Amputee Rehabilitation

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BELIEVE in a way back
Magee Rehabilitation Hospital

KINETIC PROSTHETICS
GET MOVING

Objectives

- Participants will be able to identify common causes for upper and lower extremity amputation and demonstrate an understanding of the medical complications that require management throughout both the pre and post-prosthetic phases of rehabilitation.

- Participants will be able to identify each phase of rehabilitation for the lower extremity amputee and list several interdisciplinary goals related to each phase.

- Participants will be able to identify basic upper and lower extremity prosthetic componentry and recognize more advanced options for prosthetic componentry.

Objectives

- Participants will demonstrate an understanding of coding and reimbursement issues related to upper and lower extremity prosthetic prescription.

- Participants will be able to identify several resources available to the individual with upper and lower extremity amputation.

Course Outline

- Demographics & Etiology
- Terminology
- Surgical Considerations
- Phases of Amputee Rehabilitation
- Amputee Education
- Current Prosthetic Management
- Case Study
- Amputee Resources

Demographics & Etiology

Demographics & Etiology

Currently, there are an estimated 2-3 million people living with limb loss in the United States

Lower limb amputations performed annually in the USA

1989: 127,000 per year

1999: 185,000 per year

The number of people living with limb loss in the USA is expected to double by 2050 due to growing rates of diabetes and vascular disease.

Demographics & Etiology Lower Extremity Amputation

Main Causes of Lower Extremity Amputation

1. Disease
2. Trauma
3. Cancer
4. Congenital

Demographics & Etiology
Lower Extremity Amputation

#1 Cause of Amputations → Disease

Diabetes Mellitus (DM)

Peripheral Vascular Disease (PVD)

Chronic Venous Insufficiency (CVI)

Diabetes

- According to the Centers for Disease Control and Prevention, in 2009 there were 68,000 amputations due to complications from diabetes
- Of persons with diabetes who have a lower extremity amputation, up to 55% will require amputation of the second leg within 2-3 years.
- 25% mortality 1 year after amputation.
- 50% mortality 3 years after amputation.

Demographics & Etiology Lower Extremity Amputation

#2 Cause of Amputations → Trauma

Leading causes of trauma:

40.1% - Machinery

27.8% - Powered tools and appliances

8.5% - Firearms

8% - Motor Vehicle Crashes

Demographics & Etiology
Upper Extremity Amputation

Incidence

- Less than 5% of all amputations are UE amputations

Etiology

- 90% Trauma
- 5% Congenital
- 5% Other

Demographics & Etiology

- In 2009, hospital costs associated with amputation totaled more than $8.3 billion.

- The lifetime healthcare cost for people with a unilateral lower-limb amputation is estimated to be more than $500,000.

- For people with a unilateral lower-limb amputation, the two-year healthcare costs is estimated to be $91,106.

Terminology

Terminology

Amputation

Trans:

- When the amputation is across the axis of a long bone

Disarticulation:

- When the amputation is between long bones, which anatomically is through the center of a joint

Partial:

- Amputations of the foot distal to the ankle joint and of the hand distal to the wrist joint

Terminology

Sound Limb

- The intact “healthy” limb

Residual Limb

- The extremity of a limb left after amputation, “Stump”

International Organization for Standardization

ISO Standard Nomenclature for the Lower Limb

- Ankle (Syme) Disarticulation
- Transtibial Amputation
- Knee Disarticulation
- Transfemoral Amputation
- Hip Disarticulation
- Transpelvic Amputation

International Organization for Standardization

ISO Standard Nomenclature for the Upper Limb

- Wrist Disarticulation
- Transradial Amputation
- Elbow Disarticulation
- Transhumeral Amputation
- Shoulder Disarticulation
- Forequarter Amputation

Through Shoulder (Shoulder Disarticulation) / Forequarter 1.5%

Above Elbow (Transhumeral) 4%

Through Elbow (Elbow Disarticulation) 0.5%

Below Elbow (Transradial) 8%

Hand amputations 2%

Through Hip (Hip Disarticulation) and hemipelvectomy 2%

Above Knee (Transfemoral) 31%

Through Knee (Knee Disarticulation) 1%

Below Knee (Transtibial) 47%

Through Ankle (Symes or Ankle Disarticulation) 3%

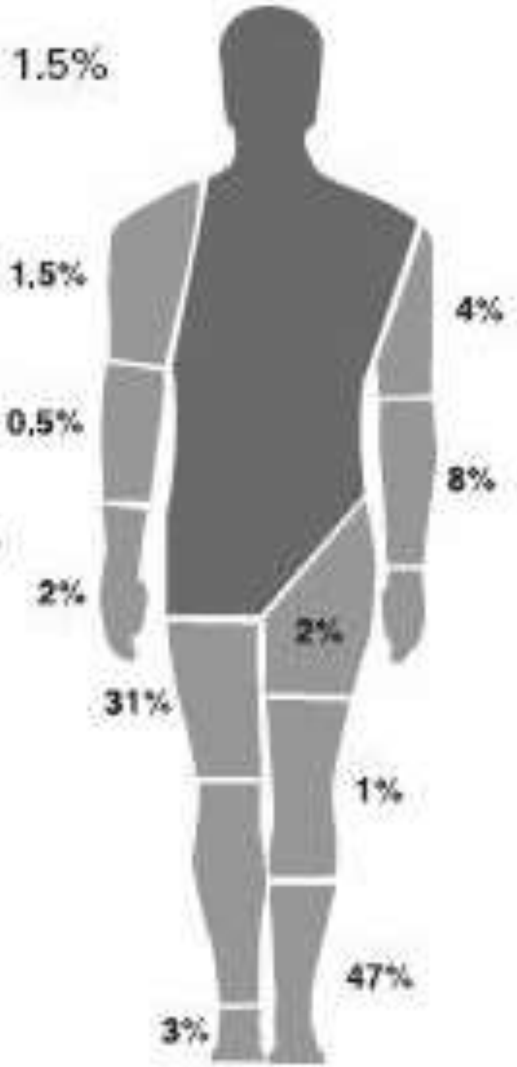


Fig. 1.1

Partial Foot Amputation

Toe Amputation

- Excision of any part of one or more of the toes
- Common – Accounts for 24% of DM amputations

Toe Disarticulation

- At metatarsophalangeal joint
- May result in biomechanical deficiencies:
- Amputation of Great Toe
- 2nd Digit Amputation

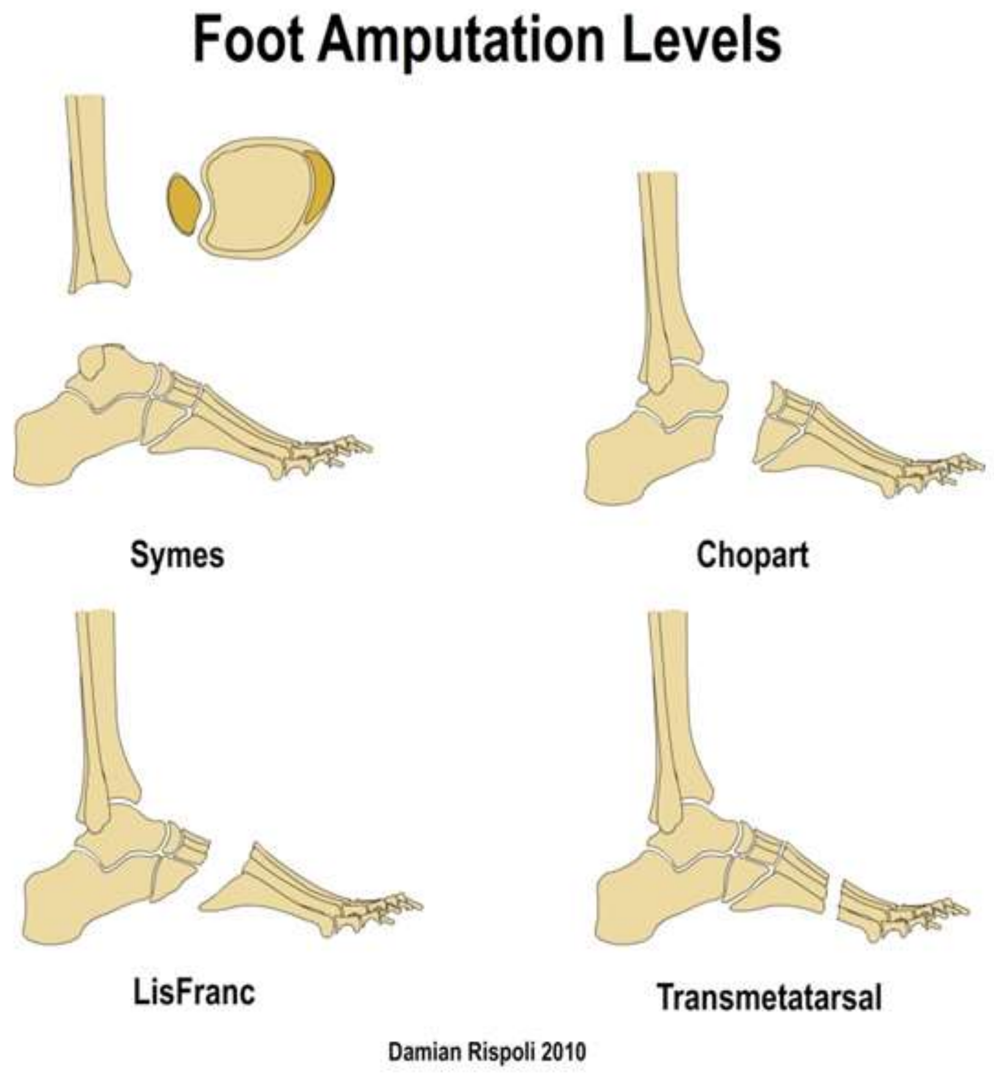


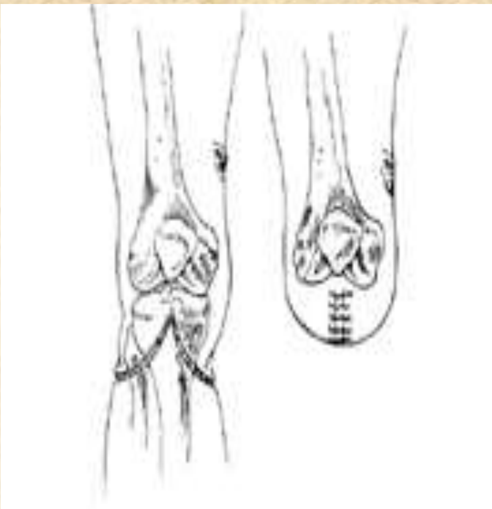
Figure 3. Foot amputation levels.

Below Knee Amputation→ Transtibial Amputation

- Most Common LE Amputation…47%
- Amputation through the tibia (and fibula)
- Fibula is usually transected 1-2 cm shorter than tibia to avoid distal fibula pain

Knee Disarticulation

- Amputation through the knee joint
- Offers good weight distribution ability and retains a long, powerful femoral lever arm
- Yields a non-cosmetic socket due to need for external joint mechanism



Supracondylar Amputation

- Patella is left for better end weight-bearing
- Area between end of femur and patella may delay healing

Above Knee Amputation → Transfemoral Amputation

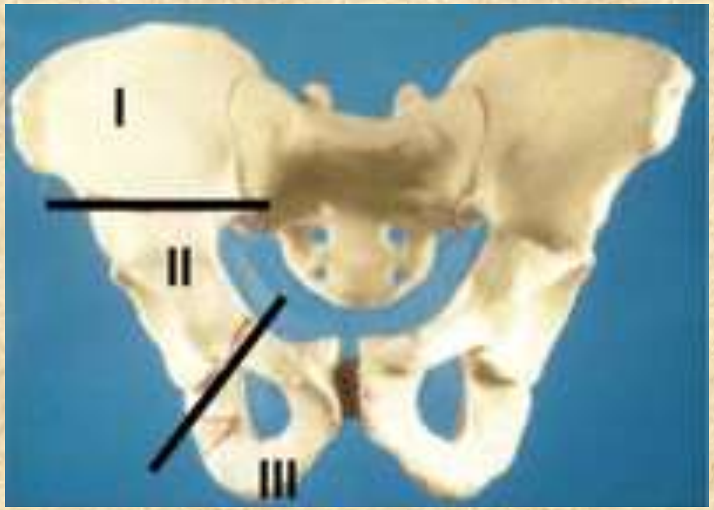
- Common…31%
- Amputation through the femur

Hip Disarticulation

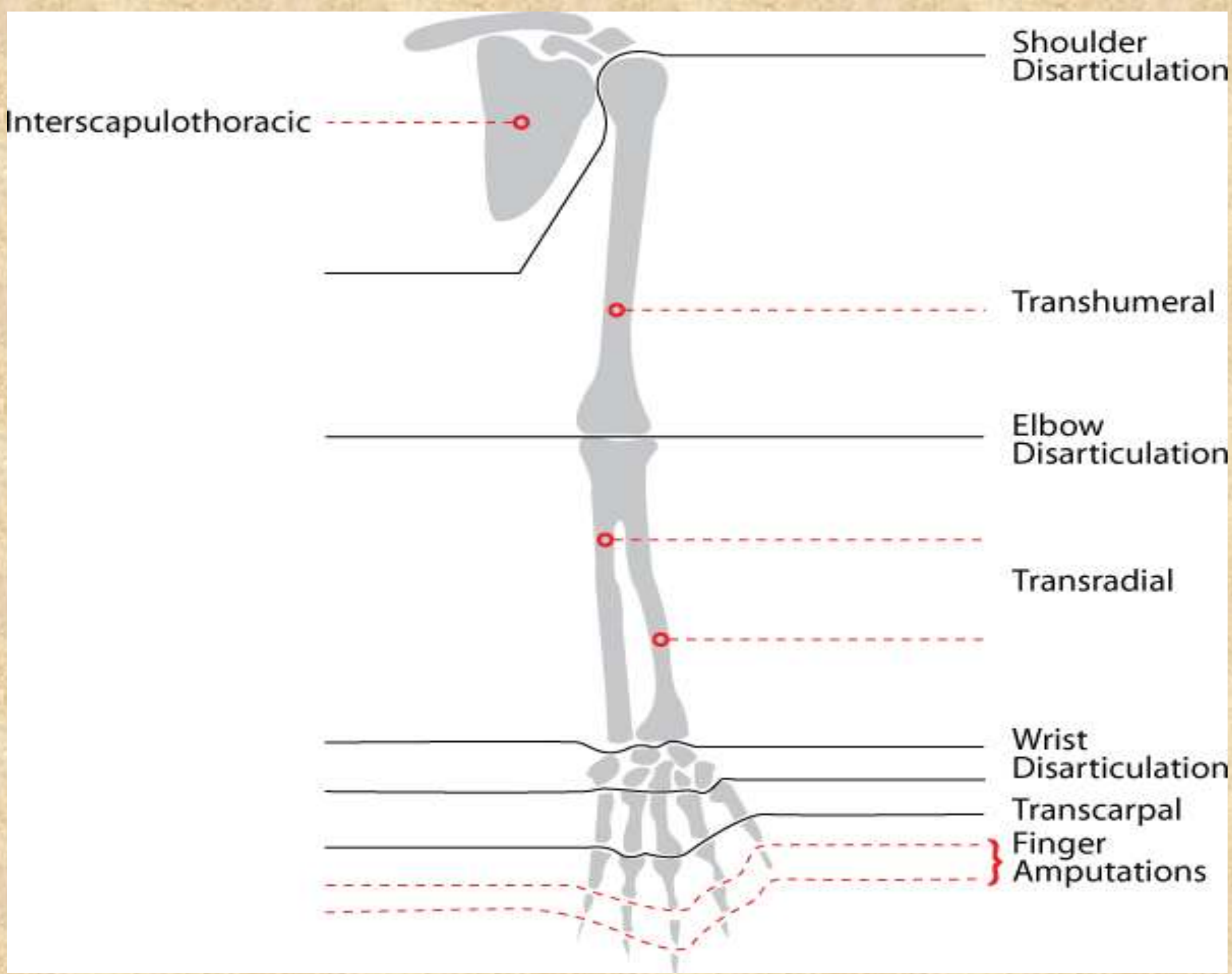
- Uncommon
- Involves loss of all of the femur
- Usually done in cases of malignant tumors, extensive gangrene, massive trauma, or advanced infection

Hemipelvectomy → Transpelvic Amputation

- Uncommon
- Involves loss of any part of the ilium, ischium, and pubis
- Usually done in cases of malignant tumors, extensive gangrene, massive trauma, or advanced infection

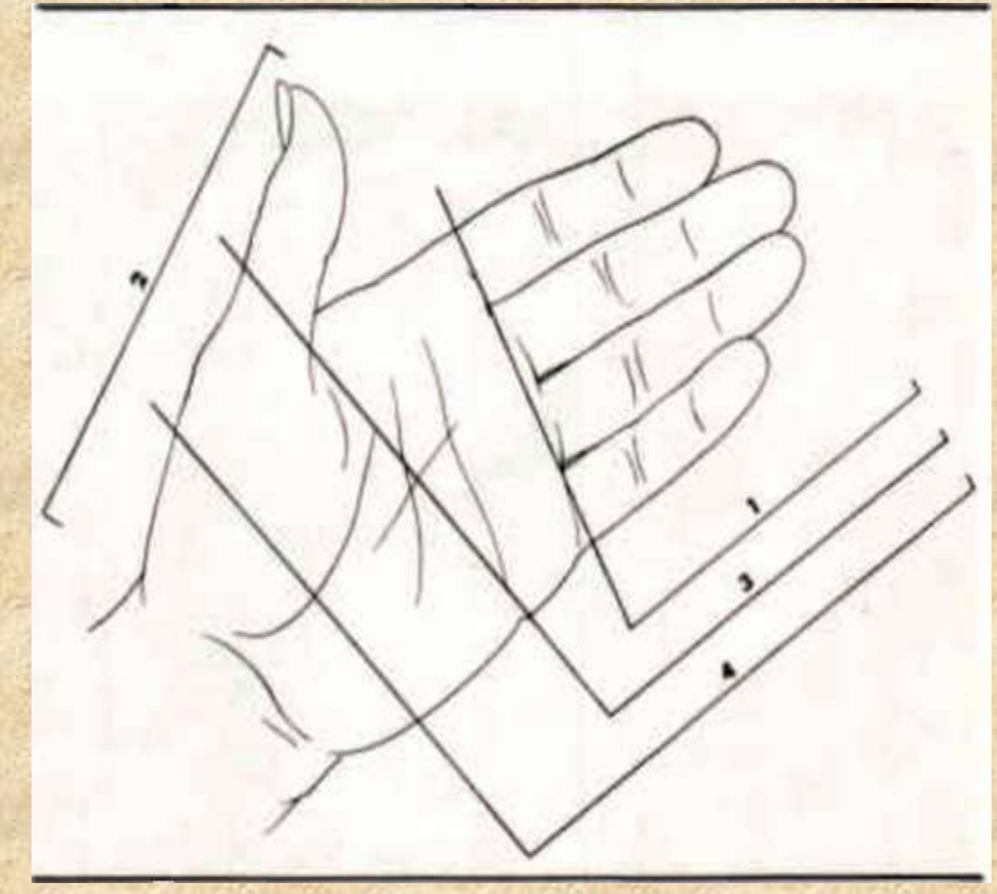


Upper Extremity Amputations



Upper Extremity Amputations

- Partial Hand Amputation



Levels of partial hand amputation:

1. Transphalangeal; thumb spared.

2. Thenar partial or complete.

3. Transmetacarpal, distal; thumb spared or involved.

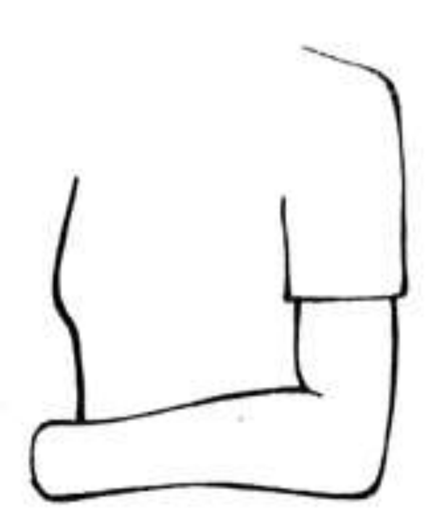
4. Transmetacarpal, proximal; thumb spared or involved.

Upper Extremity Amputations

- Partial Hand Amputation

Upper Extremity Amputations

- Wrist Disarticulation
  - Amputation through the wrist joint

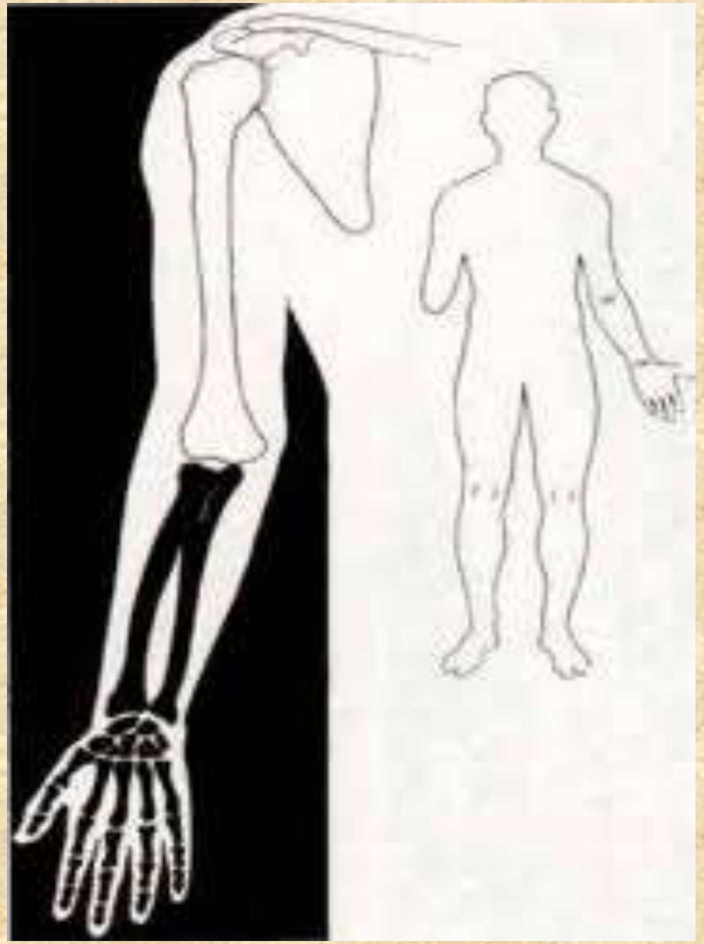


Upper Extremity Amputations

- Transradial Amputation
  - Amputation through the radius (and ulna)

Upper Extremity Amputations

- Elbow Disarticulation
  - Amputation through the elbow joint



Upper Extremity Amputations

- Transhumeral Amputation

-Amputation through the humerus

Upper Extremity Amputations

- Shoulder Disarticulation

Surgical Considerations

Surgical Considerations

- Ultimate Question:

Amputate?
or
Limb Salvage?

Fracture Stabilization

Tissue Transfers

Chemotherapy

Vascular Reconstruction

“The notion that limb salvage needs to be obtained in all patients at all costs may often lead to the triumph of technique and technology over reason.”

Surgical Considerations

- Amputation is a reconstructive operation
- Pre-operative planning is essential
- Surgical Objectives:
  - Remove all diseased and damaged anatomy
  - Construct a residual limb <u>that functions</u>
  - Preserve as much <u>functional</u> length as possible

Surgical Considerations

Amputations should be performed at the most distal site compatible with wound healing to achieve the optimal potential for ambulation

Lowest Palpable Pulse

Skin Temperature

Bleeding at Surgery

Surgical Considerations

The residual limb should have sufficient soft-tissue coverage to resist the shear forces involved in prosthetic ambulation

Surgical Considerations

- Plan flaps (for mobile and sensate skin)
- Bevel bone ends
- No periosteal stripping
- Balance muscle forces
- Perform Myodesis
- Perform proximal nerve resection – stretch & severe nerves, decreases incidence of neuromas

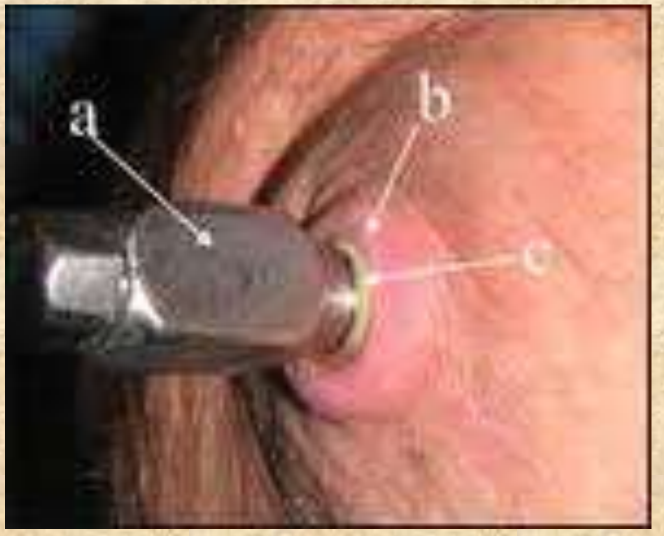
Surgical Considerations

- Bevel bone ends

Surgical Considerations

Something New….

- Osseointegration
  - Metal titanium permanently incorporated into the bone



Phases of Amputee Rehabilitation

Who is on the TEAM?

- PATIENT
- Patient’s Personal Support System/Caregivers
- MD
- PT
- Prosthetist
- OT
- Nursing
- Psychology
- Vocational Rehabilitation
- Dietician
- Case Management
- Outside Support Systems

What are the responsibilities of the team?

- Evaluate the patient
- Ensure medical stability of the patient
- Prepare the patient for life as an amputee
- Prescribe prosthesis (if appropriate)
- Fabricate prosthesis
- Evaluate fit of prosthesis
- Educate the patient on use of and care of prosthesis
- Follow-Up care for the patient
    - for maintenance, problems, changing status, need for different equipment

Pre-Amputation Phase

- Primary Goal: Education & Prevention!
- Educate:
  - Explore patient's expectations
  - Reinforce realistic expectations
  - Explain sequence of upcoming events
  - Answer any questions

This is the "ideal" time to get a patient who is going to have an amputation!

Immediate Post Surgical Phase

- Goals
  - Ensure medical stability
  - Promote wound healing
  - Reduce edema
  - Prevent loss of motion
  - Increase UE and LE strength
  - Promote mobility and self-care
  - Promote sound limb care
  - Assist with limb loss adjustment
  - EDUCATE, EDUCATE, EDUCATE!
- Where?
  - Acute Care Hospital

Pre-Prosthetic Training Phase

- Goals
  - Continue healing without complications
  - Continue to manage edema
  - Maintain ROM
  - Continue with increasing UE and LE strength
  - Continue with promoting mobility and self-care
  - Promote sound limb care
  - Assist with limb loss adjustment
  - Order prosthesis (if/when appropriate)
  - EDUCATE, EDUCATE, EDUCATE!

Pre-Prosthetic Training Phase

- Where?
  - Acute Care Hospital, In-Patient Rehab, SNF, Home, Outpatient Rehab
  - Post-Amputation Placement
    - Inpatient Rehabilitation – 36%
    - Skilled Nursing Facility – 35%
    - Outpatient Rehabilitation – 27%
    - Home – 2%

Prosthetic Training Phase

- Goals
  - Continue to manage edema
  - Continue with increasing UE and LE strength
  - Continue with promoting mobility and self-care
  - Incorporate use of prosthesis into all activities
  - Maintain skin integrity
  - Promote sound limb care
  - Assist with limb loss adjustment
  - EDUCATE, EDUCATE, EDUCATE!
- Where?
  - In-Patient Rehab, SNF, Home, Out-Patient Rehab

Lifetime Follow-Up

- Recommend regularly scheduled follow-ups with MD who specializes in prosthetics
  - Physiatry – the branch of medicine that deals with the prevention, diagnosis, and treatment of disease or injury, and the rehabilitation from resultant impairments and disabilities, using physical and sometimes pharmaceutical agents.

Amputee Education

Education

- Post-Op Complications
- Sound Limb Care
- Residual Limb Care
  - Pain
  - Edema Management
  - Contracture Prevention/Positioning
  - Strengthening/HEP Development
- Prosthetics
    - Prosthetic Components & Prescription
    - Skin Integrity
    - Sock Management

Post-Op Complications

- Pulmonary Complications
- DVT
- Delayed Wound Healing and Infection
- Contractures
- Physical Deconditioning
- Pain

Sound Limb Care

- Daily Skin Inspection
  - Systematic Inspections
  - Attention to bony prominences
  - Attention to problem areas
  - Ensure patient can see feet

- Inspect the Foot
  - Toe Nails: Broken, Cracked, Sharp Nails
  - Broken Skin: Between Toes, Sides of Feet, Top and Ends of Toes and Soles of Foot
  - Soft Toe Corns: Check Between Toes
  - Callus: Check for Cracks
  - Drainage: Check Socks
  - Odor: Unusual Odors from Any Part of Foot

Sound Limb Care

- Skin Cleansing
  - Routine on a daily basis, And if soiled or after exercise
  - Avoid hot water
  - Use mild cleaning agents, Avoid perfumed soaps

- Minimize Negative Environments
  - Low humidity → Dry skin
  - High humidity → Damp skin
  - Avoid extreme hot and cold surfaces without proper footwear
  - Minimize skin exposure to excessive moisture (Perspiration, Wet weather, Wound drainage, Incontinence) however maintain adequate moisture (Reduce friction, Hydrate skin, Maintains tissue elasticity)

Sound Limb Care

- Footwear
  - NEVER walk barefoot
  - Dry Cotton or Wool Socks, White Preferred
  - Extra Depth or Custom Shoes…Need support!
  - Inspect shoes for tacks, nails, rocks

- Medicare Therapeutic Shoe Bill of 1993
  - Yearly financial support for patients with DM
  - 1 pair of appropriately inlay-depth shoes and 3 custom foot orthoses (inserts) OR 1 pair of custom-molded shoes (including inserts) and 2 additional pair of inserts

Residual Limb Care

Goal:

To prepare the residual limb for prosthetic usage, while providing protection to the incision and limb and maintaining an optimal environment for wound healing.

Residual Limb Care

- Pain
- Edema Management/Limb Shaping
- Contracture Prevention/Positioning
- Strengthening/HEP Development

Pain

85% of all amputees experience phantom sensation, phantom pain or residual limb pain.

Pain

- Phantom Sensation
  - Sensations perceived as originating from the amputated limb
- Phantom Pain
  - Sensations of pain perceived as originating from the amputated limb
- Residual Limb Pain
  - Pain originating from the intact extremity

Pain

Phantom Sensation	Phantom Pain	Residual Limb Pain
Touch Pressure Cold Wetness Itching Formication Fatigue General Pain Telescoping Limb Phantom Movement	Dull Aching Burning Stabbing Knife-Like Sticking, Squeezing Electrical Shocks Leg is Being Pulled Off Trauma Related Pain Pre-Operative Pain Unnatural Positioning	Prosthetic Neuroma Sympathetic Referred Abnormal Tissue Joint Pain Bone Pain Soft Tissue Pain Residual Limb Changes

Pain

Causes of Phantom Sensation

Causes of Phantom Sensation

Pain

Treatment for Phantom Pain

- Surgery
- Acupuncture
- Electric Stimulation Therapy
- Vibration Therapy
- Ultrasound
- Analgesics
- Psychological Interventions
- Sensory Overload
- Mirror Therapy

Edema Management/Limb Shaping

- 4 Main Functions of Residual Limb Management Techniques:
  1. Volume containment, Edema reduction
  2. Shaping
  3. Protection
  4. Desensitization

Edema Management/Limb Shaping

Post-Operative Dressing Selection

- Soft Dressings
  - Elastic Wrap (Ace-Wrap)
  - Shrinker
- Semirigid Dressings
- Rigid Dressings
  - Non-removable rigid dressing
  - Removable rigid dressing
- Immediate Post-Operative Prosthesis (IPOP)

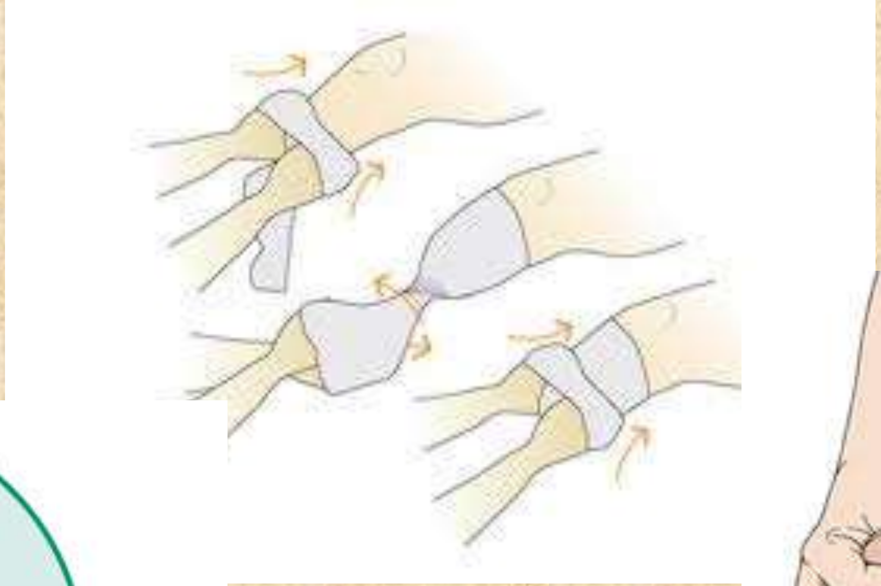
Edema Management/Limb Shaping

Elastic Wrap

- Advantages
  - Can assist in shaping limb
  - Low cost
  - Wound accessibility
  - Easy to apply with some patients
  - Can be laundered
- Disadvantages
  - Must be reapplied every 2 hours for edema control
  - Can be difficult to apply
  - Tourniquet may result if applied improperly
  - Can slip off limb with exercise or mobility

Edema Management/Limb Shaping

Shrinkers



Edema Management/Limb Shaping

Shrinker

- Advantages
  - Can be easily applied
  - Wound accessibility
  - Graded pressure (high to low) from distal to proximal
- Disadvantages
  - May cause incision dehiscence if applied improperly
  - May be too painful to apply and wear immediately post-op

Contracture Prevention/Positioning

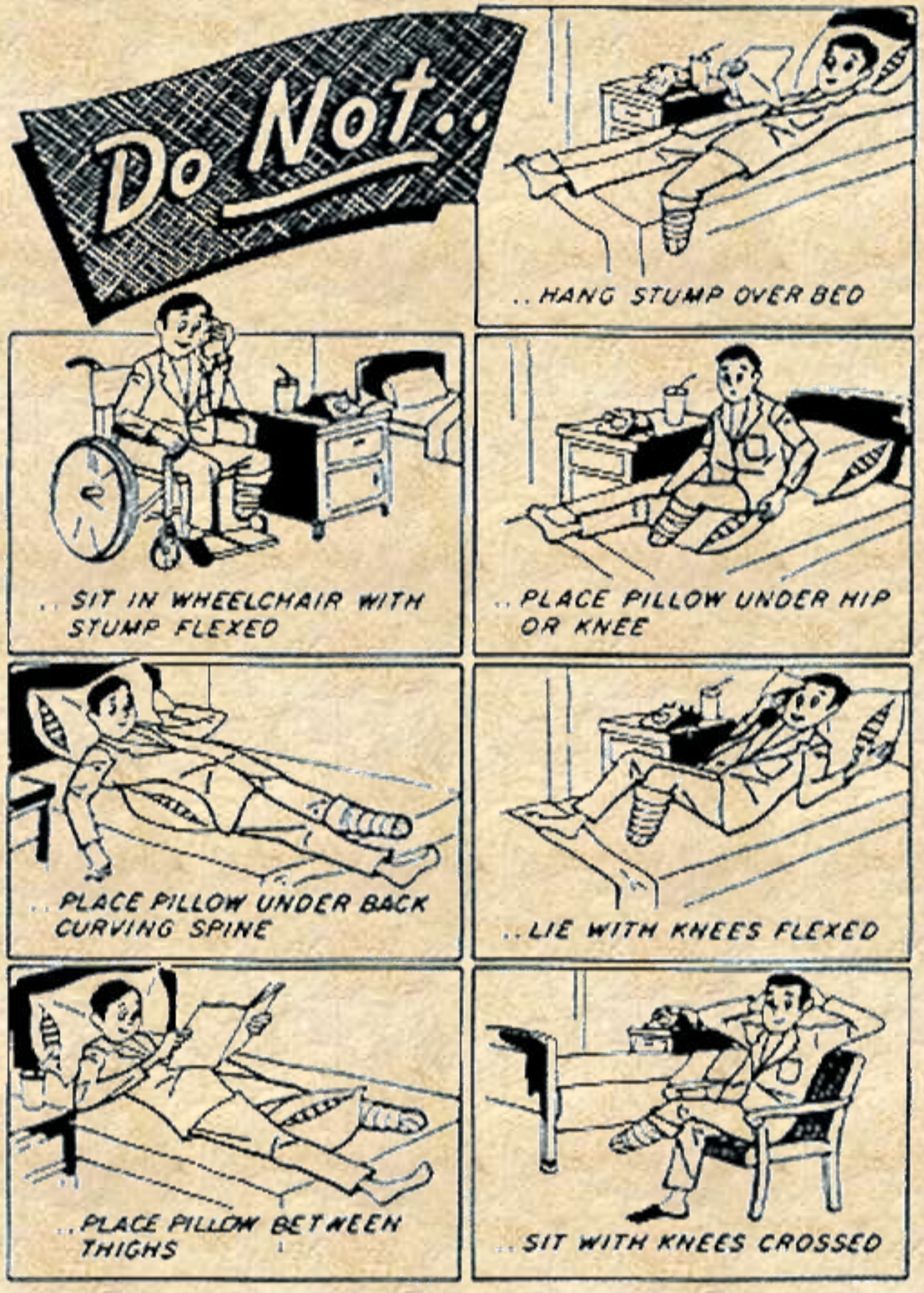
Contracture

- A condition of shortening and/or hardening of muscles, tendons, or other tissue, often leading to deformity and rigidity of joints.

Contracture Prevention/Positioning

- Transtibial
  - Contractures: Knee Flexion, Hip Flexion, Hip ABDuction, Hip External Rotation
    - →AVOID THESE!

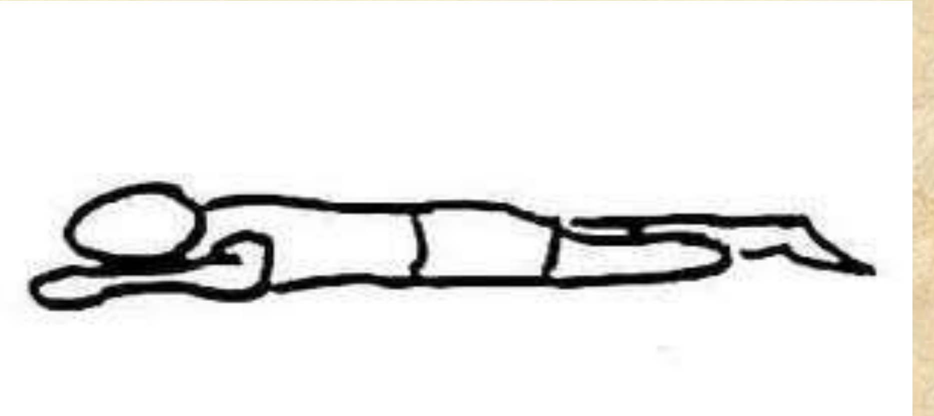
- Things to do: Prone Lying, Knee Extension Board on Wheelchair, Knee Extension Brace

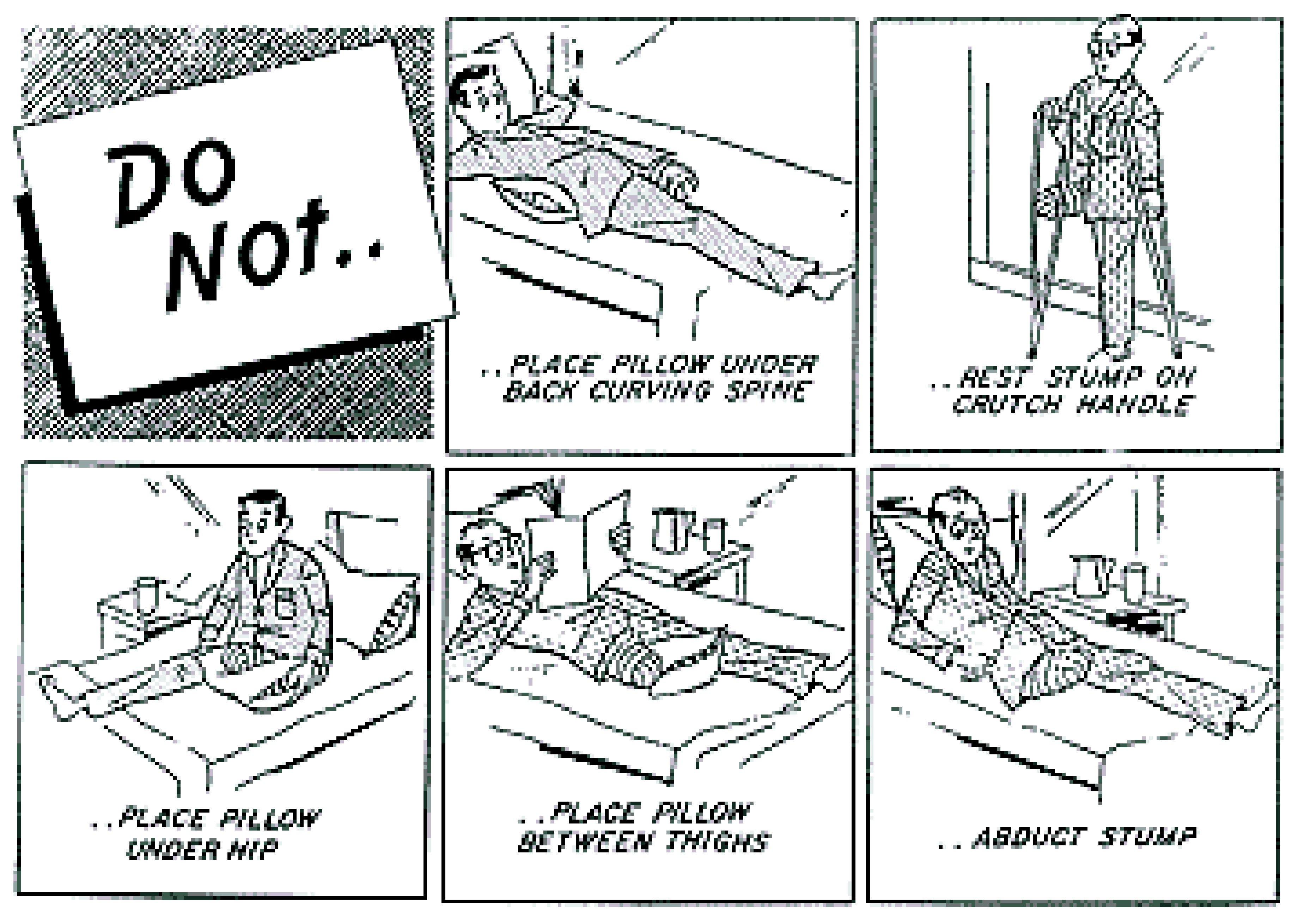

Do Not..
..HANG STUMP OVER BED
..SIT IN WHEELCHAIR WITH STUMP FLEXED
..PLACE PILLOW UNDER HIP OR KNEE
..PLACE PILLOW UNDER BACK CURVING SPINE
..LIE WITH KNEES FLEXED
..PLACE PILLOW BETWEEN THIGHS
..SIT WITH KNEES CROSSED

Contracture Prevention/Positioning

- Transfemoral
  - Contractures: Hip Flexion, Hip ABDuction, Hip External Rotation
    →AVOID THESE!

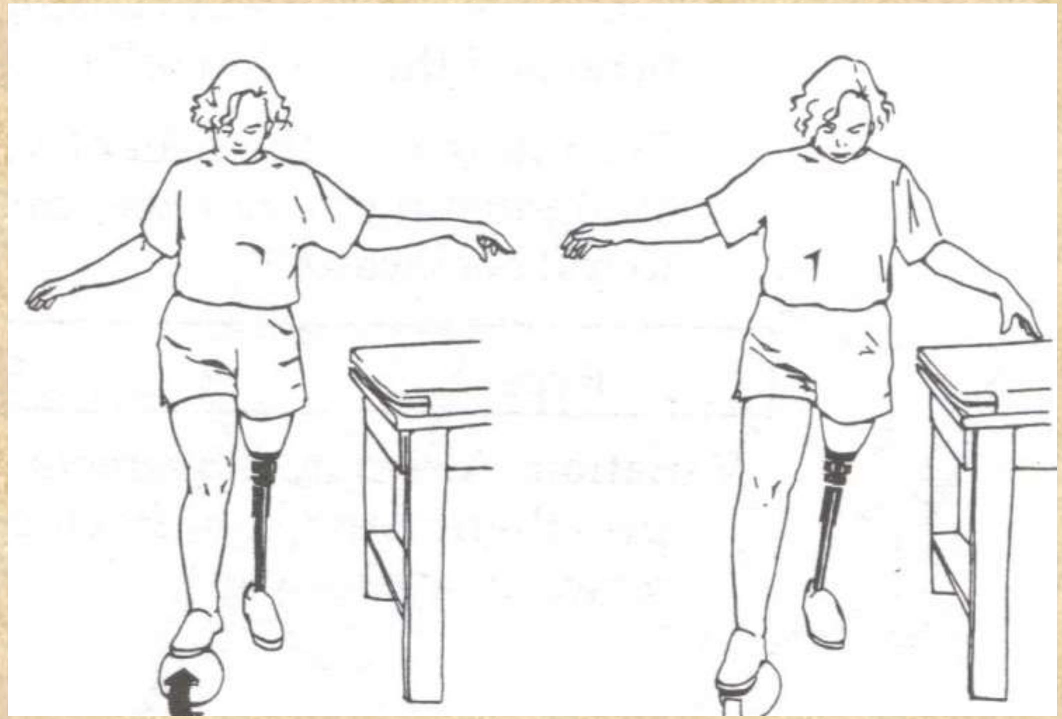
  - Things to do: Prone Lying




DO Not..
..PLACE PILLOW UNDER BACK CURVING SPINE
..REST STUMP ON CRUTCH HANDLE
..PLACE PILLOW UNDER HIP
..PLACE PILLOW BETWEEN THIGHS
..ABDUCT STUMP

Strengthening/HEP Development

- LE AROM/AAROM/PROM
- Strengthening
- Balance & coordination
- Endurance
- Mobility



Need to keep in mind DC disposition!

KINETIC PROSTHETICS

GET MOVING

Current Prosthetic Management

An Overview of Upper and Lower Extremity Fitting Processes, Designs and Componentry

Outcomes Based Practice

- Success is measured by the patients’ ability to reintegrate into their pre-amputation quality of life
  - Physically
  - Psychologically
  - Socially

What Determines Socket Design?

- **PATIENT!!!**
  - Potential activity level
  - Skin condition
  - Co-morbidities
  - Patient's pre-amputation lifestyle
    - A transtibial should be able to return to the same level of mobility prior to amputation
  - **SOCKET FIT** and patient care management is critical

Types of Prosthetic Designs

- Immediate Post-Operative Prosthesis (IPOP)
  - Success depends on the skills/coordination of the clinic team
- Preparatory Prostheses
  - Frequently used for several weeks or months until the residual limb has stabilized before the definitive prosthesis is provided.
    - Energy efficient foot modules, knees not utilized
- Definitive Prostheses
  - Design is based on short term AND long term goals
  - 30% cost savings by going directly to definitive prosthetic design[1]

1. Kahle, J. et al. Practical strategies for reducing prosthetic costs. In Motion; Vol. 21, Issue 4; July/Aug 2011; pp.42-44.

Types of Prosthetic Designs

- Preparatory Prosthesis
  - First Prosthesis (3-6 months)
    - Used while patient’s limb volume stabilizes
    - Prosthesis is comprised of basic componentry
      - Allows patient to rehab, integrate into daily routine and complete ADLs
      - With proper prosthetic care, patient will reach the potential of the preparatory prosthesis before reaching their individual prosthetic potential
    - Once the preparatory prosthesis no longer fits, patient has a “spare prosthesis”

Types of Prosthetic Designs

- Definitive Prosthesis
  - Design is based on the not only the short term goals but long term goals as well
  - Benefits of utilizing flexible inner
    - Comfort
    - Adjustability
    - Relieve Bony anatomy
    - Volume change

Diagnostic Test Sockets (DTS)

- Assess fit both statically and dynamically
- Ensures proper fit and function of the prosthesis

Diagnostic Test Sockets (DTS)

- Transtibial
  - On case-by-case basis, send patients out on DTS.
  - Allows for custom socket adjustments.
  - Helps ensure the laminated prosthesis will provide the patient with the best possible outcome.

Diagnostic Test Sockets (DTS)

- Transfemoral
  - Ensure socket design has all the features necessary for comfort, function and control
  - Dynamic alignment

Transtibial Socket Design

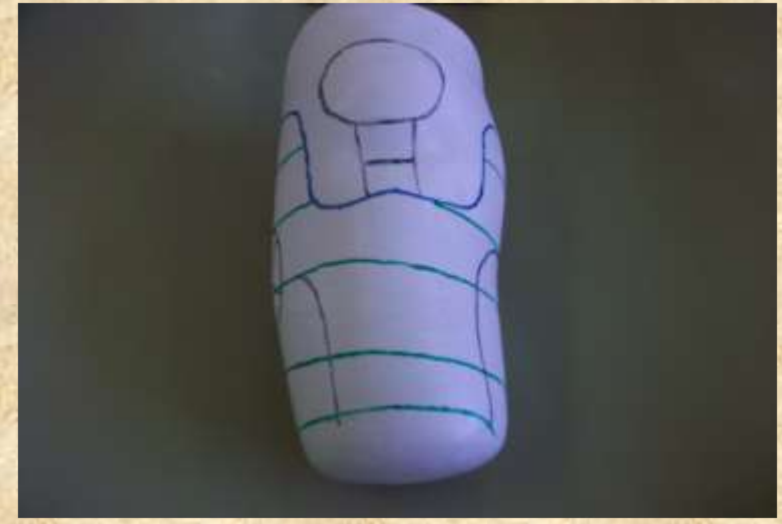
Patellar Tendon Bearing (PTB)

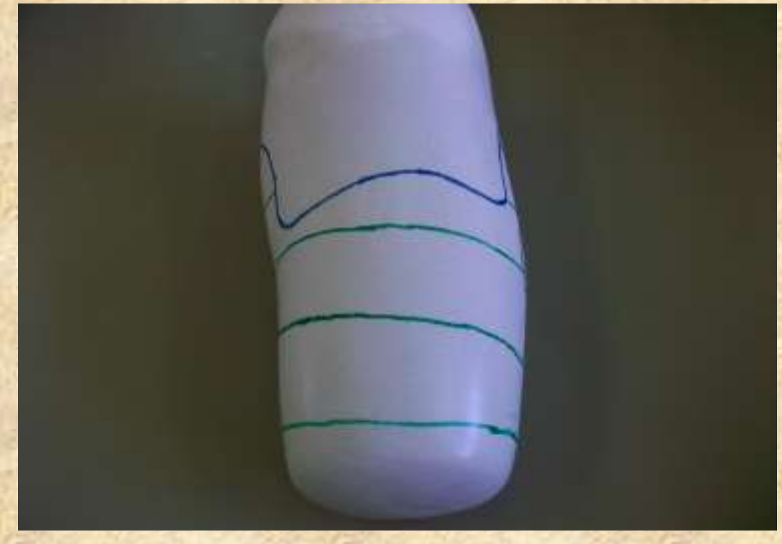
- Loads specific weight-bearing areas and relieves non-weight bearing areas
- Total Contact
- Transverse plane control due to "anatomical lock"

Total Surface Bearing

- Loads uniformly and indiscriminately
- Total Contact
- Lack of transverse plane control due to cylindrical design
  - Suspension is the primary mechanism of transverse plane control

Transtibial Socket Design

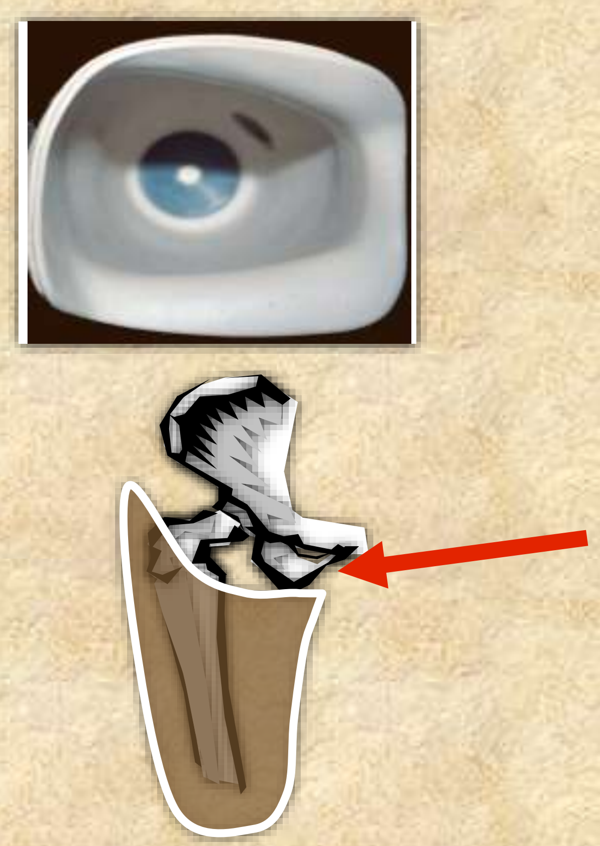


TransFemoral (TF) Socket Design

Narrow M/L Ischial Containment Socket	Quadrilateral Socket
Ischium contained within the socket	Ischium sits on a shelf
Custom Shape	Not a true custom shape
Indicated for a majority of wearers	Indicated for previous wearers/patient preference

TF Socket Design

Ischial Containment Design



Quadrilateral Design

Ischial Containment Socket

- Advantages
  - Increased Skeletal Control
  - Intimate proximal trim lines
  - Increased proximal weight-bearing
  - Can be contoured for specific anatomical control and weight bearing
  - Ability to fit HD as a TF
- Disadvantages
  - High proximal trim lines
  - Ant/Post trim lines limits ROM while sitting
  - Posterior proximal trim lines can impede sitting comfort
  - Ischial strut allows “Lazy” gait
  - Specifically loaded soft tissues are stressed

Subischial Socket Design

- Advantages
  - Uniform loading of tissues
    - Decreased stress on soft tissues
  - Positive suspension
    - No inherent pistoning
  - Increased ROM while sitting
  - Increased demand to utilize existing musculature
  - Comfort

- Disadvantages
  - Pressure management
  - Problem solving (seal)
  - Coronal plane control while ascending and descending stairs is more demanding
  - NEW
    - Lack of long term subject and objective experience
  - Increased demand to utilize existing musculature

Subischial Socket

Hip Disarticulation (HD)/HemiPelvectomy

- Very Involved Fitting and Rehab Process
- High rate of non-prosthetic users
  - Never given an opportunity to try
  - Poor socket comfort
  - High energy expenditure

HD/ HemiPelvectomy Socket Design

- New materials have allowed for more comfortable socket designs
  - Bikini Socket ™ Design
  - NPS Design
    - Utilizes a silicone liner between the skin and socket frame

Hip Joints

- 7E9
  - Hydraulic monocentric hip joint
- Helix Hip Joint
  - Hydraulic multi plane hip joint
- Littig Hip™
- Modular Hip Joint
  - Extension Assist

Suspension

- Pin Locking
  - Clutch lock, rachet lock, friction lock
- Seal-In Liner
- Suction with Sleeve Suspension
- Anatomical
- Direct Contact Suction
- Elevated Vacuum



Prosthetic Feet

- Solid Ankle Cushion Heel (SACH) foot
- Single Axis
- Multiaxial
- Dynamic Response
- Multiaxial Dynamic Response
- Vertical Shock
- Microprocessor

What is an Appropriate Foot?

- SACH Foot - 39% Energy return
  - Studies have shown more fore shear impulse on the sound side when a SACH foot is utilized
- Seattle Foot – 71 % Energy Return
- Flex Foot – 89% Energy Return
- Human Foot – 246% Energy Return

2. Schneider, K. et al. Dynamics of below-knee child amputee gait: SACH foot versus Flex foot. Journal of biomechanics, 26(10), 1191-1204

Microprocessor ankles

- Swing Phase only Microprocessor ankles
  - Ossur Proprio
  - Ottobock 1C66
  - Endolite Elan
- Powered Propulsion Microprocessor ankle
  - Bionx BiOM

Benefits of Microprocessor Ankles

- Decreased Energy Expenditure[3]
- Increased Gait Symmetry while negotiating Stairs and Ramps[4]
- Reduce Stress on other Joints [5]
- Increased Stability/Safety negotiating uneven terrain[6]

3. Herr, H. et al Bionic ankle–foot prosthesis normalizes walking gait for persons with leg amputation, *Proceeding of the Royal Society B*, 279(1728), 2011.
4. Agrawal, V. Evidence related to microprocessor prosthetic feet and ankles during stair and ramp negotiation. JPO; Fall 2015; Vol. 25, Num. 4
5. Grabowski, A. et al. Effects of a powered ankle-foot prosthesis on kinetic loading of the unaffected leg during level-ground walking, *Journal of Neuroengineering and Rehabilitation*, 10(49), 2013.
6. Rosenblatt NJ et al.. Active dorsiflexing may reduce trip-related fall risk in people with transtibial amputation. J Rehabil Res Dev. 2014; 51 (8):1229-42

Bionx Powerfoot BiOM

Categories of Prosthetic Knees

- Monolithic
- Polycentric
- Weight Activated Stance Control (WASC)
- Single Axis
- Outside Hinges

What is an Appropriate Knee Unit?

Goal:

- To provide the patient with an activity appropriate knee unit that allows or will allow the patient to perform their ADLs or specific activities by providing them the most energy efficient and safest knee unit available while simulating normal knee function and human locomotion as much as possible

Prosthetic Knees

- Monolithic
  - Increase energy expenditure by 15% when compared to articulating knee units
- WASC
  - Traditional WASC knee units require the patient to hip hike in order to unload prosthetic toe to allow prosthetic knee to bend
  - Not energy efficient

Prosthetic Knees

- Single Axis Hydraulic Knee Units
  - Excellent for high activity
    - Able to tolerate high frequency of repetitions
  - Not all provide stance flexion
  - Can only resist flexion through the first 30 degrees

Microprocessor Knee (MPK) Units

- Most are single axis knee units
- Alignment is Key!!!!!!
- Real Time Processing (60-80 times a second)
- Stumble recovery
- Swing Phase Control
- Less Conscious Effort by User
- Several Unique MPK designs

Microprocessor Knee Units

- The original emphases on energy costs and kinematic and kinetic gait variables have largely been replaced by our understanding of the abilities of MPKs to affect variables such as safety, confidence, and cognitive burdens, particularly during the navigation of environmental obstacles and tasks.
  - Recognition that less able subjects seem to benefit from the enhanced stability features offered by the technology and may ultimately benefit from them more than the early target populations

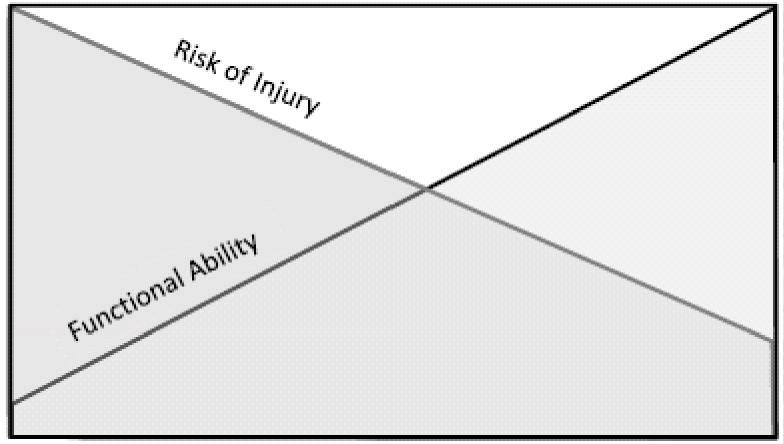


Figure 1. Inverse relationship between functional ability and risk for injury during daily activity in transfemoral amputees.

7. Stevens, P. Clinical Provision of Microprocessor Knees: Defining Candidacy and Anticipated Outcomes, JPO. 2013 Vol. 25, Num. 4; pp47-52.

MPKs

- Individuals wearing a microprocessor knee have an 88.1 percent increase in confidence and security and 88.4 percent improvement in gait and maneuverability when compared to a passive or nonmicroprocessor knee[8]
- Decreased number of falls with the integration of MPK in the prosthetic design.[9]

8. Berry et al. Perceived Stability, Function, and Satisfaction Among Transfemoral Amputees Using Microprocessor and Nonmicroprocessor Controlled Prosthetic Knees: A Multicenter Survey. JPO. 2009 Vol. 21; Num. 1; pp. 32-42.
9. Wong et al. Benefits for Adults with Transfemoral Amputations and Peripheral Artery Disease Using Microprocessor Compared with Nonmicroprocessor Prosthetic Knees. Am J Phys Med Rehabil. 2015 Oct; 94(10):804-10.

MPK Case Study – 65 year old male, Right TF secondary to vascular disease 04/11/2008

- Prescribing Physician believed in patient's potential
  - Pt had not worn a prosthesis successfully since 2010 – Pt had history of distal limb pain, did not tolerate Ischial Containment socket design, depression
- Prosthetic Design – TF sub ischial socket design, Carbon fiber frame with flexible inner liner, seal-in liner suction suspension, axial rotator, Ottobock X3 knee unit, and Ossur LP-Variflex
  - Initially fit at Kinetic Prosthetics in October 2015
  - Weekly follow-up visits – Pt lives 76 miles from office *
- Physical Therapy Regimine – 3 Days/week
  - Rehab did not start until December 2015

MPK Case Study

Delivery of Prosthesis

- Pt scored 26 on the Amputee Mobility Predictor (AMPPro) qualifying as a K1 ambulator
- Assistive Device: Rollaider Walker and Wheelchair
- Pt Weighed 88.8 lbs
- 28 Degree Hip flexion Contracture

8 Weeks Post-Delivery

- Pt scored 39 on the AMPPro qualifying as a K3 ambulatory
- Assistive Device: Single Point Cane
- Pt weighed 120.6 lbs (Pt goal is 135 lbs)
- 18 Degree Hip Flexion Contracture

Ottobock X3

X3 Knee Unit – How is this knee different?

- Utilizes 6 inputs
  - Axial load, ankle moment, knee moment, linear acceleration, knee angle sensor, and shank inclination
  - The knee unit is not just calculating the Ground Reaction Force (GRF) but also the orientation
    - Allows the knee to function is crowded/closed environments
    - Allows the user to utilize the knee unit while walking backwards
    - Promotes decreased mental and physical effort by the user

Upper Extremity

- EFFICIENT TEAM APPROACH IS CRITICAL TO PATIENT SUCCESS!!!!
  - The goal is to have a prosthesis fit within the first 1-2 months after amputation whenever possible
    - Patient has greater prosthetic acceptance
      - Patient is quickly developing strategies to accomplish tasks and these habits are challenging to break
    - Self image is enhanced
    - Functional independence is frequently restored

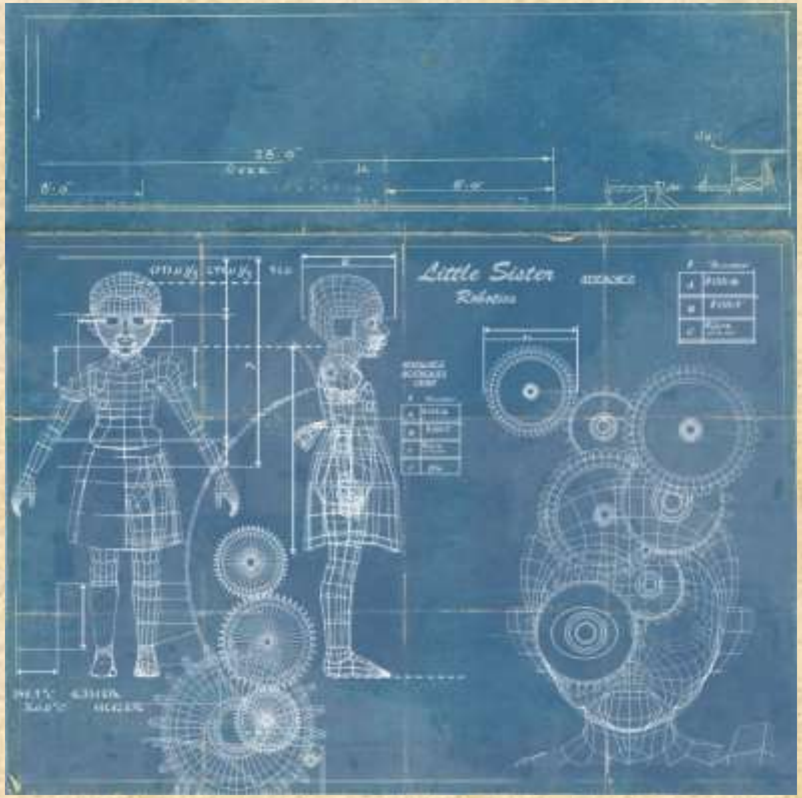
Upper Extremity Post Surgery and Pre-Prosthetic Therapy Program

- Major Goals of a Pre-Prosthetic Program
  - Control Edema
  - Maximize Joint Range of Motion/Increase Muscle Strength
  - Maximize Independent Living Skills (ILS)
  - Desensitization
  - Instruct in Good Hygiene
  - Maintain Skin Mobility
  - Muscle Site Testing and Training
  - Peer Support
  - Introduce Various Prosthetic Options/Components

10. Atkins DJ: Postoperative and pre-prosthetic therapy programs, *Comprehensive Management of the Upper-Limb Amputee. pp11-15*

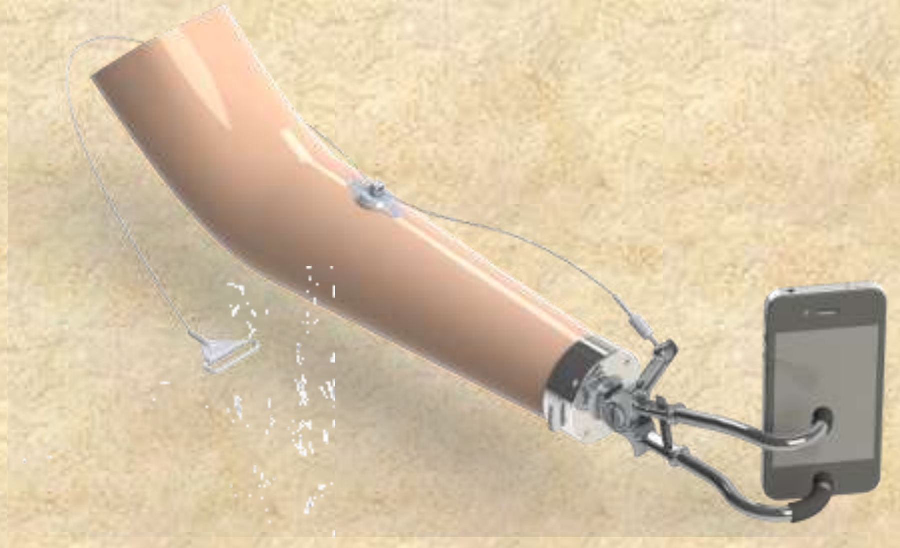
Upper Extremity Prosthetics

- Suspension System
- Socket
- Interposed Joints
- Terminal device
- Control Mechanism



Types of Upper Extremity Prostheses

- Body Powered Prostheses
  - Body motion/strength is captured to operate terminal device (hook, hand, etc)
- Externally Powered Prostheses
  - Electrical signal on the surface of the skin is used to communicate to the terminal device and power is supplied by an external battery
- Hybrid Prostheses
- **Passive Prostheses!!**



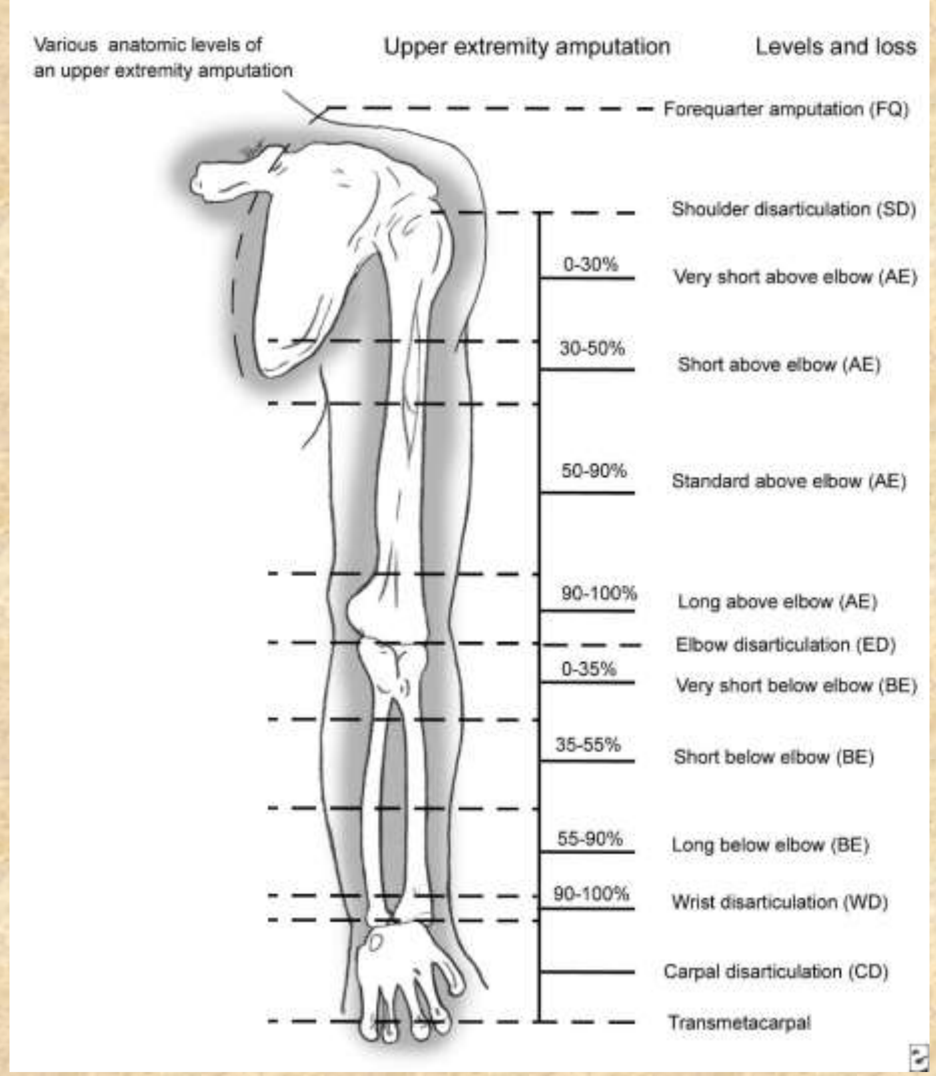
Control Strategies – Externally Powered Systems

- Single Site/Dual Site Surface Electrodes
- Touch Pads
- Linear Tranducers
  - Hybrid systems
- Radio Frequency Identification (RFID) tags
  - For use with multi-articulating hands
  - RFID strategy is designed to be less difficult, tiring, and frustrating than the EMG strategy

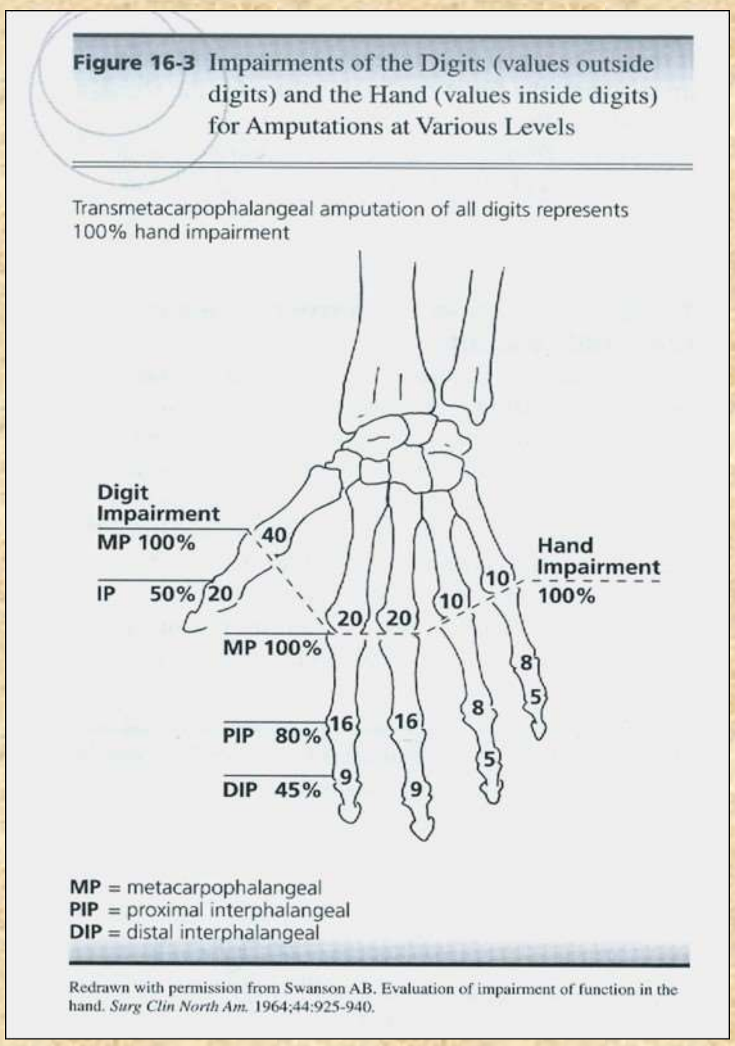
11. Vilarino et al. Outcomes and Perception of a conventional and Alternative Myoelectric Control Strategy: A Study of Experienced and New Multiarticulating Hand Users. JPO; 2015 Vol. 27, Num. 2; pp. 53-62.

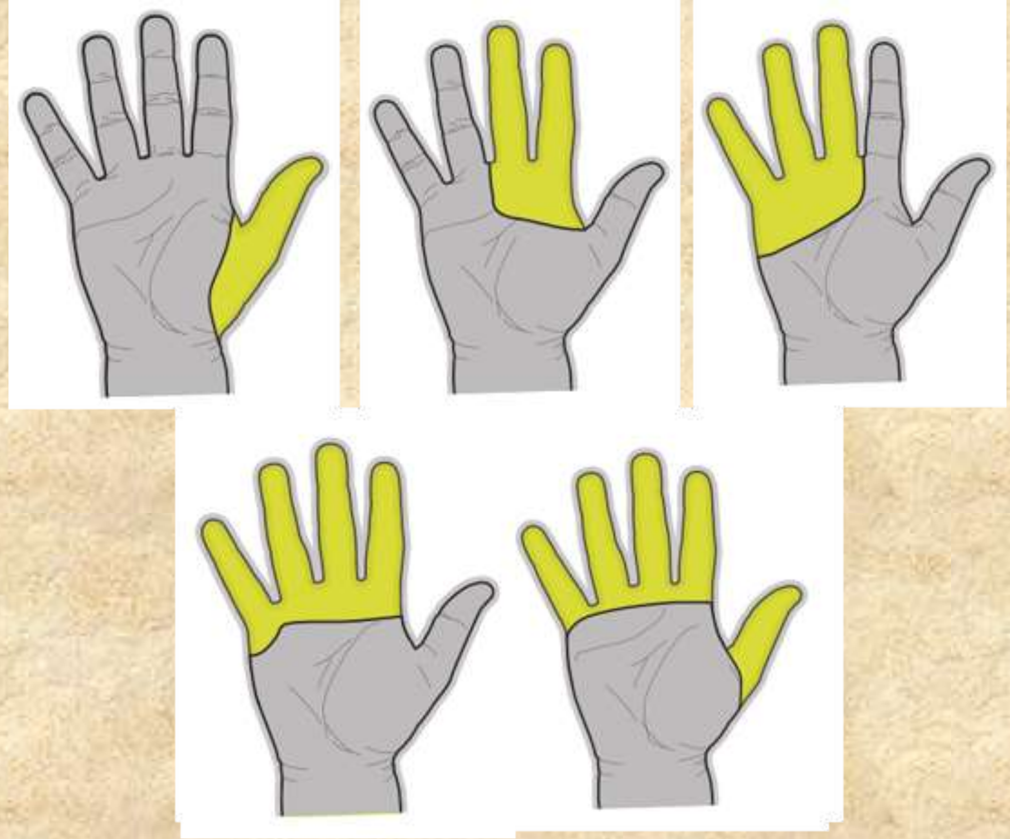
Upper Extremity

- Partial Hand Solutions
- Below the Elbow/Wrist Distarticulation (trans radial) Solutions
- Above the Elbow (transhumeral) Solutions
- Shoulder Disarticulation/Forequater Solutions



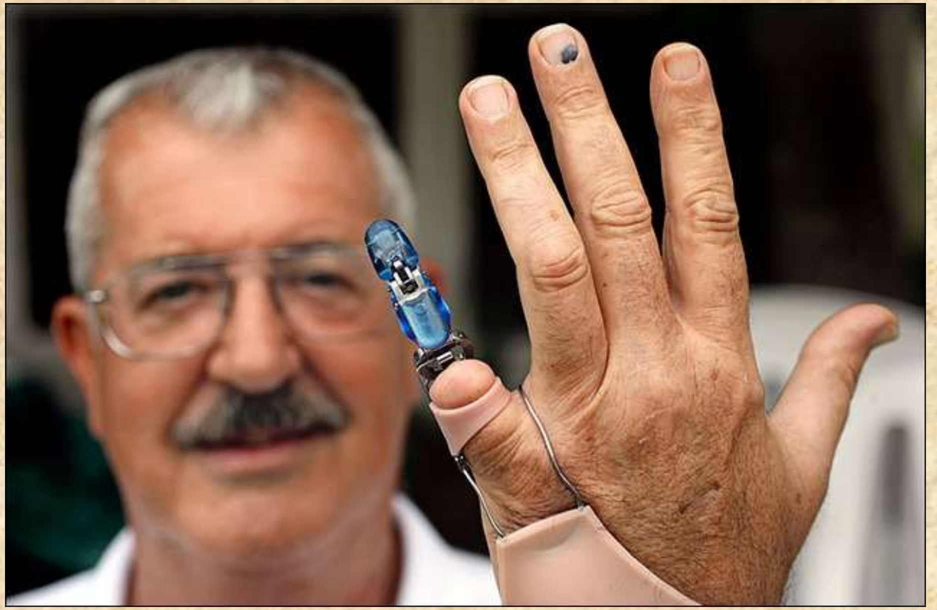
Partial Hand Amputations





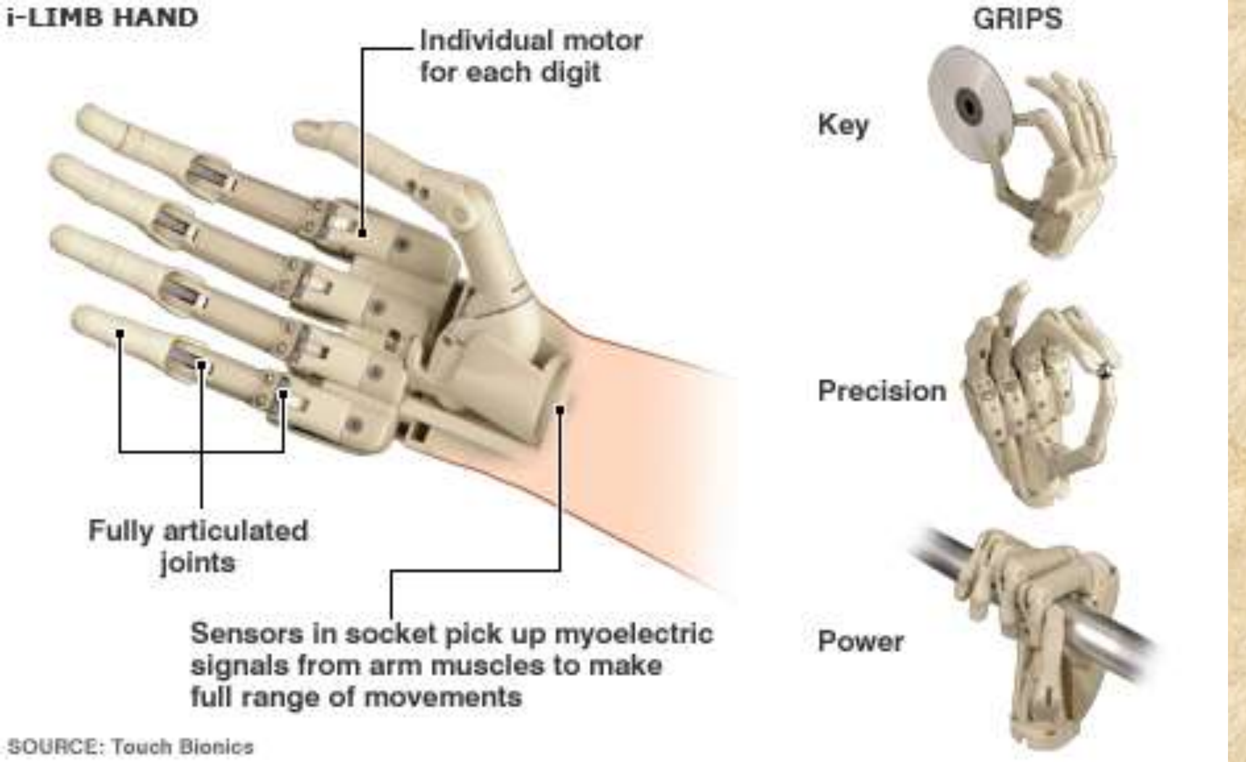
Partial Hand Solutions

- X-Finger
  - Captures motion at remaining joint/joints
- Silicone Restorations
- Externally Powered Prostheses



Partial Hand Externally Powered

- Huge Strides in managing partial hand amputations since 2008
  - TIMING WAS EVERYTHING!!!
    - I-Limb developed first commercially available fully articulating prosthetic hand
    - Silicone and carbon fiber technology had been refined and able to be used to make custom socket designs and suspension methods



Partial Hand Solutions

Partial Hand Externally Powered

- Benefits
  - Allows patients with limited residual grasping ability to grasp larger and heavier objects.
    - This phenomenon is opposite from more proximal levels of amputation, where precision grasping is the most difficult because there is no residual grasping ability.
  - Positive patient feedback

12. Phillips et al. Experiences and Outcomes with Powered Partial Hand Prostheses: A Case Series of Subjects with Multiple Limb Amputations. JPO; 2012 Vol. 24, Num 2; pp93-97.

Trans Radial/Wrist Disarticulation Management

- Suspension Methods
  - Anatomical
  - Suction
  - Locking liner
- Length of limb, skin integrity, activity level, and prosthetic design determine design

Trans Radial/Wrist Disarticulation Management

- Terminal devices
  - Hook
    - Very Functional
      - Available body powered, externally powered
  - Conventional Hand
    - Available body powered, externally powered, and passive
  - Multiarticulating Hand
  - Activity Specific

Trans Radial/Wrist Disarticulation Solutions – Body Powered

Trans Radial/Wrist Disarticulation Solutions

Trans Radial Wrist Disarticulation Solutions

Trans Radial Wrist Disarticulation Solutions

Trans Humeral Management

- Prosthetic Elbow Options
  - Body powered
  - Hybrid system
  - Electronic

Transhumeral Solutions

Shoulder Disarticulation/Forequarter Amputation

- Very Involved Fitting
  - Challenges in suspension
  - Challenges in user operation
    - Typical Myo-electric design would include a carbon frame socket with manual position/lock shoulder, nudge switch, powered elbow, powered terminal device
    - Defense Advanced Research Projects Agency (DARPA) has invested money to develop technology and prosthetic efficiency – DEKA ARM

Photo courtesy of LTI

DEKA ARM

- Degrees of Freedom
  - Flexion/extension and abduction/adduction of the shoulder joint
  - Humeral internal/external rotation
  - Flexion/extension of the elbow joint
  - Flexion/extension and pronation/supination of the wrist joint
  - Six grasping patterns of the hand: open-fingered pinch, closed-fingered pinch, lateral pinch (key grip), power grip, three-jaw chuck, and tool grip

13. Phillips et al. Endpoint Control for a Powered Shoulder Prosthesis. JPO; 2013 Vol. 25, Num. 4; pp193-200

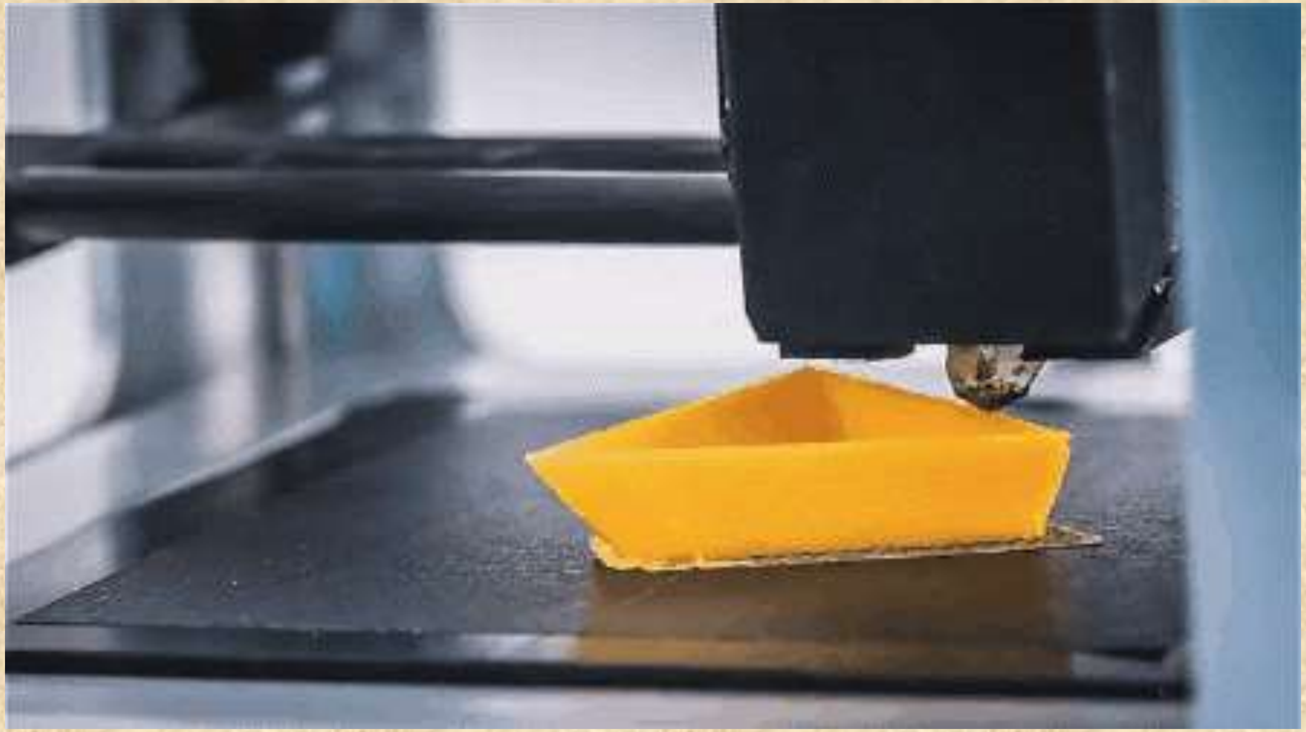
DEKA ARM -

- Utilizes Endpoint Strategies
  - User thinks to open hand to grasp and the endpoint control software program identifies the joints that must be activated to make the prosthetic hand move up in space
  - The use of endpoint eliminates the need to control specific movements of the shoulder and elbow joints because the endpoint software automatically moves those joints to achieve the endpoint position of the terminal device
    - Easier for the end user!!!

13. Phillips et al. Endpoint Control for a Powered Shoulder Prosthesis. JPO; 2013 Vol. 25, Num. 4; pp193-200

Adaptive Options

- Order from manufacturer
  - TRS
  - Texas Assistive Devices
  - Hosmer
- 3-D printing



Adaptive Options

Coding Upper and Lower Extremity Prosthetics

Components of the Prosthetic Prescription

- Desktop Prescription Stating the General Prosthetic Order
- Detailed Written Order

Desktop Prescription

- Team approach – Multi disciplinary
  - Interactive discussing the patient's needs and goals
    - Both current and future
  - Execution of the RX is discussed
    - When is the fitting, timing the rehab progression (pre-prosthetic to prosthetic training), etc.
- Contains the ICD-10 code/codes

Detailed Written Order

- Contains the Healthcare Common Procedure Coding System (HCPCS) codes for the prosthesis and quantities
  - The HCPCS represents the function or item in the prosthesis
  - There is a base code depending on the device followed by add on codes
    - Can range from 2 codes to 30 codes per device
  - Every patient is different so the coding can vary

Example HCPCS Coding

- L5700 – Base Code
  - Defined as Replacement, socket, below knee, molded to patient model
  - Provides the user with a nylon socket with polyester resin lamination
- L5620 – Add on
  - Defined as Test socket below the knee
  - Provides the PETG test socket(s) used for the fitting
- L5637 – Add on
  - Defined as total contact
  - Sockets used to be made open ended – plug fit sockets

Kinetic Prosthetics

720 East Market Street, Suite 102 Tel: (610) 701-8266
West Chester, PA 19382-4874 Fax: (610) 701-8972

Detailed Written Order and Letter of Medical Necessity

Patient Information

Patient Name (Last, First, MI)	Patient ID	Patient DOB	Device Type
Sample, I'm, A	**0**		**Right Transtibial**

Street Address	City, State, Zip/Postal Code	Country
111 vee st	**dee, AL 19555**	**USA**

K Level

K3 Functional Level 3. The patient has the ability or potential for ambulation with variable cadence. Typical of the community ambulatory who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion.

L-Code	Qty	Description
L5301	1	BELOW KNEE, MOLDED SOCKET, SHIN, SACH FOOT, ENDOSKELETAL SYSTEM **Justification:** A definitive prosthesis is medically necessary to provide the <<first/last name>> with a device that will allow <<him/her>> to progress through rehab and return to their previous level of activity. <<full name>> has no prosthetic history and is motivated to walk again. <<full name>> is an excellent prosthetic candidate and will use this <<k-level>> prosthesis to achieve <<goals>>.
L5620	2	ADDITION TO LOWER EXTREMITY, TEST SOCKET, BELOW KNEE **Justification:** Test sockets are medically necessary to assess socket fit both objectively and subjectively. The test socket allows for critical socket fit assessment and adjustment. Utilizing test sockets is clinically relevant to prevent skin breakdown, pain and discomfort, and associated decreased activity secondary to a poor socket fit.
L5637	1	ADDITION TO LOWER EXTREMITY, BELOW KNEE, TOTAL CONTACT **Justification:** Total Contact is medically necessary to prevent skin breakdown, increase prosthetic device proprioception, increase loading surface to allow pt to ambulate with more comfort and control.
L5940	1	ADDITION, ENDOSKELETAL SYSTEM, BELOW KNEE, ULTRA-LIGHT MATERIAL (TITANIUM, CARBON FIBER OR EQUAL) **Justification:** Ultralight material is medically necessary to allow the pt to walk further and increase activity level in general with a decreased metabolic cost due to the reduced weight of the prosthesis. The ultralight material is also medically necessary to allow for increased durability of the socket
L5910	1	ADDITION, ENDOSKELETAL SYSTEM, BELOW KNEE, ALIGNABLE SYSTEM **Justification:** Alignable system is medically necessary to allow for clinically indicated angular and linear alignment adjustments. The alignable system also allows for continued clinical follow-up care to ensure proper gait biomechanics and efficiencies.
L5629	1	ADDITION TO LOWER EXTREMITY, BELOW KNEE, ACRYLIC SOCKET **Justification:** Acrylic Socket is medically necessary to allow for a lightweight socket design. Acrylic Socket is also Medically necessary secondary due to the physical properties acrylics and its ability and durability to maintain the socket shape and/or volume.
L5645	1	ADDITION TO LOWER EXTREMITY, BELOW KNEE, FLEXIBLE INNER SOCKET, EXTERNAL FRAME **Justification:** Flexible Inner Socket is medically necessary to allow for increased patient limb comfort. Flexible Inner Socket is medically necessary to decrease the transmitted forces between the socket wall and residual limb during both sitting and ambulating activities at any cadence thereby decreasing risk of skin breakdown.
		ADDITION TO LOWER EXTREMITY, BELOW KNEE/ABOVE KNEE, CUSTOM FABRICATED

L5673	2	FROM EXISTING MOLD OR PREFABRICATED, SOCKET INSERT, SILICONE GEL, ELASTOMERIC OR EQUAL, FOR USE WITH LOCKING MECHANISM **Justification:** Socket insert is medically necessary to reduce shear forces on the residual limb, allow for padding of bony prominences, and allow for the locking suspension of the socket.
L8400	6	PROSTHETIC SHEATH, BELOW KNEE, EACH **Justification:** Prosthetic Sheath is medically necessary to ensure proper contact between the socket and the limb when the limb volume fluctuates during the course of the day.
L8420	6	PROSTHETIC SOCK, MULTIPLE PLY, BELOW KNEE, EACH **Justification:** Prosthetic Sock, multiple ply is medically necessary to ensure proper contact between the socket and the limb when the limb volume fluctuates during the course of the day.
L8470	6	PROSTHETIC SOCK, SINGLE PLY, FITTING, BELOW KNEE, EACH **Justification:** Single Ply Prosthetic Sock is medically necessary to ensure proper contact between the socket and the limb when the limb volume fluctuates during the course of the day.
L5980	1	ALL LOWER EXTREMITY PROSTHESES, FLEX FOOT SYSTEM **Justification:** Foot module is medically necessary because this module will will functionally benefit patient by allowing patient to ambulate on uneven ground, reduce energy expenditure, accommodate ground reaction forces, increase the metabolic efficiency of patient gait, reduce skin shear forces on the affected residual limb and the contralateral foot, and provides the energy return to allow for patient to progress in his rehabilitation and increase patient's activity level.
L5999	1	Powered plantarflexion ankle with carbon fiber foot module, lithium ion batteries (qty 2), Litium Ion battery charger, smartphone adjustibilty **Justification:**

Prescription

Projected Monthly Frequency	Estimated Length of Need	Start Date
Daily	**Lifetime**	**8/12/2014**
Insurance/Medicare Info **ANTHEM BC/BS - Verizon ccc 111 (Primary)**	Diagnosis **Complete traumatic amputation at level between knee and ankle, right lower leg, subsequent encounter**	ICD **S88.111D**
Physician Name **Unknown, unkson (Referring Physician)**	Physician Address ,	Physician UPIN
Physician NPI		

The above procedures and any repair and/or parts to maintain proper fit and function are appropriate for this patient, and are deemed medically necessary.

unkson Unknown **Date**

What are Miscellaneous HCPCS Add-ons?!

- L7499 – Unlisted Procedures/Devices for Upper Extremity Prosthesis
- L5999 – Unlisted Procedures/Devices for Lower Extremity Prosthesis

Why are L5999 and L7499 Used?

- Technology is developing faster than the HCPCS can be updated/approved.
  - The cost of the emerging technology is not covered by existing HCPCS coding
- Repair/replacement costs of a component

Common Problem with Coding

- Misunderstanding of What the Fee Schedule of the Codes Includes
  - Fee schedule is not just the amount the socket, knee, terminal device, etc costs.
  - The Fee schedule represents:
    - Evaluations
    - All of the Fittings
    - Cost of the device itself to the prosthetic practice
    - Programming of the device
    - Aligning the device
    - Training to use the device
    - Follow-up care to continue to progress the patient and ensure the prosthesis will allow the patient to reach their goals
  - The prosthetic practice does not get reimbursed for time. There are no co-pays.

How to avoid problems?

- COMMUNICATION!!!!
  - Providing the patient a path to success is why we are here
    - If the communication breaks down, the patient's needs are not addressed and their path to recovery is detoured

Case Study

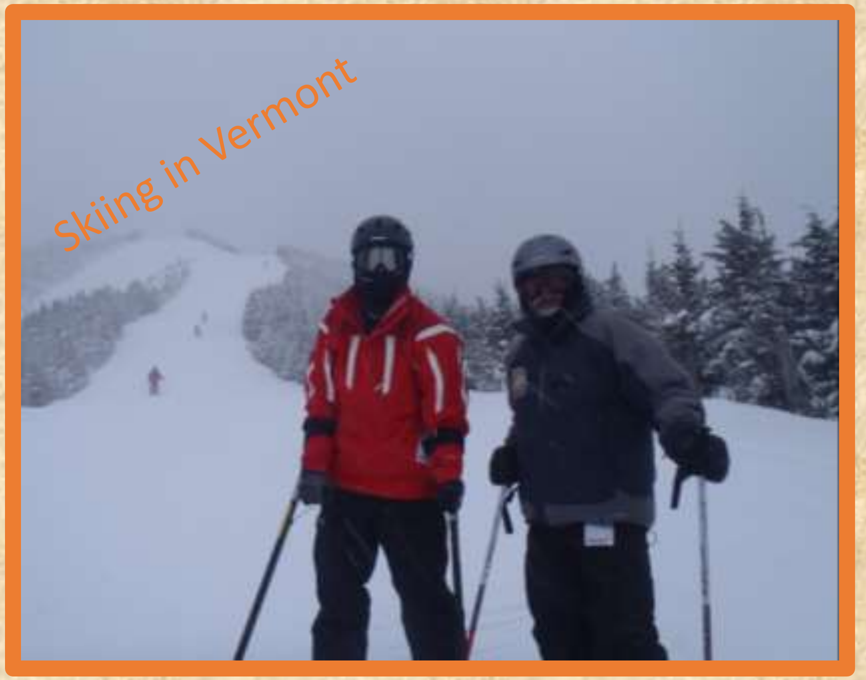
Chase

- Firefighter/Paramedic
- August 2007
  - 60% of body burned while fighting a fire – Over 84% of the burns were 3rd degree/full thickness burns or more severe
  - Ultimately:
    - Left transhumeral amputation
    - Right transfemoral amputation

Chase

- 2009 Outpatient Therapy started at Magee Rehabilitation
- 2009
- 2010
- 2012
- 2014
- 2015
- 2016

Police vs. Fire Ice Hockey Game


Skiing in Vermont


Biking in the Park

Amputee Resources

Support Systems

PENNSYLVANIA
State Resources

- Pennsylvania Centers for Independent Living
- Pennsylvania Aging and Disability Resource Centers
- National Association of Area Agencies on Aging Locator
- Pennsylvania Department of Senior Services
- Pennsylvania Department of Vocational Rehabilitation
- Pennsylvania Department of Protection and Advocacy
- Pennsylvania Department of Insurance
- Pennsylvania Department of Human Services
- Pennsylvania Assistive Technology Foundation

Support Systems

- Amputee Coalition of America
  - www.amputee-coalition.org
- Local Amputee Support Groups
- National Center on Physical Activity and Disability
  - www.ncpad.org
- Disabled Sports, USA
  - www.dsusa.org
- Special Olympics International
  - www.specialolympics.org

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THANK
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GRACIAS
ARIGATO
SHUKURIA
DANKSCHEEN
TASHAKKUR ATU
YAQHANYELAY
SUKSAMA
EKHMET
GRAZIE
MEHRBANI
BOLZÏN
MERCI
BİYAN
SHUKRIA
TINGKI
GOZAIMASHITA
EFCHARISTO
JUSPAXAR
KOMAPSUMNIDA
PALDIES
MAAKE