- If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.
- This handout is for reference only. Non-essential images have been removed for your convenience. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.

Technical issues with the Recording?

- Clear browser cache using these instructions
- Switch to another browser
- Use a hardwired Internet connection
- Restart your computer/device

Still having issues?

- Call 866-782-9924 (M-F, 8 AM-8 PM ET)
- Email customerservice@OccupationalTherapy.com

CONTINUED

Current Topics in Upper Limb Loss and Difference Virtual Conference

Guest Editor: Debra Latour, OTD, MEd, OTR/L

CONTINUED

Current Topics in Upper Limb Loss and Difference: OT for Targeted Muscle Reinnervation and Pattern Recognition Control

Kristi Turner, DHSc, OTR/L
Center for Bionic Medicine
Shirley Ryan Ability Lab

CONTINUED

CONTINUED

Acknowledgements

- The information presented is from the work completed in the Center of Bionic Medicine at Shirley Ryan AbilityLab

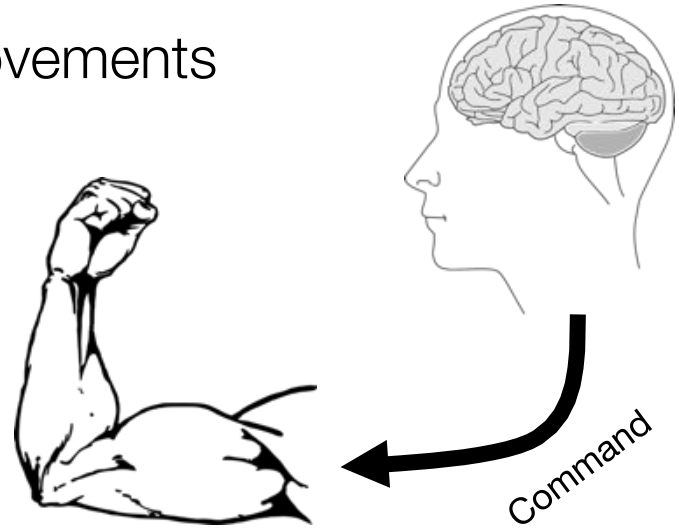
CONTINUED

Learning Outcomes

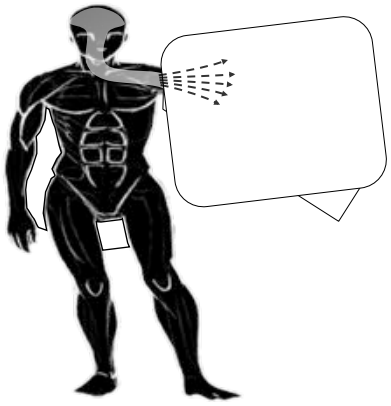
After this course, participants will be able to:

- Describe targeted muscle reinnervation surgery and the training process.
- Describe pattern recognition control and identify the difference between direct control and pattern recognition.
- Describe the benefits of pattern recognition and TMR for individuals with upper limb differences.

Movements



Nerves still there



- Even though arm is amputated, nerves going to the arm remain
- Signals are still there
- Nerves carried all of the information to arm before - so can record signals from nerves to operate

Biological solution

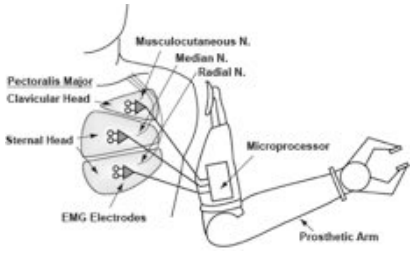
- Muscle makes myoelectric signal 1000x bigger than nerve signals
- Don't break down
- Have their own power supply

Targeted Muscle Reinnervation

Dr. Todd Kuiken, MD, PhD

TECHNIQUE

- Muscle acts as a **'biological amplifier'** of the motor command



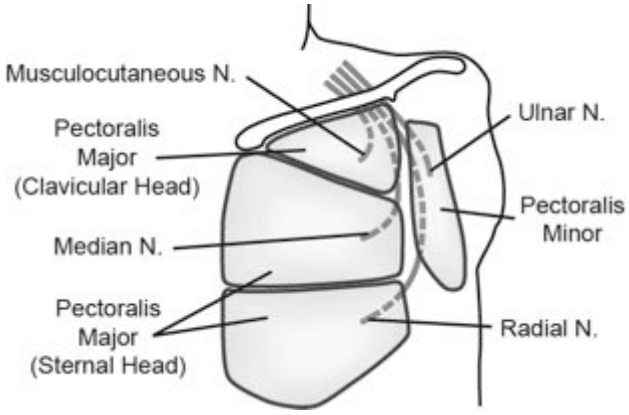
ADVANTAGES

- Additional control signals for **simultaneous** control of more DOFs
- Control signals are physiologically appropriate
- No implanted hardware required
- Can use existing myoelectric prosthetic technology

DISADVANTAGE

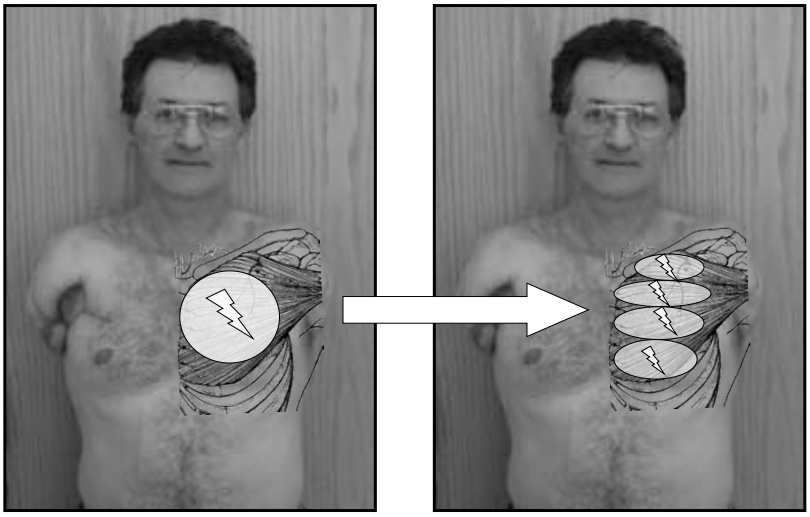
- Requires additional surgery (unless it is done at time of amputation)

First TMR participant



Dr. Gregory A. Dumanian, MD

Goal: Create more control sites



Pre-Op
1 available control signal

Post Op
4 available control signals

Motion During Contraction After TMR

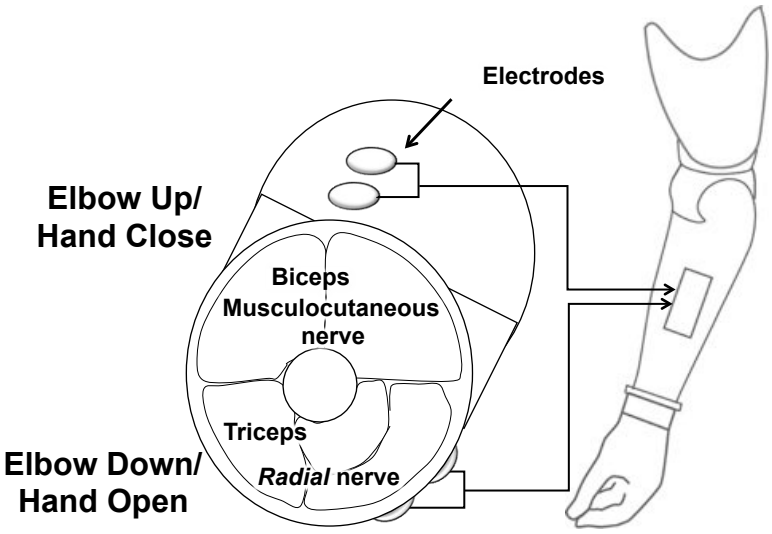
Benefit from TMR

Original Prosthesis
(Used more than 20 months)

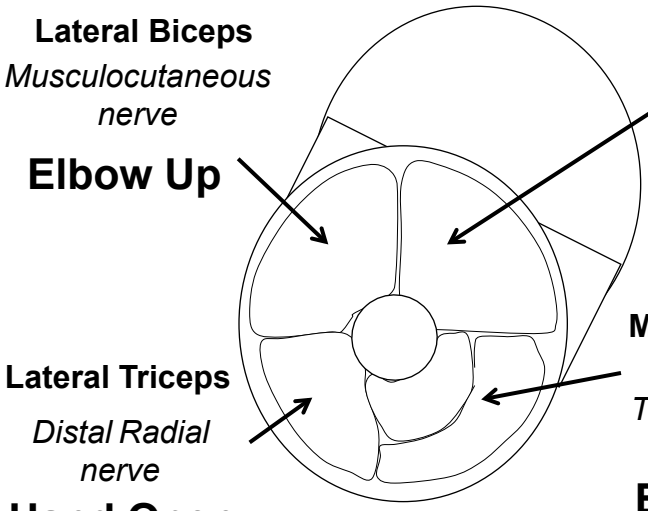
Post-TMR Prosthesis
(Used about 2 months)

First TMR Patient

Conventional transhumeral fitting



Transhumeral TMR



Differences with TMR vs. standard myoelectric

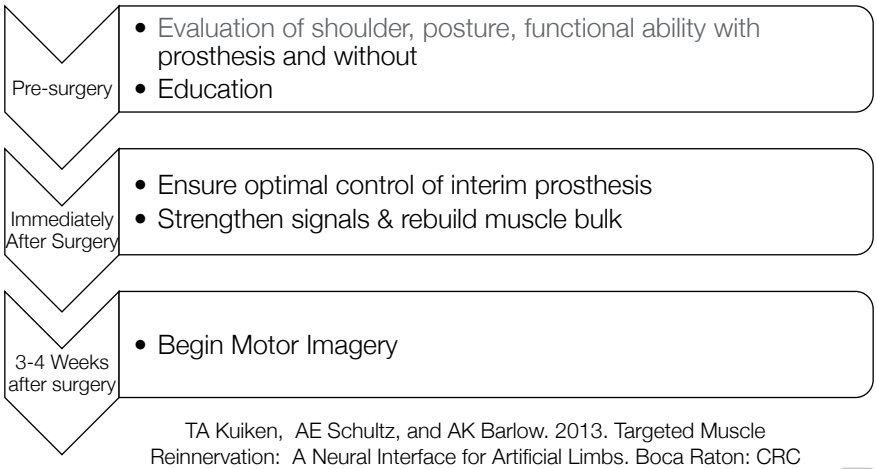
- Large amount of motor control info transferred to target muscles
- Each large transferred motor nerve contains motor control content for a variety of arm & hand functions
  - Reinnervated in a relatively small area of muscle
- Understanding of peripheral function
- Based on surgery, which nerves anticipated to reinnervate muscle regions

Native Nerve Actions

Musculocutaneous Nerve	Radial Nerve	Median Nerve	Ulnar Nerve
• Elbow Flex	• Elbow Ext • Supination • Wrist Ext • Radial Deviation • Finger Ext • Thumb Ext	• Pronation • Wrist Flex • MP & PIP Flex • Thumb Flex	• Ulnar Deviation • Ulnar Finger Flex • Finger ABD

TA Kuiken, AE Schultz, and AK Barlow. 2013. Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs. Boca Raton: CRC Press.

TMR OT Progression



TA Kuiken, AE Schultz, and AK Barlow. 2013. Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs. Boca Raton: CRC Press.

CONTINUED

TMR OT Progression

6-15 weeks after surgery
- When muscle twitching, begin motor imagery strengthening
- Gross movement patterns

10-20 weeks after surgery
- Discrete movement strengthening
- As become stronger, begin graded contraction exercises

24+weeks after surgery**
- When 3 or more potential myosites, begin prosthesis control training
- Trouble shoot: socket fit, electrode sites, best transferred nerve actions

TA Kuiken, AE Schultz, and AK Barlow. 2013. Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs. Boca Raton: CRC Press.

CONTINUED

Examples of Gross Motor Patterns

- Flexion: Median and Ulnar nerves (top)
- Extension: Radial and Ulnar nerves (bottom)

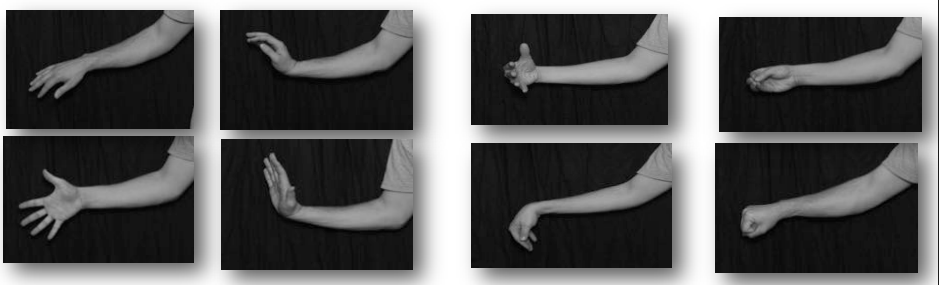
TA Kuiken, AE Schultz, and AK Barlow. 2013. Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs. Boca Raton: CRC Press.

CONTINUED

Examples of Discreet Motions

- Radial Nerve Actions
- Median Nerve Actions

Hand Open | Wrist Extension | Wrist Flexion | Hand Closed



Supination

Relax

https://www.youtube.com/watch?v=EPeXM_Wgu5o

Pronation

Document Changes in Ability

Quantitative Outcome Measures	Qualitative Outcome Measures
• Southampton Hand Assessment Procedure (SHAP) • Assessment of Capacity of Myoelectric Control (ACMC) • UNB Test of Prosthetics Function • Box & Block Test • Jebsen Taylor Hand Function Test	• Orthotics & Prosthetics User-Survey-Upper Extremity Functional Status (OPUS-UEFS) • Trinity Amputation & Prosthetics Experience Scales (TAPES) • Canadian Occupational Performance Measure (COPM) • Disabilities of the Arm Shoulder & Hand Outcome Measure (DASH) • Patient Specific Functional Scale (PSFS)

TA Kuiken, AE Schultz, and AK Barlow. 2013. Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs. Boca Raton: CRC Press.

TMR Functional Outcomes

- More than 1000 TMR patients worldwide and growing…
  - Walter Reed Army Medical Center
  - Brooke Army Medical Center
  - Vienna, Austria
  - Edmonton, Canada
  - University of Washington
  - Quito, Ecuador
  - Many more…

An individual with an above-elbow amputation from Walter Reed Army Medical Center demonstrating the use of his TMR prosthesis

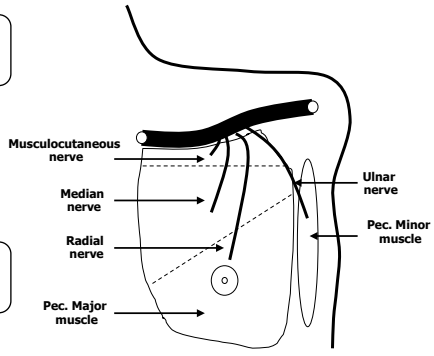
Things that Help Outcome

Communication

- Copies of the surgical report
- Know where to start looking!

Working as a team

- Prosthetic fitting should take place in conjunction with occupational therapy



Requirements for Successful TMR

Independent Signal

- Each target muscle needs to be fully denervated
- Transferred nerves to reinnervate one muscle segment

Signals large enough to record

- Strengthen nerves

Neuroma Pain Study

Traction Neurectomy with Burying

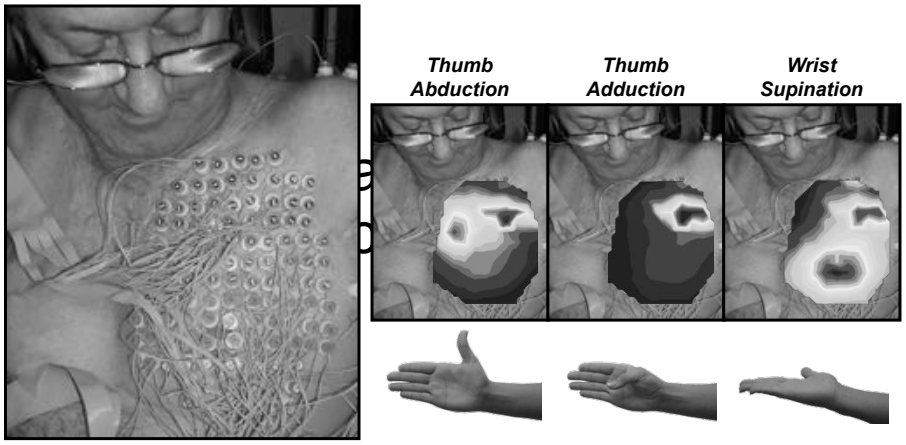
Targeted Muscle Reinnervation (TMR)

Dumanian, G. A., et al (2019) Targeted muscle reinnervation treats neuroma and phantom limb pain in major limb amputees. Annals of Surgery 270(2), 238-246

TMR for Transradial

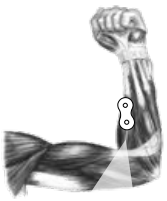
- Distal median nerve transfer to *flexor digitorum superficialis* (FDS) or *brachioradialis* muscle
- Distal Ulnar nerve transfer to *flexor carpi ulnaris* (FCU) muscle
- Improved control for multiarticulating hands?

Pattern Recognition

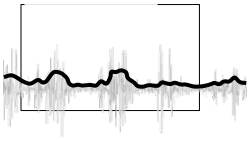


29

Direct Control vs. Pattern Recognition

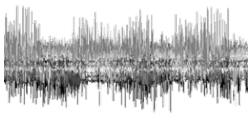


One myoelectric signal



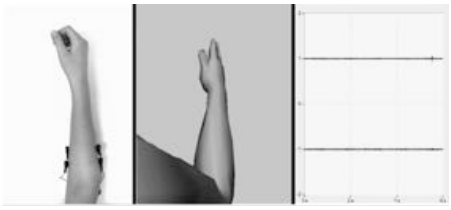
Muscle contractions produce electrical activity that we can sense using electrodes on the skin surface

Patterns of myoelectric signals

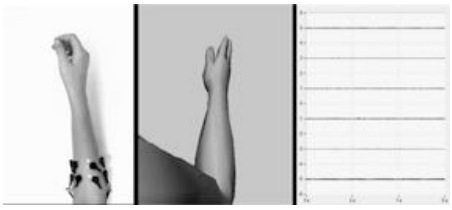


Myoelectric Prosthesis Control

- CONVENTIONAL
  - Depends on isolated myosites
  - Uses signal amplitudes
  - Requires mode switching (such as co-contraction)



- PATTERN RECOGNITION
  - Uses information from multiple myosites
  - Uses signal content (features)
  - Provides intuitive control of multiple DOF



Calibration Guided by Prosthesis

Pattern Recognition Considerations

- TR, TH, or SD prosthesis
- Motivated user with good cognitive function
- Any combination of powered components
- Earlier fittings for TMR
- Funding

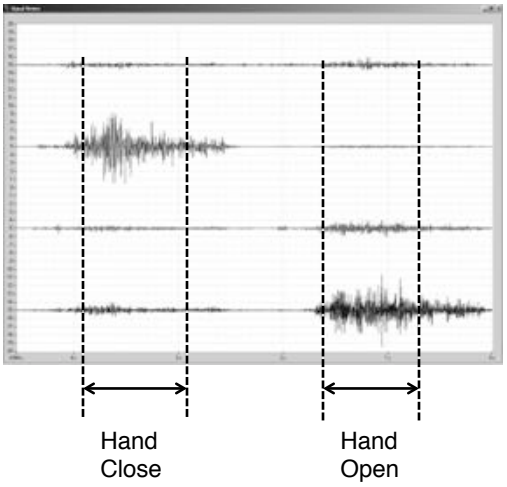
Pattern Recognition Education

- Review pattern recognition concepts
- Differences between direct control (if applicable)
- One DOF at a time
- Educate on fatigue (Physical/Mental)

- Establish unique and *repeatable* movements
  - Start with native movements and modify as needed

Pattern Recognition Education

- Understanding pattern recognition concept
  - EMG "picture"
  - Repeatability

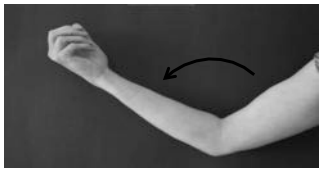


Phantom Limb Considerations

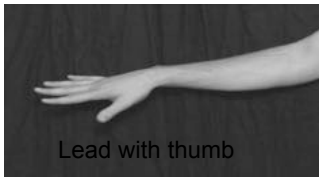
- Can they identify phantom limb position?
- Are they able to move phantom limb?

- Try to move, even if feels immobile
- Use photos to assist – can use as HEP as well

Home Exercise Program Example




Elbow Down
Elbow Up



Palm Down
Palm Up


Hand Close
Hand Open

Calibration of the Prosthesis

- Review calibration sequence
- Focus on timing of contractions/ relaxation
- Mirror with sound limb (if able)
- Therapist verbalize motions/timing

Observations

- Watch for postural changes and/or facial expressions
- May indicate too forceful contractions
- RELAX
- Watch for fatigue

Multiple Calibration

- Useful when control is not optimal in other positions
- May increase functional envelope

Same Therapy

- Pre-positioning Education
- Various sizes, weights, materials
- Different positions
- Bimanual Tasks
- Functional Tasks
- Watch for postural adaptations

Home Use

- Patient should monitor their performance with the prosthesis and learn to recalibrate as necessary
- Understand when it is beneficial to use multiple calibration data
- May achieve good control with more refined movements and less effort

Pattern Recognition: Pros/Cons

PROS	CONS
▪ No Switching	▪ Easy access to all motors
▪ Easy access to all motors	▪ Possibility of unintended movements
▪ More “natural” movements	▪ Recalibration is needed
▪ ⇩ Prosthetist time	▪ Need to educate patient of when to recalibrate
▪ Begin OT sooner	
▪ ⇩ Interruptions of OT	
▪ Can recalibrate when control is not as desired	

Troubleshooting

Unintended Movement

- Move during “No Movement” collection

Confusion with movements

- Watch posture – are they trying harder?
- Mirror movement – did they change their movement?
- Modify movements to be more unique

Hand opens too easy, fearful of dropping

- Calibrate/train that movement with stronger contraction

Take Home Points

- IMPORTANT TO RELAX
- Review phantom limb awareness/ movements as practice continues with PR
- NOT SCARY

Please Note!!!

- You **DO NOT** need to have TMR to benefit from Pattern Recognition
- You **DO NOT** need Pattern recognition if you have TMR

HOWEVER

- TMR & Pattern Recognition work well together!
- Especially for complex prosthesis

CONTINUED

References

- Dumanian, G. A., Potter, B. K., Mioton, L. M., Ko, J. H., Cheesborough, J. E., Souza, J. M.,…….Jordan, S. W. (2019) Targeted muscle reinnervation treats neuroma and phantom limb pain in major limb amputees. *Annals of Surgery 270*(2), 238-246.
- Kuiken, T. A., Schultz, A. E., & Barlow, A. K. (2014). *Targeted Muscle Reinnervation: A neural interface for artificial limbs.* Boca Raton, FL: Taylor & Francis
- Kuiken, T., Li, G., Lock, B., Lipschutz, R., Miller, L, Stubblefield, K., & Englehart, K. (2009). Targeted muscle reinnervation for real-time myoelectric control of multifunction artificial arms. JAMA, 301(6), 619-628.
- Simon, A. M., Lock, B. A., Stubblefield, K. A. (2012). Patient training for functional use of pattern recognition – controlled prosthesis. *Journal of Prosthetics and Orthotics, 24(2*), 56-64.
- Stubblefield, K., Funucane, S. B., Miller, L. A., Lock, B. A. (2011, August 14-19). *Training individuals to use pattern recognition to control an upper limb prosthesis.* Proceedings of the 2011 MyoElectric Controls/Powered Prosthetics Symposium, New Brunswick, Canada.

CONTINUED

Questions?

- kturner@sralab.org

CONTINUED

CONTINUED

Current Topics in Upper Limb Loss and Difference Virtual Conference

Mon 11/11	Unlimbited Wellness and Secondary Conditions Debra Latour, OTD, MEd, OTR/L
Tues 11/12	Problem Solving Complex Issues with Pediatric Upper Limb Loss Difference Vivian Yip, OTD, MA, OTR/L
Wed 11/13	OT for Targeted Muscle Reinnervation and Pattern Recognition Control Kristi Turner, DHSc, OTR/L
Thurs 11/14	Bilateral Upper Limb Loss Shawn Swanson Johnson, OTR/L
Fri 11/15	Electronic Multi-Articulating Hands and Digits, Toe-to-Hand Transfers, and Hand Transplantations Diane J. Atkins, OTR/L, FISPO

CONTINUED