Principles of Tendon Transfers for Persons with Tetraplegia

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Tetraplegia and Hand Function

- Physical Limitations
  - Decreased control of arm in space
  - Limited to no grip/pinch strength
- Functional Limitations
  - Decreased mobility
  - Decreased ADL performance
  - Decreased independence with work tasks
- Psychological Limitations
  - Appearance of hand
  - Confidence/social interaction

When patients asked to list importance in restoration of function:
- Hand use – 75.7%
- Bowel and bladder use – 13.5%
- Walking – 8.1%
- Sexual performance – 2.7%

Hansen, et al. (Arch Phys Med Rehab, 1976)
Tetraplegia and Hand Function

- 65-75% of patients with tetraplegia may benefit from surgery of the upper extremity
- Less than 14% of those identified as candidates actually have surgery performed

- Surgery
- Candidate
- Not Eligible


Why so few?

- Current research examines Physiatrists’ influence:
  - People with tetraplegia who learned about these procedures from physicians were significantly more likely to have a NEGATIVE first impression of UE reconstruction. (Wagner et al, 2007)
  - Physiatrists are more likely to feel that the tetraplegia population is noncompliant and lack social support (Curtin et al, 2007)

Tetraplegia and Hand Function

- Most hand surgeons and physiatrists believed that these procedures were beneficial
- An inadequate referral network between physiatrists and surgeons (Curtin et al, 2005)

Conclusions A lack of coordinated cross-specialty relationships is largest barrier to the appropriate use of upper extremity reconstruction for people with tetraplegia

Rehabilitation Institute of Chicago

- 28 bed in-patient SCI program
- Since 1998, all patients referred to tendon transfer clinic by physiatrist
  - Dr. David Chen
  - Supportive, knowledgeable and proactive regarding tendon transfer procedures for persons with tetraplegia
- Monthly Tendon Transfer clinic with an interdisciplinary and multi-institutional team:
  - Hand Surgeon
  - Physiatrist
  - SCI Occupational Therapist
  - Certified Hand Therapist

Study Participants

- Adults referred to the RIC’s tendon transfer clinic between 1998-2007.
- 113 total clinic evaluations were reviewed.
- 15 subjects had a tendon transfer procedure performed.
- Despite having all patients referred to tendon transfer clinic by a supportive physiatrist, only 7.5% of our patients have tendon transfer procedures performed.
  - Comparable to national average of approximately 10%

Identifying and Educating Surgical Candidates: Tendon Transfer Clinic
Early Presentation of Surgical Options

- General information on surgical options
  - Introduced by inpatient therapist and/or physiatrist near discharge
  - Provide written information in discharge packet
  - Offer video education materials
  - Introduce to post-op patient if at all possible
    - Volunteers
    - Video footage

Team Approach to Evaluation and Treatment of Surgical Candidates

- Patient
- Family/Caregiver
- Physiatrist/Pediatrician
- Occupational Therapist
- Nurse
- Social worker
- Psychologist
- Hand Surgeon

Tendon Transfer Clinic Goals

- Determine candidacy for tendon transfers
- Establish functional goals
- Educate patient/family regarding options
- Communicate between team members
- Determine optimal timing for surgical intervention
- Identify any prehab needs
Who is a Good Surgical Candidate?

- Has functional goals
- Is motivated
- Understands benefits and limitations of surgery
- Demonstrates emotional and psychological stability/adjustment to disability
- Is committed to post-op rehab process

Who is a Good Surgical Candidate? (cont.)

- Has adequate PROM for good post-op function
- Has muscle strength requirements for transfer
- Additional Considerations
  - Has adequate proximal stability
  - Has intact sensation or good compensatory mechanisms in place

Who is a Candidate?

- Individuals with cervical spinal cord injuries
  - SCI ASIA levels C5-C8
  - International Classification 1 or better
Classification of Upper Extremity Involvement

- ASIA Classification
  - Common classification system
  - Based on lowest functioning cord segment
  - Variability in muscle functioning in each class

International Classification for Surgery of the Hand in Tetraplegia

- Determines number of muscles present below the elbow
- For a muscle to be “present,” it must have Grade IV strength
- Note- muscles above the elbow should also be assessed (biceps, triceps, and shoulder muscles)

Manual Muscle Testing - Grading

- 5: Full motion against gravity and against full resistance
- 4: Full motion against gravity and moderate resistance
- 3+: Full motion against gravity and mild resistance
- 3: Full motion against gravity with no resistance
- 2: Full motion in gravity eliminated plane
- 2-: Partial range of motion in gravity eliminated plane
- 1: Trace motion noted/palpable or visible contraction
- 0: No contraction palpable/total paralysis
International Classification System

- 0 - No muscles functioning
- 1 - BR
- 2 - ECRL
- 3 - ECRB
- 4 - Pronator teres
- 5 - FCR
- 6 - EDC
- 7 - Thumb extensors
- 8 - Partial finger flexors
- 9 - All but intrinsic
- X - Exceptions

Common Muscles Transferred

- BR
- ECRL
- Pronator teres
- Posterior deltoid
- Biceps

Manual Muscle Testing

Brachioradialis:
1) Bend elbow to 90° with forearm in neutral rotation
   - Stabilize posterior elbow
2) Apply resistance to distal forearm (at the wrist) in downward direction while patient flexes elbow
Manual Muscle Testing

**Brachioradialis (cont’):**
3) Palpate BR at proximal forearm.
4) Try to displace muscle bulk –
   - if easily displaced, too weak for transfer

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Manual Muscle Testing

**Extensor Carpi Radialis Longus (ECRL) vs Extensor Carpi Radialis Brevis (ECRB)**

- Important to distinguish separately
  - If ECRL is transferred, need ECRB to extend wrist

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Manual Muscle Testing

**ECRL vs ECRB (Cont’)**

- ECRL and ECRB
  - Strength 5/5
  - Bean’s Sign
    - Groove or depression near the lateral epicondyle if both ECRL and ECRB functioning
- ECRL alone
  - Radial deviation of wrist
  - Wrist extension 4/5
Surgical Options

Tetraplegia and Hand Function

- Goals of tendon transfers
  - Increase independence and UE function by improving
  - Elbow extension
  - Lateral pinch (2.2 psi for 90% of ADL)
  - Self-Catheterization
  - Dressing, ADLs
  - Grasp and release
Elbow Extension
Reconstruction

Elbow Extension

- 70% of patients with tetraplegia lose elbow extension

Elbow Extension Functions

- Improved mobility in bed
- Independence with transfers
- Safety with driving
- Balance in sitting
- Weight shifting
- Overhead reach
- Manual wheelchair use
- Acts as an antagonist to brachioradialis
Elbow Extension

- Surgical Alternatives
  - Posterior Deltoid to Triceps
  - Biceps to Triceps

Posterior Deltoid to Triceps

- Deltoid to triceps transfer
  - Elevate posterior deltoid from humeral insertion
  - Raise central 1/3 of triceps tendons with a flap from olecranon
  - Weave triceps and deltoid tendons together using tibialis anterior, fascia lata, or Dacron Tape
Posterior Deltoid to Triceps

Standard Precautions

- Do not allow arm to cross midline for 11 weeks
  - Wheelchair
  - Arm trough
  - Abduction bar
  - Bed
    - Shoulder abducted 30°
    - Arm elevated on pillows

Outcomes - Posterior Deltoid to Triceps

- Elbow extension strength
  - Pre-op
    - MMT 0
  - Post-op
    - 8 grade 4
    - 8 grade 3
    - 1 grade 2

(Lacey, et. al, J Hand Surg, 1986)
Elbow Extension

- Biceps to Triceps
  - Recommended for elbow flexion contracture >30º and supination contracture
  - Must have brachialis and supinator


Biceps to Triceps

- Biceps passed medially
  - Avoid compression of radial nerve


Rehabilitation Biceps to Triceps

- Post-op Day 3-5
  - Post-op dressings removed
  - Place in hinged elbow splint
  - Elbow locked full extension for 3 weeks
  - Worn continuously for 11 weeks
  - No midline restrictions
**Biceps to Triceps**

- 8 deltoid vs. 8 biceps transfers
- At the 24-month F/U
  - 7 of 8 biceps transfers grade 3 or better
  - 1 deltoid transfer grade 3
  - Considerable but subclinical loss of elbow flexion torque
    - deltoid 32%
    - biceps 47%
- All subjects more satisfied with performance of their goals after undergoing elbow extension reconstruction


**Deltoid vs. Biceps**

- Both work well when surgery and rehab are done correctly
- Biceps transfer easier surgery
- Biceps transfer easier to rehab
- In higher level injury or combined with brachial plexus injury, must be sure supinator and brachialis are intact if transferring biceps

**Hand Reconstruction**
Hand Reconstruction

- Goals dependent on number of forearm muscles
  - Expendable
  - Functioning
- Based on International Classification System

International Classification

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - BR</td>
<td>3 - ECRB</td>
</tr>
<tr>
<td>2 - ECRL</td>
<td>4 - PT</td>
</tr>
<tr>
<td>5 – FCR</td>
<td></td>
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</tbody>
</table>

- Transfers done for pinch only
- Transfers done for pinch and grasp and release

Group 2 – Pinch and Grasp

- International Classification = OCu3 or above
  - Two-Stage tendon transfers for hand function
    - Stage 1 = extension
    - Stage 2 = power
- Goals
  - useful grasp
  - pinch
  - release

(House, J Hand Surg, 1985)
Group 2 – Pinch and Grasp

- Available for transfer
  - BR
  - ECRL
  - PT

- Functions needed
  - Finger extension
  - Thumb extension
  - Intrinsic function
  - Finger flexion
  - Thumb flexion
  - Thumb CMC stability

Group 2 – Pinch and Grasp

Extensor Phase (Stage 1)

- Finger extension
  - EDC tenodesis
  - ? Intrinsic balancing

- Thumb extension
  - EPL tenodesis
  - FPL split tenodesis

- Thumb stability
  - Thumb CMC arthrodesis

Group 2 – Pinch and Grasp

- Stage I - Extensor Phase
  - Tenodesis of EDC and EPL
  - Intrinsic tenodesis
Group 2 – Pinch and Grasp

- EDC tendons pass under horseshoe trough in distal radius
Group 2 – Pinch and Grasp

- Intrinsic tenodesis
- Zancolli lasso
- Best when Bouvier’s maneuver produces PIP extension

Bouvier Manuver

Group 2 – Pinch and Grasp

- Stage I – Extensor Phase
- FPL split tenodesis
- Allows transfer to FPL to flex MP instead of IP joint
Group 2 – Pinch and Grasp

Group 2 – Pinch and Grasp

Group 2 – Pinch and Grasp
Group 2 – Pinch and Grasp

- Stage II – Flexor Phase
  - BR to FPL
  - ECRL to FDP

- Synchronize FDP tendons
- Set tension on ECRL to FDP first

- Tension on thumb allows thumb to touch index with wrist in neutral
- Make sure fingers flex before thumb adducts to prevent thumb in palm
Material and Methods

- **Group 1**
  - 3 longitudinal incisions in FDP
  - 2nd incision 90° to others
  - 2-0 braided suture
  - Horizontal mattress at weave sites
  - 5-0 monofilament 3mm from end of each weave

- **Group 2**
  - Same as Group 1
  - Free end of FDS/FPL folded over weave
  - Simple running suture on both sides of splint over weave

Results-Load to Failure

- **Group 1**
  - 117 ± 22N
  - All failed thru weave

- **Group 2**
  - 242 ± 48 N
  - 2 failed thru weave
  - 9 failed thru bone (p<0.001)
3-5 Days post-op
- Remove splint for early motion
  - Place and hold fist
    - Passively place fingers and thumb in fist with wrist in extension
    - Release and hold position
    - Relax slowly into extended position
  - Perform 2 sets of 10 each hour

Functional Tasks
- AROM = 10 days
  - Pinch
  - Grip
- Begin light functional tasks
  - Week 2
- W/C Propulsion
  - 4 weeks
- Functional Transfers
  - 6-8 weeks

Group 2 – Pinch and Grasp
Outcomes – Multiple Procedures

- **Strength**
  - Grip 6-15#
  - Pinch 2-6#
  - Elbow extension MMT: 2 to 4 (from 0)

- **Functional**
  - Picking up objects
  - Using keyboard and telephone
  - Brushing hair
  - Driving
  - Self-catheterization

(Mohammed, Freehafer, Mulcahey, Lamb & Chan)

Outcomes - Patient Satisfaction

  - 77% report positive life impact
  - 70% satisfaction with surgery

- **Mohammed et al (JBJS, 1992)**
  - 70% good or excellent results
  - 84% surgery improved quality of life

Outcomes – Multiple Procedures

- Patients report
  - Surgeries do NOT always increase independence
  - Often Independent prior to surgery
  - DO provide
    - Increased spontaneity
    - Increased speed
    - Increased ease picking objects up
    - Ability to perform specific tasks
      - I.e. may be able to pick up a pen off the table and sign name with one hand instead of donning splint, having someone put pen in place, signing name
Conclusion

- Tendon transfers provide balance and enhanced function to an imbalanced hand
- Pre-operative assessment and conditioning are critical to the success of the procedure
- Surgery should be based on patient-identified realistic goals

THANK YOU