall for angiogenesis.

Nutritional Healing from the Inside Out

- Zinc - Essential cofactor for formation of collagen and protein synthesis
- Copper - Required for cross-linking of collagen fibers in rebuilding tissue.

Wounds Healing and Diabetes

- Over time, uncontrolled blood sugar can cause heart and kidney problem, blindness, and most commonly the loss of a foot or leg.

Wounds Healing and Diabetes

- Preventing foot ulcers is the most important step in preventing amputations.
  - Risk factors for foot ulcers include:
    - Loss of feeling in feet.
    - Pain in legs while walking.
    - Changes in shape of your feet.
    - Previous foot ulcers.

Action Steps to Prevent Foot Ulcers

- Self-exam feet daily along with a complete foot exam yearly.
- Be active everyday (Walk-dance-swim). Exercise will help control blood sugar and weight.
- Eat a healthy diet: smaller portions, less salt, fat, and sugar.

Action Steps to Prevent Foot Ulcers

- Check blood sugar daily and stay in control.
- Take medication as ordered by your doctor.

Nutritional Requirements Healthy & Wound Care Adults

Nutrient	Healthy	Wound Care
Calories	20-30/kg	35-45/kg body wt.
Protein	0.8-1.0 g/kg	1.25-2.0 g/kg
Vitamin C	60 mg	500 mg BID
Zinc	12-15 mg	220 mg
Fluids	25-30 ml/kg	30-35 mL/kg

Micronutrients Needed:

Micro Nutrient	Function
Vitamin A	Stimulant for onset of wound healing process.
Vitamin C	Necessary for collagen synthesis
Zinc	Cofactor for collagen and other wound protein synthesis
Copper	Cofactor for connective tissue production. Collagen cross linking
Manganese	Collagen and ground substance synthesis

Micronutrients Needed:

Micro Nutrient	Function
Arginine	Precursor to collagen and polyamines and enhances Immunity. Positive influence on insulin-like growth factor, a hormone that promotes wounds healing
Glutamine	Primary fuel for fibroblasts and preserves lean cell mass. Anti-catabolic, anabolic properties and stimulates release of HGH
Hydroxy-methylbutyrate	Helps protect muscle from stress-related damage. Can support a weakened immune system. Helps decrease muscle protein breakdown

Case Study: 75 Year Old Male

- Diagnosis: CVA with hemiplegia; Type 2 Diabetes; Stage IV pressure ulcer; dysphagia.
- Nutrition screen: Risk factors include:
  - Elderly, pressure ulcer, diabetes, poor response to current wound treatment after 3 weeks; unintentional weight loss; functional limitations - chewing, swallowing, mobility, dexterity.

Case Study: Nutritional Assessment

- Anthropometric measures
  - Height: 6'3" or 75"
  - Weight: Actual - 190lb / 2.2 = 86.4 kg
  - Ideal: 196 lb/2.2 = 89.1 kg
  - Usual 200/2.2 = 90.9 kg
  - Finding: unintentional weight loss of 5% over 4 weeks

Case Study: Nutritional Assessment

- 24-hour dietary recall
  - Difficulty swallowing, severe coughing.
  - Estimated intake: 5 g protein, <100 calories, 180 ml water.

Case Study: Nutritional Assessment

- Estimated daily requirements
  - Calories: 35 x 86.4 kg = 3031 calories per day.
  - Protein: 1.5 x 86.4 kg = 130 grams per day.
  - Fluid: 32 mL x 86.4 = 2765 mL per day.

Case Study: Nutritional Assessment

- Lab Results
  - Serum albumin = 3.3
  - Total lymphocyte = 1600
  - Finding: malnutrition

Case Study: Nutritional Assessment

- Recommendations
  - Notify physician of nutritional assessment findings, lab results, and slow wound healing.
  - Because of the patient's dysphagia and risk of aspiration, enteral nutrition therapy is recommended: Category I (semisynthetic isotonic) medical nutrition therapy via PEG tube.

Case Study: Nutritional Assessment

- Recommendations
  - Goal: 2400 calories per day (~10 cans per day).
  - Goal rate = 100 mL/hr x 24 hours.
  - Continue wound healing protocol and assessments.
  - Initiate patient/caregiver teaching plan.

Summary

- Adequate nutrition intake is essential for wound healing.
- Good diabetes control is important for proper wound healing.
- A registered dietitian can play a vital role in wound care by helping to assess and estimate nutrition requirements needed for wound healing.

For a complete list of upcoming programs, go to the

AIabama **P**ublic **H**ealth **T**raining **N**etwork web site at

www.adph.org/alphtn

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&
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Alabama Department of Public Health
(334) 206-5618
alphtn@adph.state.al.us
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