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Nerve Injury Assessment & Management

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Disclosure

No financial relationships to disclose relevant to my presentation.
Outline

• Nerve Injury & Recovery
• Strategies for Surgical Reconstruction
• Assessment
• Treatment Strategies
  – Early Phase
  – Late Phase
  – Sensorimotor re-training & Cortical changes
• Questions, Discussion

Nerve Injury

Sustained a fall with a humeral #
• Radial nerve?
• Brachial Plexus?


Nerve Injury
• distal receptors
• nerve
• cell body
• cortex
Recovery Following Nerve Injury
Rehab Considerations

It’s All About the Brain

Normal Nerve
- Composed of neural & connective tissue
- Proportion of neural tissue to connective tissue varies; nerve, location
- Plexus within the nerve varies along the length of the nerve

Nerve Injury

Mechanisms
- Stretch or traction
- Laceration or penetrating wound
- Crush
- Blast
- Acute nerve compression
Classification of Nerve Injury

Seddon (1943)
- Neurapraxia
- Axonotmesis
- Neurotmesis

Sunderland (1951)
- Degrees I - V

Sunderland I - Neurapraxia
- Conduction block, no nerve degeneration
- Recovery usually complete
- Up to 12 weeks
Sunderland II - Axonotmesis

- Endoneurial tubes intact
- Axonal degeneration
- Abnormal EMGs
- Regeneration 1 inch/month
- Recovery usually complete

Sunderland III

- Axonal degeneration
- Abnormal EMGs
- Regeneration 1”/month
- Incomplete recovery benefit from sensory and/or motor reeducation

Sunderland IV

- Neuroma in continuity
- Nerve continuity preserved but involved segment is scar tissue
- Needs surgery to resect neuroma and restore nerve function
Sunderland V - Neurotmesis

- Nerve continuity disrupted - transection
- Needs surgery to restore continuity

“I - V” – Mixed Nerve Injury

- Some fascicles may be normal and adjacent to fascicles of varying nerve injury

“I - V” – Mixed Nerve Injury
Nerve Injury - Response

- Neural Tissue
- Connective tissue


Nerve Injury - Response

- Nerve must regenerate within the injured connective tissue
- Regenerating axons need the structural support of the perineurium but increased connective tissue can impede regenerating axons

Nerve Injury - Response

Response of both neural and connective tissue
- ↑ stress, ↑ connective tissue
To minimize scar tissue & adhesions
- Consideration of the zone of injury & no tension at nerve repair site
- Early motion


Recovery
Classification of Nerve Injury

<table>
<thead>
<tr>
<th>Degree of Injury</th>
<th>Tinel Sign</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Neurapraxia</td>
<td>No</td>
<td>Complete</td>
</tr>
<tr>
<td>II Axonotmesis</td>
<td>Yes</td>
<td>Complete</td>
</tr>
<tr>
<td>III</td>
<td>Yes</td>
<td>Varies</td>
</tr>
<tr>
<td>IV Neuroma In-continuity</td>
<td>At level of injury</td>
<td>None</td>
</tr>
<tr>
<td>V Neurotmesis</td>
<td>At level of injury</td>
<td>None</td>
</tr>
<tr>
<td>I-V Mixed</td>
<td>Some fascicles</td>
<td>Some fascicles</td>
</tr>
</tbody>
</table>

Nerve Injury
Level of Brachial Plexus

Recovery or Surgical Intervention

- Spontaneous recovery (closed injury)
- Surgical intervention
  - nerve repair, graft, transfer
  - tendon or muscle transfer
  - depends on timing, nerve injured, patient factors

Nerve Repair

- End to end nerve repair
- Without tension
- Outside the zone of injury

Nerve Graft
Available Donors
Nerve Transfer

• Involves transfer of an innervated donor nerve to a recipient nerve to provide a source of nerve for sensory or motor innervation
• Proximal nerve injuries & avulsion injuries

Nerve Transfer

• Faster and superior reinnervation - Source of nerve closer proximity to the denervated muscle
• Examples:
  – BP injury - Fascicle from ulnar and median nerve to biceps and brachialis
  – High ulnar nerve injury – AIN to deep motor branch ulnar nerve

Assessment
Assessment
Nerve Injury vs. Nerve Compression

- Nerves involved & level
- Severity
- Change in status
- Recovery

Assessment
Nerve Injury vs. Nerve Compression

Physiological
NCS, EMGs

Clinician Reported
SWMF, 2pd, Strength, ROM

Patient Reported
Symptoms, DASH, MHQ, Health Status, HRQoL, Psychosocial

Caregiver Reported

International Classification of Functioning, Disability and Health Model

Nerve Injury

- Interrelationships: health condition, body functions/structures, activity, participation and influence of the contextual factors.
- Positive (improvement) or negative (degradation)
Health Condition
“Nerve Injury”

Body Function & Structure
Sensory, strength, ROM

Activities
Limitations in tasks

Participation
Restriction in work
Social, recreation

Environmental Factors
Work, climate, cultural, family responsibilities

Personal Factors
Age, co-morbidities, catastrophizing, self-efficacy

ICF - Assessment
Clinical Assessment – sensory & motor function
- Body Functions & Structures: physiologic function and anatomical body parts.
- Impairment of structures or functions: loss deviation from normal function.

Functional Assessment & Self-report
- Activity: ability to perform an action or task; may be limited with difficulty performing required tasks or actions.
- Participation: involvement in life situations.
- Individual’s capacity to perform actions and their environment, including personal factors reflects performance.

Contextual factors
- environmental and personal factors - includes environment in which they live & factors such as age, gender, medical co-morbidities, coping styles, other psychosocial issues

Patient Evaluation
- Subjective patient report
- Sensory
  - qualitative, quantitative
  - provocation maneuvers
- Motor
  - strength - manometers, manual muscle testing, atrophy, ROM
Patient Evaluation

History
• Mechanism of injury

Subjective Evaluation
• Symptoms
• 10 cm visual analog scale
• Body diagram

McGill Pain Questionnaire
• Adjectives
• 10 cm VAS
• Present Pain Intensity
• New version to differentiate neuropathic & non-neuropathic pain

Visual Analog Scale
• 10 cm line
• To measure intensity of symptoms

No Pain          Most Severe Pain
Unable          Able to perform
Healthy         Death
Good quality of life Worst quality of life
Subjective
Pain Evaluation Questionnaire
- pain adjectives
- body diagram
- visual analog scale
  pain, stress, coping, anger
  impact on QoL, depression
- questionnaire

Adjectives
> 3 pain descriptors

Body Diagram
Outside anatomic pattern

Questionnaire
Score > 20

Symptom Diagram
- Body
- Extremity
- Hand

Rank 0-10
- Numeric Rating Scale
Sensory Assessments

Objective
– NCS, EMG

Quantitative
– vibration thresholds
– 2pd
– SWMF

Qualitative
– Hot/cold; Pain

Sensory Evaluation

Median Nerve – Index
Ulnar Nerve – Small
Radial Nerve – Dorsum 1st web

Which sensory test is best to assess the patient after nerve injury or with nerve compression?

• Protective sensation
• Light touch
• Vibration
• Cutaneous pressure threshold
• Two-point discrimination
• Function
• Self-report
Tests of Provocation

• To identify the sites of nerve compression
• Reproduction of patient symptoms
  - Median Nerve
carpal tunnel, forearm
  - Radial Nerve
  - Ulnar Nerve
    Guyon’s canal, cubital tunnel
  - Brachial Plexus

Tests of Provocation

• Carpal tunnel
  - Tinel’s
  - Phalen’s
  - Pressure provocative test
  - Combine pressure and wrist flexion/extension
• Median nerve forearm
Tinel's Sign

Phalen's Sign
Wrist Flexion & Pressure

Median Nerve Forearm
Tests of Provocation

Ulnar nerve
• Guyon’s canal
• Cubital tunnel
  - Tinel’s
  - Pressure provocative test
  - Combine pressure on ulnar nerve and elbow flexion
Tests of Provocation

Brachial Plexus Nerve Compression
- Tinel's
- Pressure provocative test
- Arm elevation
- Combine pressure on brachial plexus and arm elevation
Tests of Provocation

Spurling’s test
- Cervical foraminal encroachment
- Cervical side flexion, slight extension with axial compression
- Positive with a “spray” of symptoms in the upper extremity

Sensory Assessment

- Which test?
- When?
- How do you choose?
Measurement

- **Valid** - measure is assessing what it intends to measure
- **Reliable** - measure is consistent and free from random error
- **Responsive** - able to detect change when it has occurred

Sensory Evaluation

**Quantitative Assessment**
- Light touch – numeric scale
- Threshold testing - vibration, cutaneous pressure
- Tactile discrimination – 2pd
Sensory Assessment

- Which test?
- When?
- How do you choose?

Sensory Evaluation – Ten Test

- Rapid screening, patient self report
- Light touch comparison to the contralateral area on a scale of 0 to 10


Semmes Weinstein Monofilaments

- Consistent testing methods
- Significant increase in pressure thresholds as contact time increased (SW p < 0.0001, stress p < 0.05, force p < 0.22)

Two-point discrimination

- Establish normal values of moving 2pd in children
- 313 children/adolescents ranging from age 4-18 years
- Moving 2pd of 2-3 mm in majority of subjects
- Unreliable responses in children ≤ 5 yrs

Hermann, Novak, Mackinnon. Dev Med Child Neurol, 1996

Vibration Threshold – Tuning Fork
30 cps vs. 256 cps

- Contralateral comparison
- Consistent application
- Not simultaneous stimulus

Vibration Threshold

<table>
<thead>
<tr>
<th>Single frequency</th>
<th>Multiple Frequency</th>
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<tbody>
<tr>
<td>120 Hz</td>
<td>8 – 500 Hz</td>
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</table>
Two-point Discrimination

Interrater Reliability for Sensory Measures

- Moving 2pd  ICC = 0.991
- Static 2pd  ICC = 0.989
- Vibration  ICC = 0.982
- SWMF      ICC = 0.965

Nerve Compression

- Varying severity
- Continuum of neural changes

Sensory Measure of Hand Function

- Relationship between hand function and 2pd
- 43 patients following median nerve repair or graft
- Hand function assessed with small and large object identification
- Strong correlation, $r = .7$

Novak, Mackinnon, Kelly. Ann Plast Surg, 1993

Sensory Measures

- Nerve Injury:
  - Return of low frequency vibration & threshold before 2pd
  - Threshold may not return to normal
  - 2pd correlates with object ID

Novak/OccupationalTherapy.com
Sensory Measures

- Nerve Compression:
  - Early changes in threshold measures
  - Provocation tests to identify compression sites
  - Severe; atrophy, abnormal 2pd

Functional Assessment

- Object identification
- Functional dexterity
- Braille ID – 9 dot pattern
  Novak et al, PRS 1993
- Composite scores: sensory, motor, & pain
  Rosen & Lundborg, JHS 2000

Self-Report Questionnaires

- General health status - SF-36, SF-12
- DASH, Michigan Hand questionnaire
- Disease specific - CTS symptom severity & functional status scale
- Cold sensitivity
- Psychosocial – pain catastrophizing, depression symptoms
Patient Specific Functional Scale

Assess functional status with items identified by the patient.
Identify 3 items: unable to perform or have difficulty with
Degree of difficulty assessed on a 10 cm VAS


Clinical Practice or Research

No one measurement tool possesses all the qualities necessary to evaluate all patients under all conditions
Nerve injury vs Nerve Compression
Severity vs. Recovery vs. Outcome

Sensory Assessment

• Select best measure or battery of measures to provide comprehensive sensory assessment
• Identify the goals of assessment
• From the perspective of the patient, hand therapist, surgeon
Treatment Strategies

Early Rehab Following Surgery
- Immobilize to protect the nerve coaptation site: repair vs. graft vs. transfer
- Range of motion
- Enhance neural mobility - with ROM exercises proximal & distal
- Nerve graft - donor site

Splinting, Range of Motion, Modalities
**Electrical Stimulation**

- Denervated vs innervated muscle
- Direct vs alternating current
- Functional ES
- Neuromuscular ES
- Threshold ES
- No published studies to support efficacy

**Nerve Stimulation**

Stimulation of the nerve
- Accelerate axonal regeneration and muscle reinnervation
- Mediates effects on the cell body & enhanced production of the neurotrophin brain-derived neurotrophic factor

Exp Neurol, 2015, 2010
Neuromedial Neural Repair, 2014

**Strengthening**
Rehabilitation

Late Postoperative
- Range of motion & strengthening exercises
- Sensory reeducation
- Motor reeducation
- Sensorimotor reeducation

Q: Do you ALWAYS include sensory reeducation after sensory nerve injury?

Q: Do you ALWAYS include motor reeducation after motor nerve injury?
Q: Do you ALWAYS include motor reeducation after sensory nerve injury?

Sensory Re-education

- After nerve injury commonly included in therapy protocols

Sensory Re-education
Does it make a difference?

No high level studies

- Searched Medline CINAHL AMED EMBASE – 2011
- 94 articles screened
- Included 7 articles

- Limited by study design
- Small sample size
- Different methods of assessment, inclusion and treatment

Sensory Re-education
Does it make a difference?

- Theory – cortical re-mapping
- Many studies
Neuroplasticity
Central nervous system
- ability to change in response to internal and external influences
Sensory Re-education
Does it make a difference?
• Neuroplasticity and cortical remapping
• Many studies evaluating surgical outcomes following nerve injury incorporate sensory re-education in post-op protocols
??? Without sensory re-education???

It’s All About the Brain
• Neuroplasticity
• CNS - changes in response to internal and external influences
• Alteration of cortical representation – influenced the amount and type of input
  – Following deprivation of input or overstimulation
  – Increased or decreased usage
  – Learning of new skills or injury

Alteration of Cortical Representation
Influenced by amount & type of sensory input
• expanded representation in reading finger of blind Braille readers
• expanded cortical region in left hand of string musicians & differences in piano vs trumpet players
Alteration of Cortical Representation with Injury

- Primate models
- Advancements in imaging: ↑ studies in humans

Somatosensory Cortex

- Use-dependent changes in brain
- Following nerve injury, changes begin immediately and continue over time

Median Nerve Injury & Repair

- Median nerve does not recover original territory
- Optimal recovery with specific training, practice & purposeful movement
Cortical Plasticity & Remapping

- Mechanisms for cortical reorganization remain unknown
- Important in maximizing sensorimotor recovery

Mechanisms for Re-mapping

- Uncovering of silent synapses
  - Speed of phantom limb development
  - Distance of remapping
- Formation of new axon arborizations
  - May contribute to larger distance remapping
  - Remapping may occur at multiple levels
    - Brain, spinal cord

How to do Sensory Reeducation?

- No standardized protocols
- No high level studies
- Variable recovery and presentation after nerve injury & different patterns of nerve injury
Neuroplasticity

Central nervous system
  • ability to change in response to internal and external influences
Changes related to experience
  • Learning of new skills
  • Injury

Alteration of Cortical Representation After Nerve Injury

  • Immediate changes
  • Continual changes with reinnervation & recovery

Immobilization

  • Alteration of cortical mapping after motor nerve injury and other non-nerve related injuries
  • Immobilization - ↓ movement
  ↓ cortical mapping
  • Motor patterns change with sensory loss & requires integration of sensory and motor function
Sensory Re-education & Timing

Q: When do you begin sensory re-education after median nerve injury & repair?

Sensory Relearning

- Rosen & Lundborg
- Maintain the cortical hand map – visuo/tactile interaction & mirror training, audio/tactile interaction and use of sensor glove
- Enhancing effects of sensory re-education – using cutaneous anesthesia to allow expansion of the cortical hand map

Cutaneous anaesthesia forearm

- Healthy subjects
- EMLA cream
- Stimulation of fingers R hand
- fMRI - Rapid change with hand represented in forearm region

Outcome after Nerve Repair with Immediate Post-op Re-learning

- RCT study design: Starting 1st week after nerve repair using mirror visual feedback and observation of touch vs. control group
- Present improved discriminative touch early results at 6 months

Personal Timetable

- Loss of sensation
  - Patient education, protection
  - Increase input to sensory map
- Return of sensation
  - Continue with protection strategies
  - Sensory & motor reed
- Improving sensorimotor function

Sensory Re-education

- Localization
- Texture
- Discriminatory tasks
  - Purposeful movement
  - Bimanual tasks
  - Keys, coins
Sensorimotor Re-education
After Nerve Injury

• Altered cortical mapping following nerve injury
• Progress exercises as sensation improves
• Need to be organized for good functional recovery & include purposeful movement and activities

“Purposeful Movement & Activities”
Patient specific activity
Bimanual tasks

Google search “hand holding keys”
Median vs Ulnar Nerve Injury

Distal Nerve Injury

Median
- Main functional deficit - lack of critical sensation
- Weakness of thumb abduction and opposition

Ulnar
- Main functional deficit – loss of motor function
- Less “critical” sensation to ulnar border of hand

Low Median Nerve Injury

Main functional deficit - lack of critical sensation

Motor – Loss of thumb opposition
Low Ulnar Nerve Injury

- Main functional deficit – loss of motor function to hand
- Less “critical” sensation to ulnar border of hand

Orthoses for Function

- Median vs Ulnar Nerve
- Provide position & stability
- Custom made or commercially made?
- Material?
- Augment or improve function

Functional Activities
Can't Reeducate a Painful Region, Digit or Extremity

Interaction with Pain & Motor Cortex

- Acute experimental pain has inhibitory influence over the motor cortex & interfere with motor learning
- Pain interacts with function
- Acute experimental pain has shown inhibitory influence over the motor cortex & interfere with motor learning

Mercier & Leonard, Physiother Can, 2010

Hyperesthesia vs. Dysesthesia vs. Allodynia vs. Hyperalgesia
IASP Taxonomy

• Allodynia: Pain due to a stimulus that does not normally provoke pain.
• Hyperalgesia: Increased pain from a stimulus that normally provokes pain.
• Hyperesthesia: Increased sensitivity to stimulation.

International Association for the Study of Pain

IASP Taxonomy

• Allodynia is suggested for pain after stimulation which is not normally painful. Hyperesthesia includes both allodynia and hyperalgesia, but the more specific terms should be used wherever they are applicable.

IASP Taxonomy

Pain

• An unpleasant sensory and emotional experience associated with actual or potential tissue damage
Personal Definition

• Hyperesthesia
• Hypersensitivity to a non-painful or painful stimulus

• What can you do about it?

Desensitization vs. Re-education

In general, in the nervous system

• All forms of activation are balanced by some kind of inactivation or inhibition.
• Applies to all levels of the nociceptive system, from the activation of nociceptive Aδ or C fibers to the excitation of nociceptive neurons in the spinal dorsal horn and the brain.

Available Treatment

• Medications
• Non-operative
– Modalities
– Sensory desensitization
– Training adaptation
• Surgery
Desensitization vs. Re-education

- Complete sensory loss
  - Protect
- Decreased sensation
  - Sensory re-ed
- Hypersensitivity
  - Desensitization

Desensitization Strategies
Visual Feedback with Mirror Therapy

Majority of literature related to:
• Amputation Injuries – pain & phantom limb
• Complex Regional Pain Syndrome
• Stroke

Mirror Visual Feedback

• 1993
• First patient – UE amputation (1982)
  1 yr following brachial plexus
• With mirror visual feedback – reduction in pain intensity and “phantom limb”

Ramachandran & Altschuler. Brain 2009

Mirror Therapy – 4 wks training

LE Phantom Limb Pain
↓ pain intensity & number, duration of pain episodes

CRPS & Stroke
↓ pain, allodynia & edema
& ↑ motor function

Chan et al. NEJM, 2007
Cacchio. NEJM, 2009
Mirror Visual Feedback

- Alleviates pain depending on the qualitative aspects of the pain
- 22 patients (UE/LE amputation, SCI, PNI)
- Intervention: exercise of the unaffected limb with mirror feedback & perform or imagine activity affected limb
- ↓ in pain intensity & deep-pain adjectives

Sumitani et al, Rheumatology, 2008

Using transcranial magnetic stim
- Mirror viewing enhanced facilitation of ipsilateral primary motor cortex

Mirror Retraining

Studies for treatment of pain related to CRPS and phantom limb
- Mirror therapy increases cortical and spinal excitability
- Sensory experiences can be evoked on the basis of visual feedback
- Visual input enhances tactile sensitivity

Internet Search: “Mirror box” & “Pain”

<table>
<thead>
<tr>
<th>Source</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>YouTube</td>
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<tr>
<td>Google</td>
<td>2,440,000</td>
</tr>
<tr>
<td>Google Images</td>
<td></td>
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How to Construct a Mirror Box for Phantom Limb Pain

YouTube Video
5.46 min

http://www.youtube.com/watch?v=gHFOkVakRkw

Mirror Visual Feedback

- Provides immediate visual feedback
- No consensus on the mechanism or protocols
- Can be used in combination with other therapies
- Not clear which patients will benefit
Clinical Scenario

- Patient with a painful “hypersensitive” neuroma
- Has surgery… nerve is transposed
- Now able to touch the area without discomfort
- But remains with pain
- ?????

Cold-Induced Pain Abnormal Response

Sensorimotor Reeducation

- Enhancing effects of sensory re-education – to allow expansion of the cortical map
- Optimize learning and brain activation
20 minutes aerobic exercise (healthy adults)

- Faster reaction time with no loss of accuracy. Total qEEG power increased 5 and 15 minutes post-exercise
Conclusion

• Benefits to cognition and cortical activity extend for at least 30 minutes after a bout of aerobic exercise
• Provides the opportunity to use this approach to prime CNS state prior to rehabilitation sessions

Positive Effects of Aerobic Physical Activity on Cognition & Brain Function

Physical activity &
• Academic performance in children
• Cognition in older adults
• Cellular & molecular changes

Hillman et al, Nature Reviews 2009

Alteration of Cortical Representation

• Immediate and continual changes with reinnervation
Cortical Plasticity

- Evidence in somatosensory cortex & associated motor cortex
- Similar plasticity in motor cortex as shown in peripheral nerve lesions with muscle transfers and nerve transfers

Changing Central Nervous System Following Intercostal Nerve Transfer

- After ICN or med pec to MC nerve transfer
- Evaluation with TMS or fMRI
- Voluntary elbow flexion had a larger facilitatory effect on motor evoked potentials of the reinnervated muscles.
- No difference in neuronal activity for biceps contraction between patients with good reinnervation and control subjects.
- The cortical “biceps area” appeared to regulate biceps contraction.


Patient (intercostal nerve to biceps) Volitional Breathing

Volitional respiratory centre away from the primary motor cortex

No activation of respiratory centre in patient with intercostal nerve donor for biceps reconstruction during elbow flexion suggests a shift in motor cortex control following this nerve transfer to the biceps.


- Rat model – power vs. control reaching tasks
- Increase in motor cortex represented by distal forelimb vs proximal compared to non-reaching controls
- Conclude: motor cortex is organized to control movement rather than simply individual muscle contraction

Motor Training

- Primary strategy – to improve motor control and skills through practice
- Learning new skills, elite training & athletes
Rehabilitation

Motor Reeducation
- Altered cortical mapping
- Muscle reeducation vs. muscle stimulation
- Effective biofeedback – motor retraining

Motor Training
- Sensorimotor training
- Exercise – to increase strength
- Task-oriented training
  - Constrained therapy
  - Motor imagery
  - Mirror training

Motor Re-education Strategies
- Re-training can begin pre-operatively
- Initially, recruit reinnervated muscle with contraction from donor
- Aim for initiation of muscle contraction and control
- Role of biofeedback (visual, mirror imagery training, audio) & FES
Motor Re-education – Nerve Transfers

- Be aware of antagonist muscle contraction
- Begin with place and hold and progress to exercises against gravity and progressive resisted exercises
- Dissociate target muscle from donor muscle contraction

Nerve Transfer - Motor

- Donor nerve near target muscle
- Expendable donor nerve
- Donor nerve with pure motor fibers
- Donor nerve with large number of motor axons
- Donor muscle is synergistic to target muscle


ICN to MC Nerve Transfer

- Training with deep inspiration
- Chalidapong et al, JBJS(Br) 2006, reported improved contraction of elbow flexors with abdominal crunches
Nerve Transfer
Medial Pec to
Musculocutaneous

Double fascicle transfer – median & ulnar to biceps & brachialis

Medial pec to Musculocutaneous nerve
Thoracodorsal to Suprascapular nerve
AIN to deep motor branch of the ulnar nerve

Nerve Transfer
AIN to deep motor branch of the ulnar nerve

Nerve Transfer
Median to Radial Nerve
9 Months Post-op

1 Year Post-op

**Median to Radial Nerve Transfers - 6 months**
- FDS to ECRB
- FCR/PL to PIN

**Median to Radial Nerve Transfers - 4 years**
- FDS to ECRB
- FCR/PL to PIN
Motor Re-education

- Anti gravity or gravity assisted positions
- Place and hold exercises in mid range
- Progress to exercises against gravity and progressive resisted exercises

Cervicoscapular

- Posture
- Cervical
  - Active ROM
- Shoulder
  - Active ROM
  - Including scapular motion
  - Rotator cuff tendinitis


Scapular GH Motion
Shoulder Function
Scapular Muscle Strengthening

- Motor retraining
- Regain “normal” scapulohumeral movement
- Begin in gravity eliminated & progress to gravity assist positions

Source: Netter Publications

Muscle Balance

- Weak response of reinnervated muscles
- Difficulty firing and isolating weak muscles
- Co-contraction of antagonist muscles
- Strengthen uninjured muscles weak from disuse
• Accessory to Suprascapular Nerve
• Medial Pectoral to Axillary Nerve
• Double fascicle transfer – median & ulnar to biceps & brachialis

Assessing Outcomes

Patient Specific Functional Scale

Assess functional status with items that are identified by the patient. Identify 3 items: unable to perform or have difficulty with Degree of difficulty assessed on a 10 cm VAS

58 yo RHD male
Onset of weakness to right hand. Brachial plexus neuritis – radial nerve function & ulnar innervated intrinsics

10cm VAS
Measure 0 – 10

How to Score?
Each item
Best
Worst
Mean
Nerve Transfers in Tetraplegia

 Courtesy Susan Mackinnon, MD

http: nervesurgery.wustl.edu

Courtesy Susan Mackinnon, MD

Brachialis-to-Extensor Carpi Radialis Longus Selective Nerve Transfer to Restore Wrist Extension in Tetraplegic Case Report

Novak/OccupationalTherapy.com
Successful Rehabilitation

- Integration of sensory & motor re-education
- Emphasis on normal movement patterns (particularly scapular muscles) & bimanual tasks
- Cortical re-mapping
- Fun, purposeful movement

Essentials

- Patient education
- Home exercise program
- Feedback, repetition & practice

It’s All About the Brain

- Cortical plasticity & remapping underestimated
- Important in maximizing motor and sensory recovery