Prosthetic Management of Lower Limb Amputees

John Rheinstein, CP, FAAOP
Hanger Clinic

Disclosures

• Hanger Clinic
• Accelerated Care Plus (ACP) is a division of Hanger Inc.
• Amputee Empowerment Partners website is hosted by Hanger Clinic
Hanger’s Continuing Education Series

Spinal Orthotics  Lower Extremity Orthotics  Upper Extremity Orthotics  Lower Extremity Prosthetics  Upper Extremity Prosthetics

Understanding Prosthetics

- Design and fitting of a prosthesis
  - Socket
  - Components
- Surgery
- Post-op care
- Biomechanics and gait
- Rehab – PT / OT
- Psychosocial issues

Topics in Prosthetics
Prosthetics & Physical Therapy

- Residual limb and prosthetic care
- Strength and flexibility
- Balance
- Mobility aids
- Cardiovascular function
- Gait Training
- ADLs
- Positive attitude

Objectives

Upon completion of this presentation, the participant will be able to:

- Outline the effectiveness of various forms of postoperative prosthetic modalities for lower extremity amputation.
- Describe the postoperative early rehabilitation process.
- List the benefits of postoperative treatment for the rehabilitation of an individual after a lower extremity amputation.
- Describe the goals of postoperative management.
- Compare the techniques for immediate and early prosthetic interventions, specifically:
  - Soft dressings and compression therapy; Removable rigid dressings (RRDs); Non-removable rigid dressings.
- Provide criteria to determine the patient’s readiness for prosthetic fitting.

Agenda

- Introduction
- Immediate & Early Prosthetic Interventions
  - Soft Dressing & Compression Therapy
  - Removable Rigid Dressings (RRDs)
  - Non-Removable Rigid Dressings
- Rehabilitation Treatment Plan
Effectiveness of Postoperative Treatments

- Over 400 articles describe postoperative treatment protocols
- Still, no consensus on optimal treatment plan
- Consistently determined benefits of post-op treatment:
  - Reduced pain; reduced time to prosthetic use & reduced hospital stay
- Key to early mobilization:
  - Healing the wound
  - Modeling/shaping the residual limb
  - Weight bearing


Introduction
Rehabilitation from amputation surgery has three phases:
- Healing
- Maturation
- Definitive

General Rehabilitation Timeline for Patients with Lower Extremity Amputation

**Individual experiences will vary. Slow healers have a different timeline**

Adapted from www.gettingbacktolife.com
Initial Rehabilitation as In-Patient

- Limb is edematous, painful, hypersensitive & weak
- Patient histories
  - Elderly
  - Traumatic
  - Malignancy
- Emotional well being

Protocols Need to be in Place

- Protocols for postoperative care & regular staff training are needed
- Protocols should be known by all staff
- Specific instructions in patient’s chart & bedside

Discharge to Out-Patient Rehabilitation Department or Home

- Generally, wounds heal
- Without proper prosthetic care, complications are likely to develop
- Quality & amount of attention devoted to rehab
Post-op Complications

- Infection/slow healing
- Pain
  - Pain vs. sensation
  - Phantom pain
  - Residual limb
- Contractures
- Edema

Goals of Postoperative Protocols

- Heal the surgical wound
- Minimize pain
- Reduce swelling & begin shaping amputated limb
- Protect the amputated limb from trauma
- Preserve & improve ROM & strength of entire body

Goals of Postoperative Protocols, cont’d.

- Enable patient to learn to use appropriate mobility aids
- Begin controlled weight bearing
- Accomplish functional activities
- Facilitate psychological adjustments to limb loss
Introduction

- Patient-centered plan
- Ultimate objective of rehab = return to daily life at highest possible level

Immediate & Early Prosthetic Interventions

1. Soft Dressings & Compression Therapy
   A. Pressure bandaging: Ace Wrap, tubular gauze
   B. Shrinker socks
   C. Liners

2. Removable Rigid Dressings (RRDs)
   A. Plaster/fiberglass cast
   B. Plastic, bi-valved
   C. AmpuShield™ Program by Hanger Clinic

3. Non-Removable Rigid Dressings
   A. Non-weight bearing
   B. Weight bearing

1. Soft Dressings & Compression Therapy

   A. Pressure Bandaging = Ace wrapping
      - Oldest technique
      - Frequently used
      - Worn 24/7
### ACE Wrapping

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inexpensive</td>
<td>• Re-applied several times a day</td>
</tr>
<tr>
<td>• Readily available</td>
<td>• Requires flexibility, hand strength, dexterity, visual acuity &amp; endurance</td>
</tr>
<tr>
<td>• Minimal tension across suture</td>
<td>• Complication if incorrectly applied</td>
</tr>
<tr>
<td></td>
<td>• Doesn’t limit knee flexion</td>
</tr>
<tr>
<td></td>
<td>• Minimal protection from accidental trauma</td>
</tr>
<tr>
<td></td>
<td>• Non-weight bearing</td>
</tr>
</tbody>
</table>

![Ace Wrapping - Transtibial](image1)

**Correct**

**Wrong**

![Ace Wrapping - Transfemoral](image2)
Tubular Gauze

- For bulbous, sensitive limbs
- Double layering of material
- Same advantages & disadvantages as Ace wrapping
- Uniform compression

1. Soft Dressings & Compression Therapy

B. Shrinker Socks

- Various lengths, widths & grades of compression
- Receive 2 at a time
- Careful application
- Used once suture line healed sufficiently
- Assistance with donning after recent amputation

Shrinker Socks

**Advantages**

- Many sizes readily available
- Can be more effective than elastic bandage in reducing limb volume

**Disadvantages**

- Can be difficult to don without assistance
- Apt to roll down the transfemoral (TF) limb
- Must be replaced as they stretch out or as volume decreases
- No allowance for bony prominences or pressure sensitive areas
1. Soft Dressings & Compression Therapy

C. Silicone Liners

- Rolled, not stretched over limb
- Excellent adhesion and compression
- Can be easily removed for incision inspection
- Easily cleaned or sterilized
- Early patient involvement

Silicone Liners

**Advantages**

- Provides equalized compression with excellent adhesion
- Compression and properties of gel can help to minimize scar tissue
- Provides patient early opportunity to learn to use silicone liner

**Disadvantages**

- Liner traps heat & moisture
- Requires hand dexterity & strength to don/doff
- Minimal protection against trauma
- Daily cleaning

2. Removable Rigid Dressings

A. Plaster &/or Fiberglass Cast

- Components
- Edema control & limb protection
- Simulated weight bearing can occur
- 24 hours/day
2. Removable Rigid Dressings

B. Bi-valved Design

- Components
- Cast, custom fabricated- or pre-fabricated shells
- Extends above knee

A. B. C. D. E. © Hanger Clinic

2. Removable Rigid Dressings

C. AmpuShield™ by Hanger Clinic

- Post-operative limb protectors
- Custom-fit or custom-made from Insignia scan &/or measurements
- Allows for wound inspection, dressing changes & physical therapy
- Light weight & easy to clean
- Not for weight bearing
- Not too tight

C. AmpuShield™ by Hanger Clinic

AmpuShield™ Designs

Table 1

<table>
<thead>
<tr>
<th>Name</th>
<th>AmpuShield™ Custom Fit</th>
<th>AmpuShield™ Mild with Frame</th>
<th>AmpuShield™ Mild</th>
<th>AmpuShield™ Rigid</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Sizes</td>
<td>Custom</td>
<td>Custom</td>
<td>Custom</td>
<td>Same day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-48 hours</td>
<td>24-48 hours</td>
<td>24-48 hours</td>
<td>24-48 hours</td>
</tr>
</tbody>
</table>

© Hanger Clinic
Removable Rigid Dressings

**Advantages**
- It is removable for limb inspection
- Protects & compresses limb
- Improves healing & reduces hospital stays
- Patient uses & learns concept of 'lock-ny' fit
- Plastic pre-fab's shells & AmpuShield™ designs can be washed
- Bi-valved & AmpuShield™ limits knee flexion
- Simulated weight bearing

**Disadvantages**
- It is removable
- Requires skilled team
- Plaster/fiberglass shorter version doesn't limit knee flexion
- May need to be replaced with significant volume loss
- Not designed for ambulation


Removable Rigid Dressing

**Weight Bearing**

3. Non-Removable Rigid Dressing

**A. Non-weight bearing**
- Plaster or fiberglass cast applied by trained personnel in operating room
- Controls edema, pain & protection
- 7-15 days, until suture removal
  - Sooner with signs of complications!!
- By itself or with prosthetic components attached for ambulation
- Not as frequently done due to advances in removable systems

© Hanger Clinic
Non-Removable Rigid Dressing - Non-Weight Bearing

Advantages
• Controls edema, fosters healing & shapes the limb
  — Ensures rest to the healing tissue
  — Daily wound site inspection is not required
  — May facilitate earlier prosthetic fitting
• Protects the wound
• Prevents knee flexion contracture

Disadvantages
• Applied by a skilled practitioner
• Must have an initial sterile field under cast
• Visual wound inspection is not possible
• Frequent follow-up to ensure proper fit and reduce chances of skin breakdown due to lack of total contact
• Postop pain maybe mistakenly attributed to dressing

3. Non-Removable Rigid Dressing

B. Weight Bearing Immediate

• Also known as Immediate Postoperative Prosthesis (IPOP)
• Rigid dressing with a pylon and foot
  — Pylon & foot can be removed in bed
• Touch down weight bearing within 24 hours
• Discontinue weight bearing if wound healing complications arise
• Patient compliance is mandatory

Non-Removable Rigid Dressing - Weight Bearing

Advantages
• Benefits of rigid dressing + allows standing and ambulation
• Can help reduce falls
• Assists in acceptance of limb loss with early ambulation
• Early introduction to ambulation therapy & prosthetic use

Disadvantages
• Bulky & heavy, poor suspension
• High potential for internal trauma to limb
• Patient could apply too much weight too soon
• Must have patient compliance
• Trained and diligent rehab team is a must
Rehabilitation Treatment Plan

- Postoperative Pain Management
  1. Massage & Tapping
  2. Desensitization
- Scar Mobilization
- Emotional Well Being
- Functional Mobility
- Gait Training

- Exercise Program
  1. Strengthening
  2. Stretching
  3. Balance

- Weekly follow-up
- Patient/Family Education
- Contraction Prevention

Treatment Plan

Postoperative Pain Management

1. Massage & Tapping
   - 2-5 minutes
   - 3-4 times/day

2. Desensitization
   - 2-5 minutes
   - 1-2 times/day
Treatment Plan

Postoperative Pain Management
1. Massage & Tapping
   • 2-5 minutes
   • 3-4 times/day
2. Desensitization
   • 2-5 minutes
   • 1-2 times/day

Images from Amputee Coalition of America. www.amputee-coalition.org

Treatment Plan

Scar Mobilization
• To keep skin & scar tissue loose
• Done when dressings are removed
  • Daily
  • 1-2 minutes

Images from Amputee Coalition of America. www.amputee-coalition.org

Treatment Plan

Emotional Well Being
• Patient counseling
• Regular follow-up with Prosthetist and Therapists
• Peer support
  • Individual
  • Group face-to-face
  • Online

Images from Amputee Coalition of America. www.amputee-coalition.org
Treatment Plan

Functional Mobility
• Bed mobility
• Transfers

Gait Training
• With crutches
• Non-weight bearing

Exercise Program
• Strengthening
• Stretching/ROM activities
• Balance activities

Strengthening LEs
• Strengthening UEs and Core
Treatment Plan

Exercise Program

*Strengthening LEs*

*Strengthening UEs and Core*

Images from www.kramesonline.com

---

Treatment Plan

Exercise Program

*Stretching*

*Balance & Endurance*

Images from CSUDH O&P Program and Otto Bock

---

Treatment Plan

- Residual limb assessed weekly
  - Girth
  - Wound healing
- Patient/Family Education
  - Positioning, skin inspection, assistance by family members

Images from CSUDH O&P Program
Treatment Plan

6. Contraction Prevention
   • Positioning

In Preparation for a Prosthesis

• Independent residual limb care
  — Bandaging, shrinker, skin care, positioning
• Independent in mobility, transfers & functional activity
  — Partial weight bearing to full
  — Single leg ambulation with aid
• Demonstrate home exercises & positioning
• Psychological adjustment
• Understand the prosthetic rehabilitation process

Summary

• Pre-operative interview very helpful
• Team input is critical
• Education of patient/family & rehab team
• Full evaluation
• Determine protocol
• Implement
• Follow-up, follow-up, follow-up
How can we achieve the best outcomes for our patients?

- Surgeons
- PMR
- Therapists
- Prosthetists (CP/CPO)
- Peer Support
- Payers

Collaboration

Thank you

John Rheinstein, CP, FAAOP
jrheinstein@hanger.com
Cell 917-589-1015

877-4HANGER (877-442-6437)
Email: info@hanger.com

Questions?
Citations


Citations, cont’d.


References


3/21/2014
Introduction to Prosthetic Feet
Finding the Foot That Fits

Objectives

Upon completion of this presentation, the participant will be able to:
• Summarize anatomic foot and ankle function during gait.
• Describe Medicare Functional K-levels and the ambulatory needs for each level.
• Describe types of prosthetic feet that have been assigned to each K-level and how the feet then benefit users.
• Identify enhancements that can supplement prosthetic foot function.

References

Agenda

- Anatomic Foot/Ankle Function
- Medicare Functional K-Levels
- Matching Feet to Function
  - SACH
  - Single Axis
  - Multi Axis
  - Energy Storage & Return
- Endoskeletal Construction
- Footshells
- Other Specialty/Enhancements
- Review
- Case Studies

Review of Foot and Ankle Function

Heel Rocker
Controlled plantarflexion
Absorb loading forces
Reduces knee flexion moment
Maintain forward progression

Perry and Burnfield, 2010.

Ankle Rocker
Stable tripod foot-flat posture
(Heel, 1st and 5th MT)
Maintain forward progression

Perry and Burnfield, 2010.
Review of Foot and Ankle Function

Heel Rocker
- Controlled plantarflexion
- Absorb loading forces
- Reduces knee flexion moment
- Maintain forward progression

Ankle Rocker
- Stable tripod foot-flat posture
  (Heel, 1st and 5th MT)
- Maintain forward progression

Forefoot Rocker
- Forefoot locks and becomes rigid
- Heel rise against a rigid forefoot lever
- Energy storage in the plantarflexors

Perry and Burnfield, 2010.

Review of Foot and Ankle Function

Force Attenuation
- Ground Accommodation
- Rigid Lever Arm

Medicare Functional Levels

Patients function at different levels

- K0 – K4
- A method of rating functional abilities and potential to ambulate
- Determined by the physician, often with input from the prosthetist
- Can change over time
  - Never underestimate
- Bilateral considerations

Noridian Healthcare Solutions
## Medicare Functional K-levels

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>K0</td>
<td>The patient does not have the ability or potential to ambulate or transfer safely with or without assistance, and a prosthesis does not enhance quality of life or mobility.</td>
</tr>
<tr>
<td>K1</td>
<td>The patient has the ability or potential to use a prosthesis for transfers or ambulation on level surfaces at a fixed cadence. With a prosthesis, the patient achieves limited or unlimited household ambulation status.</td>
</tr>
<tr>
<td>K2</td>
<td>The patient has the ability or potential for ambulation, including the ability to traverse lower-level environmental barriers such as curbs, stairs, or uneven surfaces. With a prosthesis, the patient is considered a limited community ambulator.</td>
</tr>
<tr>
<td>K3</td>
<td>The patient has the ability or potential for ambulation with variable cadence. He or she is likely to achieve community ambulation, with the ability to traverse most environmental barriers, and may have vocational, therapeutic or exercise activity that demands prosthetic use beyond simple locomotion.</td>
</tr>
<tr>
<td>K4</td>
<td>The patient has the ability or potential for prosthetic ambulation that exceeds basic ambulatory skills, exhibiting high impact, stress, or energy levels during activity. This category includes most children, active adults or athletes with amputation.</td>
</tr>
</tbody>
</table>

## K Level Component Selection

- **K0**: Bed or Chair Restricted
  - Prosthesis not medically necessary
- **K1**: Transfers & Household Ambulation
  - SACH or Single Axis
- **K2**: Limited, Single Speed Community Ambulating
  - Flexible Keel or Multiaxial ankle/foot
- **K3**: Variable Speed, Community Ambulating
  - Energy storing, Multiaxial/Dynamic Response, Flexfoot, Flexwalk
- **K4**: No Limitations

## K Levels Overview

**There is no single “best” prosthetic foot**
- The “best” foot for an individual patient will be defined by their functional abilities and associated needs
- It may change through the course of rehabilitation
Matching Feet to Function

**K1** - Transfers & level terrain; Enable safety early stance

© Medical University of South Carolina
Perry and Burnfield, 2010.

Matching Feet to Function

**K2** - Limited community; Adapt to uneven terrain

© Hanger Clinic
Perry and Burnfield, 2010.

Matching Feet to Function

**K3 & K4** - Variable speed; Energy storage & return

© Hanger Clinic
Perry and Burnfield, 2010.
Consider how such forces are resisted in a socket
- Residual tibia extends into the socket
- Creates localized pressures

Consider implications of a rigid ankle/stiff heel
- Flexion moment at the knee
- Potentially unstable
- Especially with weak knee extensors

K1: Enable Safety

Stiff heels create potentially dangerous knee flexion moment

Compressive heel reduces flexion moment, shifts GRF anterior

SACH: Solid Ankle Cushion Heel

- Simple
- Inexpensive
- Durable
- Indications

© Ossur

Perry and Burnfield
K1: Enable Safety

**Single Axis Foot**
- Reduces flexion moment;
- Shifts GRF anteriorly quicker.
- Mechanical axis w/ bumpers;
- Resistance to dorsi- & plantarflexion.

**Indications**
- Rapid foot flat
- Increased weight
- Increased maintenance

**Posterior Bumper:**
Eccentric Dorsiflexors
- What would you see if this was too stiff?

**Anterior Bumper:**
Eccentric Plantarflexors
- What would you see if this was too soft?
K2: Adapt to Uneven Terrain

Multi-axial Foot

• Provides multiaxial foot movement
  • Plantarflexion/dorsiflexion
  • Inversion/eversion
  • Internal & external rotation
• Preferred for un-even terrain
• Absorbs gait torque to reduce shearing forces on the residual limb

Adapt to Uneven Terrain

Multiaxial Foot with Dynamic Response
Willow Wood Fusion Foot

K3: Energy Storage and Return

Energy Storing Foot

Dynamic Response w/ multiaxial ankle unit

"Flex Foot" (long spring)

"Flex Walk" (short)

Shank foot with vertical loading pylon
K3: Energy Storage and Return

- Initial contact opens to allow plantarflexion
- Internal keel structure "absorbs" energy during mid-stance and terminal stance
- "Releases" energy at pre-swing (toe off) to provide a smoother gait.

Benefits are more apparent at faster speeds

- Smoother dynamics during gait
- Reduced impact on the sound side heel strike

Endoskeletal Construction

- Facilitates multiple alignment options /changes
  i.e. the relative position of the foot underneath the prosthesis
- Allows feet to be interchangeable
Endoskeletal Construction

Four set screws acting against an inverted pyramid enable angular alignment changes...

...which, in turn, affect the relative "length" of the "toe" and "heel" of the foot.

---

Endoskeletal Construction

Heel Height Considerations: Transtibial

- Prostheses are aligned to a single heel height
- A change in shoes can dramatically affect overall alignment

---

© College Park Knapp, 2013
Endoskeletal Construction

Heel Height Considerations: Transfemoral
• Considerable attention is given to the relative position of the prosthetic knee over the prosthetic foot.

Footshells
• Come in different colors or skin tones
• Worn over blade-style feet
• Split toe options

Other Specialty: Feet/Enhancements

Rotational Torque Adapter
• Reduces shearing forces
• Built into the foot or attached as a separate component
• Provides rotation mobility for standing and twisting movements
Other Specialty: Feet/Enhancements

**Vertical Shock Absorbers**
- Built into the foot or attached as a separate component
- Reduce impact forces during stance phase
- Reduce sheer forces within the socket
- Improves prosthetic rotational forces at heel strike

---

Other Specialty: Feet/Enhancements

**Running Feet**
- Efficient J-shaped springs
  - "Absorb" energy during loading
  - "Release" energy at toe off
- Not conducive for general walking
  - Too stiff
  - No heel

---

Other Specialty: Feet/Enhancements

**Heel Height Adjustable Foot**
- Patient can change height to accommodate various shoes
- This does not change overall prosthetic alignment
Other Specialty:
Feet/Enhancements

Activity Specific Feet
• You may be surprised!
• Discuss with your prosthetist

Foot Review

There is no single “best” prosthetic foot
• The “best” foot for an individual patient will be defined by their functional abilities and associated needs
• It may change through the course of rehabilitation

What are other factors to consider?

As we look at these people, what else might influence foot selection?
Case Study

"Tom"
- 48 y/o male w/ transtibial amputation 2 years ago.
- Uses his prosthesis daily, both in his home and in the community.
- Works in an office environment
- Enjoys golf on the weekends

- Define Tom’s likely K-level
- Suggest possible foot types

Case Study

"Tom"
- Variable speed community ambulator
  - K3 level function

- Energy Storing/Dynamic Response
  - Dynamic Response w/ multiaxial ankle
  - Torque absorber
  - "Flex-walk" system

Case Study

"John"
- 78 year old male, recent transfemoral amputation
- Comorbid diabetes
- Anticipated function: Predominantly indoor walking with occasional usage outside the home.
  - Elevated walking speeds are unlikely.

- Define John’s likely K-level
- Suggest possible foot types
Case Study

“John”

- Single speed, limited community ambulation
  - K2 functional level
- Single Axis, Multi-axis or Flexible Keel foot
  - Foot flat quickly
  - Induce knee extension moment
  - Adapt to irregular surfaces in the community

Summary

Foot type is determined by a patient’s ability and potential

- Indoor vs. community walking
- Environmental obstacle negotiation
- Single speed vs. variable speed

Thank you

John Rheinstein, CP, FAAOP
jrheinstein@hanger.com
Cell 917-589-1015

877-4HANGER (877-442-6437)
Email: info@hanger.com
Questions?

Thank you!
Introduction to Prosthetic Feet
Finding the Foot That Fits

Citations

References


