Advancements in Upper Limb Prosthetic Technology and Rehabilitation

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DISCLOSURE STATEMENT

Bambi Lombardi, OTR/L and Patrick McGahey, LCPO both work as specialists for Hanger Clinic in the Upper Limb Prosthetics Program.

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LEARNING OUTCOMES

• Attendees will learn about the advancements in the different types of technology available to the upper limb prosthetic end user.

• Attendees will understand the functional differences between each type of upper limb prosthetic technology presented.

• Attendees will be able to engage the patient in various training methods specific for the prosthetic technology used.
Therapist as Coach
Upper Limb Amputation Levels

Interscapulothoracic

Shoulder Disarticulation

Transhumeral

Elbow Disarticulation

Transradial

Wrist Disarticulation

Transcarpal

Finger Amputations

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UPPER LIMB FUNCTIONS

Fine Manipulation
UPPER LIMB FUNCTIONS

Power Grasp
UPPER LIMB FUNCTIONS

Communication
UPPER LIMB FUNCTIONS

Interact with environment
UPPER LIMB FUNCTIONS

Self-Image

What matters most is how you see yourself.
MULTIPLE PROSTHESSES

• No single prosthetic system meets all needs.
PROSTHETIC GOAL

Provide appropriate appearance and function to increase independence with ADLs and improve quality of life.
PRESCRIPTION CRITERIA - GOALS

- VOCATION
  - TOOL HANDLING
  - CUSTOMER INTERACTION
  - GRASP & PREHENSION REQUIRED
  - PRECISION VERSUS POWER REQUIRED
- BODY COMPOSITION
  - STRENGTH
  - ROM
  - SKIN CONDITION
- MENTAL & PSYCHE HEALTH
  - PROSTHETIC MAINTENANCE
  - HYGIENE
  - APPROPRIATE ACTIVITIES
  - LIMB/PERSONAL CARE
- SECONDARY OR SUPPLEMENTS
  - AVOCATIONS
  - SPECIAL CONSIDERATIONS DURING FABRICATION AND DESIGN
- APPROPRIATENESS
PROSTHETIC OPTIONS

- No Prosthesis
- Oppositional prosthesis / Passive functional prosthesis
- Body powered prosthesis
- Externally powered prosthesis (myoelectric)
- Hybrid prosthesis
- Activity-Specific prosthesis
OPPOSITIONAL / PASSIVE FUNCTIONAL
Oppositional/Passive Functional Prosthesis

**Benefits:**
- Provides opposition
- Can be lightweight
- Most are simple
- Usually little maintenance

**Limitations:**
- No active prehension
- Limited function
- Patient can have unreal expectations for cosmesis
BODY POWERED PROSTHESIS
Powered and controlled by gross body movements captured by a harness system.
Body Powered Prosthesis

**Benefits:**
- Can be less expensive
- Can be heavy duty construction and function
- Environmentally resistant
- Increase in sensory feedback

**Limitations:**
- Grip strength or pinch force limited
- Restrictive and uncomfortable harness – functional envelope limited
- Poor static and dynamic cosmesis
- Axilla anchor (possible sound side nerve problems)
VOLUNTARY OPENING

Standard hook

Work hook

1 RB = 1-1.5 LBS.
EXTERNALLY POWERED PROSTHESIS
SWITCH OR MYOELECTRIC CONTROL

• Powered by battery systems

• Controlled by various input devices such as switches or electrodes
EXTERNALY POWERED PROSTHESIS
SWITCH OR MYOELECTRIC CONTROL

Benefits:
• Increased grip strength
• Harness system reduced or eliminated
  – Improved comfort
  – Increased functional range of motion
• Minimal energy expenditure

Limitations:
• Initial cost
• Maintenance cost
• Weight*
• Requires battery power

*Note: Weight may vary depending on specific prosthesis model.
MyoHands and Greifer Ottobock

MyoHand
VariPlus Speed®
SensorHand Speed®

Greifer DMC
VariPlus

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Program 1 = Four Channel Control
Program 2 = Co-Contraction
Program 3 = Safety Co-contraction
Program 4 = Switch Control
Program 5 = One-Electrode Control
(Default Program is Program 1)
Motion Control Hand
Motion Control

Wide grasp

Multi-flex or flexion wrist option

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Motion Control Hand – Wrist Flexion Unit

Motion Control

- Hand is in better position for reading
- Multi-flex or flexion wrist
- Easier to get to midline for dressing, zipper
- Hand is in better position. Minimizes compensatory motions at shoulder and trunk
Electric Terminal Device (ETD)  
Motion Control

- High pinch force
- Slender tips and high pinch force
- Water-Resistant
- Good visibility
- Wide opening
MICHELANGELO
OTTOBOCK

• Fast and powerful
• Powered thumb rotation
  o 2 positions
  o Return to neutral option
• Natural appearance
• Relaxed hand posture
• Flexible OVAL wrist - 8 lock options
• Powered Wrist Rotation Option
• 7 grasp patterns
Axon Hook Interchange with Michelangelo Hand

AxonHook
Product Information

Gripping small objects
Carrying objects
Open palm
Large opening width
• Individually powered fingers
• 2 position thumb rotation
• Thumb position determines grip pattern
• 14 different grip patterns and hand positions
i-limb HAND
Touch Bionics

**ultra**
- 5 individually powered digits
- Friction thumb rotation
- 14 grip patterns, some custom
- Pulsing for grip strength
- Flexion wrist option

**quantum**
- imo™ technology .....the first upper limb prosthesis that can change grips with a simple gesture
- Available in 4 sizes and up to 30% stronger and faster
- The battery life is 50% longer

**ultra revolution**
- All features of ultra
- Automatic or manual thumb
- 24 grip features
- 12 my grips
- grip chips™
ACTIVITY-SPECIFIC
ACTIVITY-SPECIFIC
New Advancements: Pattern Recognition and Targeted Muscle Reinnervation (TMR)

Pattern Recognition: Instead of one or two electrode sites, an array of electrodes is used to capture a pattern of movement that is more intuitive for the end user.

Targeted muscle reinnervation can create **new** myoelectric control sites.

Multiple joints can be **simultaneously** controlled with myoelectric signals.
Osseointegration

- Titanium fixture implanted directly to bone
- Fixture protrudes through skin
- Prosthesis directly attaches to fixture
  - Solves many current socket fitting problems
  - Has problem with infection at fixture site
- Recently, FDA just awarded SLC/VA group permission for human subject testing
PHASES OF CARE

• Preprosthetic Management
• Prosthetic Training Phase
PREPROSTHETIC MANAGEMENT

KEY COMPONENTS:

• Patient Education
• Psychological Support in the Grieving Process
• ADLs and Change of Dominance
• Edema Control and Limb Shaping
• Desensitization / Scar Massage
• Mirror Therapy
• Functional AROM, Strengthening, Body Symmetry
• Myosite testing / training
PSYCHOLOGICAL SUPPORT IN THE GRIEVING PROCESS

The Five Stages of the Grieving Process

Denial
Denial is usually experienced by people who go through traumatic amputations. Meaningless, overwhelmed. How can I go on, how can I get through another day?

Anger
Often people will blame God, the doctor, or others for their loss.

Bargaining
In this stage, patients may attempt to postpone the reality of amputation and most patients will try to bargain with their doctor to go back in time or through a higher authority such as a religious figure, alternative therapies or experimental drugs.

Depression
In this stage, anger is replaced by depression. This is probably the most complicated stage of grief, but it too will go away. This is not clinical depression. It is normal. Common symptoms include sleeping either too much or too little, negative feelings about the environment and the future, feelings of hopelessness, and talking about death. Depression is not a sign of weakness, however, and should not be seen as such. It is treatable, and you should not hesitate to seek help from your doctor, nurse, family and friends.

Acceptance and Hope
Eventually, you will come to terms with your loss and start living again. This is more easily achieved if you have a visit from a peer counselor who has been through this entire process and can give you some tips on coping with your loss.

The Psychological Aspects of Amputation, by Saul Morris, PhD
PSYCHOLOGICAL SUPPORT IN THE GRIEVING PROCESS

Peer support and community resources:

**AMPOWER**
Beyond clinical care, Hanger Clinic created and supports the AMPOWER Program, a three tiered program designed to empower and strengthen those affected by amputation or limb difference through peer mentorship, education and community. EmpoweringAmputees.org, which was established to provide guidance and encouragement for those with limb deficiency and limb loss. AMPOWER also provides in-person and over-the-phone support, education and the opportunity for community connection.

[HangerClinic.com/AMPOWER](HangerClinic.com/AMPOWER)

www.amputee-coalition.org
ADL’s / Assistive Devices: SELF-CARE

- Button hook
- Nail clipper
- Nail brush
- Elastic shoelaces
- Hair dryer stand
ADL’s / Assistive Devices: **SELF-CARE**

- **Body scrubber**
- **Wash mitt**
- **Sensor soap dispenser**
- **Hands-free wall mounted shower dispenser**
ADL’s / Assistive Devices: HOME MGMT.

- **Chopper / food processor**
- **Can Opener**
- **Zim jar opener**
- **Rocker knife**
- **Cutting board**
ADL’s / Assistive Devices: HOME MGMT.

Dycem (non-skid mat)

Keyless entry
CHANGE OF HAND DOMINANCE

Handwriting For Heroes
Learn to Write with Your Non-dominant Hand in Six Weeks
Kathleen E. Yancosek, MS, OTR/L, CHT
and Kristin Gulick, OTR/L, CHT
Illustrated by Erin M. Spears

RADIAL DIGIT COORDINATION

SEPARATION OF RADIAL & ULNAR SIDES OF HAND

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CHANGE OF HAND DOMINANCE
EDEMA CONTROL / LIMB SHAPING

Compressogrip, Tubigrip

Compressive Wrap

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DESENSITIZATION / SCAR MASSAGE

Elastomer
Graded Motor Imagery (GMI)
Phantom Pain

3 Stages of GMI
- Left Right Discrimination
- Explicit Motor Imagery
- Mirror Therapy

Mirror Therapy
12-15 minutes/day
5 days/week
4 - 8 weeks

http://www.gradedmotorimagery.com/
AROM, STRENGTHENING, SYMMETRY

Weight Bearing

CORE, Cardio, Upper limb

Body Symmetry
MYOSITE TESTING AND TRAINING

Myoelectrode Position

Fit of Socket

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PHASES OF CARE

• Preprosthetic Management

• Prosthetic Training
  o Prosthesis: **non-dominant role, assists sound limb**
    • Lacks sensation and fine motor control
  o Encourage RELAXED posture
    • Minimizes compensatory motions and inadvertent co-contraction
  o With comprehensive training, most patients can become independent in all functional activities
PROSTHETIC TRAINING

• Communication with Prosthetist
• Independent donning and doffing
• Changing terminal devices
• 3 Phases of Prosthetic Training
  - Basic Control
  - Gaining Control
  - Bi-manual Skills Training
DONNING PROSTHESIS
CHANGING TERMINAL DEVICE
PROSTHETIC TRAINING

- Communication with Prosthetist
- Independent donning and doffing
- Changing terminal devices

- 3 Phases of Prosthetic Training
  - *Phase 1: Basic Control*
  - *Phase 2: Gaining Control*
  - *Phase 3: Bi-manual Skills Training*
PROGRESSION OF TREATMENT

To Challenge Patient...

• Begin in sitting with tasks at midline.
• Progress to right/left of midline, overhead, close to ground
• Standing
• Walking / dynamic activities

Encourage normal movement patterns and watch for compensatory motions.
PHASE 1: BASIC CONTROL

Mirroring
PHASE 1: BASIC CONTROL

POSSIBLE SOURCES OF DIFFICULTY

- Co-contraction of muscles
- Improper fit of socket
- Gains may need to be adjusted

DO NOT PROCEED UNTIL PATIENT HAS MASTERED THESE MANEUVERS.
PHASE 2: GAINING CONTROL

UNILATERAL ACTIVITIES to master 3 control skills:

• Prepositioning of terminal device (TD)
• Proportional control
• Opening width
PHASE 2: GAINING CONTROL

PREPOSITIONING of terminal device (TD)

• Placing the terminal device in the most optimal position before initiating grasp/release.

• Minimizes compensatory movements at the trunk, shoulder and elbow.

• Reduces unnecessary or awkward movements.
PHASE 2: GAINING CONTROL

Compensatory Movement
PHASE 2: GAINING CONTROL
PHASE 2: GAINING CONTROL

UNILATERAL ACTIVITIES to master 3 control skills:

• Prepositioning of terminal device (TD)
• Proportional control
• Adjust opening width
PHASE 2: GAINING CONTROL

PROPORTIONAL CONTROL: Precise control of TD

• Strong muscle contraction ➔ fast grasp
• Light muscle contraction ➔ slow, delicate grasp
PHASE 2: GAINING CONTROL

Prehension Control
GOALS IN PHASE 2: GAINING CONTROL

• Master each control skill independently
  o Prepositioning
  o Prehension Control
  o Opening width

• Then, practice applying these skills simultaneously.
PHASE 3: BI-MANUAL SKILLS TRAINING

• The longest and most challenging phase of prosthetic training.

• Patient directed. Use checklist to identify goals that are important and meaningful to the patient.

• Allow patient to problem solve. Intervene only as needed.

• As therapists, we may learn more from our patients than we may be able to teach them.

• Repetition and practice. Takes time to learn a new way of doing things.
<table>
<thead>
<tr>
<th>Name:</th>
<th>Age:</th>
<th>Occupation:</th>
<th>Date(s) of Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapist:</td>
<td>Sex:</td>
<td>Type of terminal device:</td>
<td></td>
</tr>
</tbody>
</table>

**RATING GUIDE KEY:**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impossible</td>
<td>Accomplished with much strain, or many awkward motions</td>
<td>Somewhat laborious, or few awkward motions</td>
<td>Smooth, minimal amount of delays and awkward motions</td>
</tr>
</tbody>
</table>

**ACTIVITIES OF DAILY LIVING**

<table>
<thead>
<tr>
<th>PERSONAL NEEDS</th>
<th>GENERAL PROCEDURES</th>
<th>HOUSEKEEPING PROCEDURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don/butt-on shirt</td>
<td>Turn key in lock</td>
<td>Perform laundry</td>
</tr>
<tr>
<td>Dress button-down shirt: cuffs and front</td>
<td>Operate door knob</td>
<td>Fold clothes</td>
</tr>
<tr>
<td>Manage zippers and snaps</td>
<td>Place chain on chain lock</td>
<td>Set table on watch</td>
</tr>
<tr>
<td>Don/butt-on pants</td>
<td>Plug cord into wall outlet</td>
<td></td>
</tr>
<tr>
<td>Don/butt-on belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lace and tie shoes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don/butt-on pantyhose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tie tie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don/butt-on bra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don/butt-on glove</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut and file fingernails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polish fingernails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screws/screw cap of toothpaste tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squeeze toothpaste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open top of juice bottle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set hair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take bill from wallet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open pack of cigarettes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light a match</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don/butt-on prosthetics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform personal hair care</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EATING PROCEDURES:**

| Carry a tray | Manipulate hot pots |
| Cut meat | Thread a needle |
| Butter bread | Sew a button |
| Open milk carton | |

**DESK PROCEDURES:**

| Use phone and take notes | Hammer |
| Use pen and take notes | Screw drivers |
| Sharpen pencils | Tape measure |
| Use scissors | Wrenches |
| Use ruler | Power tools: drill, sander |
| Remove and replace ink pen cap | Plane |
| Fold and seal letter | Shovel |
| Use paper clip | Rule |
| Use stapler | Wheel barrel |

| WRAP PACKAGE: | |
| USE COMPUTER: typing, access | |
| Internet | |
| Demonstrate handwriting | |

**COMMENTS:**

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BI-MANUAL FUNCTIONAL SKILLS TRAINING
PRACTICE

- Tying shoelace
- Opening a tube of toothpaste
- Using scissors to cut paper
- Zipping a jacket
- Donning socks
- Buckling a belt
- Applying a Band-Aid®
- Cutting food
- Using a fork and knife
- Folding towels
- Buttering bread
- Stirring (in a bowl)
- Opening and closing various packages, boxes, containers and jars.
TYING SHOE LACES (ETD)
THE SHAPE OF SUCCESS

Prosthetist

Patient

S
U
C
C
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S
S

Therapist
REFERENCES


THANK YOU!!