Diabetes as a Factor

• 70% of all lower limb amputations are related to diabetes
• An amputation related to Diabetes is performed every 30 seconds around the world

Mortality After Diabetic Related LE Amputation

14% will die in 30 days,
42% in 3 years,
62% in 5 years

• Contributing factors:
  - Age
  - Race
  - Renal or cardiac co-morbidity
  - Level of amputation
  - Tobacco use

Trans-Tibial Amputation

• Aim is to preserve the knee
• Avoid skin grafts unless to save the knee
• Long posterior flap is preferred
• Residual tibia should be beveled and no longer than the junction of distal 1/3
• Fibula should be slightly shorter than tibia
• Perform myodesic closure
• Post-operative cast for protection
Joint Flexion Contracture

- Flexion contractures are frequent
- Predisposes ulceration
- Easily prevented with early rehabilitation
- Not easily treated
- Makes prosthetic fitting and walking more difficult

Post-Operative IPORD

- Rigid dressing:
  - Maintains good knee position
  - Controls edema
  - Protects skin from trauma
  - Allows early rehabilitation

Immediate Post Operative Pylon

- Reduces edema and joint contractures
- Promotes wound healing and stump maturation
- Allows early weight bearing and in some cases ambulation, i.e. trauma
TF Level Surgical Intervention

- Always try to preserve the knee.
- Use fish mouth closure with myoplastic closure for stability and improvement of hip control.

New Surgeries

- Keep-Walking® Device

New Surgeries

- Osseo Integration
Pain in Limb Amputation

- Four major sources of pain:
  - Post surgical pain
  - Residual limb pain
  - Prosthetic related pain
  - Phantom pain

HO in Amputation

- Incidence in up to 70% of traumatic amputees
- Less than 30% for vascular amputees
- More frequent in TFA

Heterotopic Ossification
Preparatory Prosthesis Phase

- Pre-prosthetic management
- Gait training with temporary prosthesis (pylon)
- Promote limb maturation
- Edema control and limb shape
- Pain management
- Prosthetic component selection

The Rx

- Can you please write a prosthetic Rx for a 39 year old female with left TTA 2nd to trauma.
- The patient is a MRI technician and cares for her 11 year old daughter and 9 year son.
Prosthetic Rx
• Construction design
• Socket
• Suspension
• Connecting parts
• Foot
• Knee (in TFA or higher)
• Cosmetic cover
• Accessories
• Regulatory requirements

Prosthesis Selection Criteria
• Desired function
• Match to patient needs and abilities
• Weight
• Cost

TT prostheses
Endoskeletal Systems

- Adjustable
  - flexion / extension
  - abd / adduction
  - rotation
  - limited translation
- Re-alignable
- Allows for component interchange or replacement
Single Axis Ankle-Foot

Multi-Axis Ankle-Foot

Energy Storing Feet

Subjective sense of active push-off
For increased activity level
Works best when no AD used
Moderate to higher cost based on design
Adding Mobility to ES Designs

- Adjustable resistance

Split toe design allows some degree of inversion-eversion

Shock Absorbing and Rotating Pylons

- Ceterus
- TT Pylon
- Vari-Flex

High Performance feet
Silicone Partial Foot

Foot Selection Criteria

- Desired function
- Patient capabilities
- Cost
- Weight

Prosthetic Foot Weight

<table>
<thead>
<tr>
<th>Type</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot Type</td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td></td>
</tr>
<tr>
<td>Dynamic</td>
<td></td>
</tr>
<tr>
<td>Fixed</td>
<td></td>
</tr>
<tr>
<td>C-Section (FD)</td>
<td></td>
</tr>
<tr>
<td>C-Section (PD)</td>
<td></td>
</tr>
<tr>
<td>Foot Type (FD)</td>
<td></td>
</tr>
<tr>
<td>Foot Type (PD)</td>
<td></td>
</tr>
<tr>
<td>Total Foot</td>
<td></td>
</tr>
</tbody>
</table>
The newly designed Pro-Flex TS feet produced improvement in walking, functional rating as well as benefits in self-rated performance and stability. This new feet design should be considered as an excellent choice for patients with Medicare functional ambulatory category 2 through 4. Tests of function and satisfaction should be used in future prosthetic foot trials and considered in foot prescription.
Energy Cost of Ambulation at Different Levels of Lower Limb Amputation

% Increase in Energy Expenditure

Symes TTA TK A TFA HD Normal

Transtibial Socket and Suspension

Abnormal Pressures
Pressure Distribution

intolerant
tolerant

Prosthetic Socks

Transtibial Suspension
Sleeve Friction Suspension

- Neoprene
- Spandex
- Elastic rubberized
- Rubber

Esquenazi
Amputee - adjustable
Accommodates gross volume changes [e.g. ESRD]
Often requires Waist Belt
Pistoning inevitable

Strap Suspension Cuff

Very short RL
Delicate or sensitive skin
Knee contracture
Cannot tolerate full WB
Ligamentous disruption
Bulky, heavy, awkward
Quadriceps atrophy

Thigh Corset & Joints

Cosmetic Cover
**Trans Femoral Componentry**

**Transfemoral Sockets**
- Plug Fit
- Quadrilateral Ischial Weight Bearing
- Modified IPOS
- Ischial containment

**Ischial Containment Frame**

Suction Socket
Donning a prosthesis
Push-in          Pull-in

Transfemoral Suspension
• Suction
• Friction / Vacuum
• Anatomical
• Adjustable
• Straps
• External Joint

Suction Socket Suspension
• Not adjustable
• Very secure
• Allows full range of motion
Silicone Suspension

Adjustable Socket

Silesian Belt  TES Belt
Pelvic Belt & Hip Joint

- Reduces hip torque
- Increases ML stability
- Bulky, heavy, awkward
- Interferes with toileting and seating in a car or low chair

Suspension Challenges

Knee Joints
Manual Locking

- Knee of last resort
- Maximum stability + chronic gait deviations
- Interferes with sitting, falling safely
- Try to avoid using 2 locking knees

Weight Activated Stance Control

- Adds stance phase weight-activated stability
- For limited ambulators + slow walkers
- Hip flexion deformity
- May make sitting very difficult for bilateral

Weight Activated Stance Control
Knees
Carbon Graphite Hydraulic
• Reliable
• Some maintenance
• Manually adjustable
• Swing & Stance controllers
• Rubber seals may dry up over time

Polycentric (4 bar)
• Excellent stability + good swing phase function
• Use to increase confidence while walking
• To accommodate very long RLs such as KD

Swing / Stance Controllers for Knees
Swing / Stance Controllers for Knees

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Approximate Weight</th>
<th>Power Source</th>
<th>Intended User</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLK Self Learning Knee</td>
<td>DAW Industries</td>
<td>Lithium -ion battery lasts up to six months, depending on use</td>
<td>K3, K4</td>
</tr>
<tr>
<td>Smart Adaptive Knee</td>
<td>Endolite</td>
<td>Rechargeable for 15 days / Average</td>
<td>K3, K4</td>
</tr>
<tr>
<td>P&amp;I Microprocessor Knee</td>
<td>Freedom Innovations</td>
<td>Lithium -ion battery, approximately 15 hours of use</td>
<td>K3, K4</td>
</tr>
<tr>
<td>Max Knee</td>
<td>Exact</td>
<td>Lithium -ion battery lasts up to 50 hours of continuous use</td>
<td>K4</td>
</tr>
<tr>
<td>C-Leg</td>
<td>Otto Bock</td>
<td>Lithium -ion batteries hold 15-15 hours of continuous use</td>
<td>K3, K4</td>
</tr>
<tr>
<td>GeriKnee</td>
<td>Otto Bock</td>
<td>Lithium -ion batteries hold 10-15 hours of continuous use</td>
<td>K3, K4</td>
</tr>
<tr>
<td>4-bar Power Knee</td>
<td>Yulu</td>
<td>Batteries last up to 3 years, depending on intensity level</td>
<td>K3, K4</td>
</tr>
<tr>
<td>Fusion Power Knee</td>
<td>Yulu</td>
<td>Batteries last up to 3 years, depending on intensity level</td>
<td>K3, K4</td>
</tr>
</tbody>
</table>

Hydraulic Cylinder Microprocessor Controller

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<td>Otto Bock</td>
<td>Lithium -ion batteries hold 10-15 hours of continuous use</td>
<td>K3, K4</td>
</tr>
<tr>
<td>4-bar Power Knee</td>
<td>Yulu</td>
<td>Batteries last up to 3 years, depending on intensity level</td>
<td>K3, K4</td>
</tr>
<tr>
<td>Fusion Power Knee</td>
<td>Yulu</td>
<td>Batteries last up to 3 years, depending on intensity level</td>
<td>K3, K4</td>
</tr>
</tbody>
</table>
Hip Disarticulation

Knee Selection Algorithm

Able to control knee in stance?

No

Able to control during swing?

No

Manual locking knee

Yes

Weight activated stance control

Polycentric knee

Yes

Level of activity

Potential benefit from increased stability

Medicare Functional Levels (K system)

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>K0</td>
<td>None ambulatory</td>
</tr>
<tr>
<td>K1</td>
<td>Household ambulator</td>
</tr>
<tr>
<td>K2</td>
<td>Community ambulator</td>
</tr>
<tr>
<td>K3</td>
<td>Community ambulator, light sports</td>
</tr>
<tr>
<td>K4</td>
<td>High level activity, sport</td>
</tr>
</tbody>
</table>
Medicare Components Benefit

<table>
<thead>
<tr>
<th>Level</th>
<th>Component Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>K0</td>
<td>None</td>
</tr>
<tr>
<td>K1</td>
<td>SACH or single axis foot No fluid control knee</td>
</tr>
<tr>
<td>K2</td>
<td>Flexible keel, multiaxis foot No fluid control knee</td>
</tr>
<tr>
<td>K3</td>
<td>Energy storing, flex or multiaxis foot Fluid and microprocessor knees</td>
</tr>
<tr>
<td>K4</td>
<td>All except for powered components</td>
</tr>
</tbody>
</table>

Microprocessor Functional Capability

- Functional Level 3-4
- Provides resistance to flexion/extension during swing phase
- Enables variable cadence; ability to change walking speeds without hesitation
- On board microprocessor analyzes gait and selects appropriate resistance for smooth swing phase.
- Provides variable cadence and ability to change walking speeds without hesitation
- Added expense due to computer technology
- Maintenance is essential

BTF Amputation

Esquenazi
• Patient wears an instrumented insole under the intact foot with a transmitter
• The forces on the insole determine the movement and location of the non-amputated leg
• Power Knee calculates and motors adjusts where the prosthetic leg should be

Power Knee Genium Knee

Microprocessor Controlled Powered Prostheses (HP)
Prescribe based on function

- Limited ambulator = basic design
- Greater activity level = more sophisticated componentry design