Tendon Transfer…
To Do, or not To Do?

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STEP AHEAD
in Podiatric Surgery

At the 6th Annual ASPS Surgical Conference

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Cleveland Marriott Downtown at Key Center | Cleveland, Ohio
Disclosures

Consultant:
- Bioventus
- Arthrex
Objectives

Attendees should increase their knowledge in the following:

• Anatomy and function of tendons
• Indications for tendon transfer
• Contraindications for transfer of tendons
• Concepts in tendon transfer with understanding various fixation techniques
• Various Surgical techniques in tendon transfers around the foot and ankle
Schematic of Tendon

- Collagen organized hierarchically:
  - Fibrils
  - Fibers
  - Fascicles
- Cellular content is dominated by tenocytes
Collagen

- Type I is most abundant: 95%
- Type II is in the tendon sheets
  - Found abundantly in pathologic tendon
  - First collagen formed during healing
Support Structures

- Straight Course
  - Paratenon
  - Ie...Achilles

- Angled Course
  - Tendon Sheath
  - Synovial Sheath
  - Ie... most ankle tendons
Stress and Strain Curve

Collagen fibers:
- As Age increases:
  - maximum load capacity decrease
  - tear resistance decrease
  - peak values in the third decade
- Elastin:
  - contributes to the flexibility of a tendon,
  - can elongate up to 70% of its length without rupture
  - breaks at 150% of its length.
**Axis of Motion/Fulcrums**

- **Fulcrums:**
  - increase the angle of application
  - improve the efficiency of tendon function
  - Ie…sesamoids are fulcrums for FHB
  - Ie…cuboid is fulcrum for PL

- The ratio of torque for muscles/tendon
  - (1:4) anterior leg : posterior muscles.
  - long lever arm of the forefoot increases the force of the anterior leg muscles.

- The proximity of a tendon to a joint axis will determine whether its force is primarily stabilizing or rotary

- The cross-sectional mass will determine the strength of the force (96,97 and 98).
Tendon Transfer

• relocates the insertion of a functioning muscle tendon-unit (MTU) in order to restore lost movement and function of another site.
Indications

• Permanent peripheral nerve injury*
• Late stage nerve injury with motor end-plate fibrosis
• Others Indications:
  – Loss of muscle post trauma
  – Central neurogenic deficits:
    • Spinal Cord Injuries
    • Cerebral Palsy
  – Tendon ruptures (RA)
  – Rare disorders (Polio or Leprosy)
## Applications for Tendon Transfers

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<thead>
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<tbody>
<tr>
<td>1</td>
<td>Post Poliomyelitis</td>
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<tr>
<td>2</td>
<td>Leprosy</td>
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<td>3</td>
<td>Duchenne Muscular Dystrophy</td>
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<td>4</td>
<td>Cerebral Palsy</td>
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<td>5</td>
<td>Multiple Sclerosis</td>
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<td>Discogenic Disease</td>
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<td>7</td>
<td>Sciatic Nerve Palsy</td>
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<td>8</td>
<td>Common Peroneal Nerve Palsy</td>
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<td>9</td>
<td>Flexible Flatfoot</td>
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<td>10</td>
<td>Forefoot Equinus</td>
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<td>11</td>
<td>Flexible Hammertoes</td>
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<td>12</td>
<td>Ankle Stabilization</td>
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<tr>
<td>13</td>
<td>Achilles tendon repair augmentation</td>
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</table>
Principles and Pre-Requisites

1. Supple joints
2. Soft tissue equilibrium
3. Donor of adequate excursion
4. Donor of adequate strength
5. Donor that is expendable
6. Straight line of pull
7. Synergy
8. Single function per transfer
1. Supple Joints

• Joint being moved by tendon transfer must have a maximum passive ROM pre-op
• Tendon transfers fail in stiff joints
• If contracture release is necessary, it should be done prior to tendon transfer
• Pre-op PT and aggressive post op PT
2. Soft Tissue equilibrium

• Tendon transfer should pass through healthy tissue (no inflammation, scar, or edema) to minimize adhesions

• After acute injury, allow time to pass before transfer

• If necessary, excise scar and replace with flap
3. Donor of Adequate Excursion

• Excursion should be adequate to achieve desired movement (should be similar to original muscle)

• Tenodesis technique can be used to augment excursion
4. Donor of Adequate Strength

• Strength should be adequate but not too strong to overpower antagonist muscles
• Evaluate relative strength as opposed to absolute strength
5. Expendable Donor

- There should be another remaining muscle that can continue to adequately perform the transferred tendon’s original function
6. Straight Line of Pull

- Straight line of pull is most effective
- Direction changes diminishes force
- “End-to-end” transfer will result in better function and force than the “end-to-side” transfer because straighter line of pull
- If direction change is necessary, tendon should be passed around a fixed smooth structure that acts like a pulley
7. Synergy

• Certain muscle groups usually work together (in phase)
• This synergistic transfer is more effective than non-synergistic
8. Single function per transfer

• Single muscle unit should be used to restore a single function

• Transfer to restore multiple functions will compromise strength and movement
Contraindications

Absolute Contraindication:
- Lack of donor
- Muscle strength < Grade 5
- Re-innervated muscles
- Underlying progressive neuromuscular disease
- Stiff joints
General Principles

• Patient factors
  – Not all patients require the same function/motion
  – Age
  – Functional disability with poor prognosis
  – Understand nature and limitations of surgery
  – Motivated with post op PT
Donor Muscle Factors

• Amplitude of Donor Muscle
  – Should match unit being replaced
  – Increased by increased number of joints crosses
  – Free fascial attachments to donor tendons
  – Insert tendon closer to joint being moved (but need increased power due to leverage)
Donor Muscle Factors

• Power of Donor Muscle
  – Tendon transfer loses at least 1 grade of strength
    • Grade 5 are satisfactory
    • Grade 4 (85% strength) may be sufficient
  – Maximize strength pre-op
  – Overly powerful muscle will cause an imbalance
  – Increased strength by inserting farther from joint
## Donor Muscle Factors

<table>
<thead>
<tr>
<th>Polio Foundation</th>
<th>Lovett</th>
<th>Kendall</th>
<th>Description</th>
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<tbody>
<tr>
<td>5</td>
<td>normal</td>
<td>100%</td>
<td>Against full resistance</td>
</tr>
<tr>
<td>4</td>
<td>good</td>
<td>75%</td>
<td>Against partial resistance</td>
</tr>
<tr>
<td>3</td>
<td>fair</td>
<td>50%</td>
<td>Against gravity</td>
</tr>
<tr>
<td>2</td>
<td>poor</td>
<td>25%</td>
<td>With gravity removed</td>
</tr>
<tr>
<td>1</td>
<td>trace</td>
<td>10%</td>
<td>Contracture without movement</td>
</tr>
<tr>
<td>0</td>
<td>absent</td>
<td>0%</td>
<td>None</td>
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</tbody>
</table>

The table above categorizes muscle strength based on the Polio Foundation scale, with Lovett and Kendall descriptors for 100%, 75%, 50%, 25%, and 10% strength against various resistances.
Tensioning Tendon Transfer

• Place under maximum tension in the position that reverses the proposed activity
  – (Listers 4th Edition)

  – My preference is in the neutral position of the joint being worked on due to creep
    • Ie... 90degrees of ankle position for FHL transfer
Selected Arthrodesis

- Simplify poly-articular systems
- Stabilize joints
- Ie... PIPJ fusion for digital FDL transfer
Maximizing Success

1. Incision should not cross path of transferred tendon
2. Avoid interference with normal structures
3. Tendon should insert around joint at 90 degrees to maximize power and excursion
4. Insert distance away from joint to improve power (at expense of decreased excursion)
5. Create strong insertion (tendon-tendon or tendon-bone) to maximize mobilization
6. Tension set to maximal muscle contraction. (Overcorrect bc some stretch is normal)
7. Initial immobilization in a position to relieve tension at insertion of transfer
8. Consider the Reverse order:
   1. Prepare recipient site
   2. Tunnel
   3. Then harvest muscle/tendon
Fixation Techniques

Side to side anastamosis
Fixation Techniques

• End to end

• Gift Box techniques
Fixation Techniques

Tendon to bone:
- Trephine plug
- Biotenodesis screw
- Tendon with osseous insertion
- Screw and washer
- Soft tissue anchors into bone
1. Rehabilitation = surgical execution (equally important in success)

2. Goals of Rehabilitation/physiotherapy:
   1. Regain joint mobility lost during splinting
   2. Training tendon to glide in a new course
   3. Teaching new neural pathways and new tendon function

3. The greater the disability, the greater the motivation, so the easier the retraining

4. Children managed with static protocols/longer protective phase
The stages of tendon healing are:
Planning a tendon transfer

• What works

• What is available

• What is needed

• Matching

• Staging
FF Transfers
MTPJ Balancing

- Girdlestone-Taylor
  - Flexor tendon transfer
  - For reducibly contracted toes

- If rigid contracture:
  - PIPJ arthroplasty
  - PIPJ arthrodesis
Flexor Tendon Transfer
Flexor Tendon Transfer with Interference Screw
• Suture tendon end medially or laterally to augment lateral or medial drift of MPJ
Forefoot

- Jones Tenosuspension
  - Flexible plantarflexed 1\textsuperscript{st} ray
  - Hallux malleus
    - EHL Tendon Transfer
    - 1\textsuperscript{st} metatarsal neck
    - IPJ fusion adjunctively

- Hibbs EDL Transfer
  - For plantarflexed lesser metatarsals
  - Transfer EDL to 3\textsuperscript{rd} Cuneiform to increase DF ankle
  - Decrease MPJ buckling
SPL(AT)T

- For spasticity varus deformity
- Post CVA w/ TAL
  - 73 limbs
  - Increased ability to ambulate
  - Increased ability to wear normal shoes
  - Decreased necessity for orthoses
SPL(AT)T

- Edwards (1993)
  - 21 Patients with 1 year follow-up
  - 83% good or excellent results
  - 100% ambulatory with improved gait
  - 35 % able to D/C orthoses
Rearfoot/Ankle Transfers
• Through the interosseous membrane
• “Out-of-Phase” tendon transfer
• May need to stabilize rearfoot to prevent iatrogenic flatfoot
PL to PB tendon transfer

- PL detached as it enters peroneal groove
- Then sewn into brevis
- Useful in CMT patients
  - Augments weak PB
  - Reduces plantarflexion of 1st ray
FHL Tendon Transfer

• INDICATIONS:
  – >50% debridement of Achilles or
  – Obese or
  – Immuno-compromised or
  – Revision
FHL Tendon Transfer

- In-phase with Achilles tendon
- Improves blood supply to Achilles
  - Adjacent low ms belly
- 30% of power of the Achilles
- No clinical or pedobarographic changes that suggest morbidity of FHL tendon harvest have been reported.
- Same incision
Sural N
Full Thick Flap
Harvest as much as possible

FHL Tendon in Tarsal Tunnel

Harvest as much as possible
Guide Pin placed at angle anterior-lateral to avoid medial NV.

Remember your implant sizes to determine drill hole:
- 4mm x 10mm
- 4.75 x 15mm
- 5.5 x 15mm
- 6.25 x 15mm
- 7 x 10mm
- 7 x 23mm
- 8 x 12mm
- 8 x 12mm

Measure tendon thickness and drill appropriate diameter
- .5 - 1 mm larger than tendon
- >2mm longer than implant
ALTERNATIVE TECHNIQUE:
Interference Screw—“Blind Tunnel”
PTT Dysfunction

• Things to consider
  – Torn tendon vs. dysfunctional (weak painful scar tissue)
  – Plane of Deformity
  – Amount of Arthritis and location of symptoms
  – Equinus
  – Ligament laxity
  – Ankle Valgus
  – Neurologic?
  – Age (physiologic)
  – Weight of Patient
  – Expectations and functional demands
Causative Factors

• Rheumatoid Arthritis
  – Ghormley, Anzel, Kettlekamp, Downey

• Seronegative Spondyloarthropathy
  – Myerson

• DM, HTN, or Obesity found in 50% of patients with PTTD
  – Holmes and Mann - 1992

• Direct injury; Pathologic Rupture; Idiopathic Rupture; Functional Rupture
  – Mueller

• Flatfoot not caused by PT rupture alone
  – Deland, et. al.; Chu and Myerson - based on cadaver experiments

• Pre-existing flatfoot in almost 100% PTTD
PTTD Treatments

• Conservative Care:
  – AFO – 67% good-excellent results
    » Chao et. al. 1996
  – AFO better than orthotic;
  – cadaver study showed importance of deltoid and interosseous talocalcaneal ligament support
    » Hintermann - 1995
Flatfoot Correction Options

- Synovectomy
- Primary Repair
- **FDL Transfer (combo with MCO):**
  - Good if no fixed deformity
  - Not for >70, obese, lig lax
  - Medializing Calcaneal Osteotomy — MCO
    - Flex valgus RF
- Achilles/Gastroc Lengthening

- **Lateral Column Lengthening — LCL**
  - Evans Calcaneal Osteotomy
  - CalcaneoCubiod Distraction Arthrodesis
- Medial Column Stabilizing
  - Lapidus
  - Cotton Osteotomy
- Arthroeresis (augmentation)
- Deltoid Reconstruction
- TN, STJ, Triple, Pan Talar Arthrodesis
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<td>Partial Tear</td>
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<td>Reduceable FF supinatus</td>
<td>Fixed FF Varus</td>
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<td>Normal Hindfoot</td>
<td>Normal Hindfoot</td>
<td>&lt;5 degree hindfoot valgus</td>
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<tr>
<td>Synovectomy</td>
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<td>FDL transfer</td>
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<td>Med Calc Osteotomy</td>
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<td>Cotton or TMT Fusion</td>
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<td>Lat Column lengthening if talar head uncovered &gt;40%</td>
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<td>Or Arthroeresis</td>
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<td>Cotton</td>
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Why Tenodesis for FDL Transfer

• Less Morbidity
  – Smaller Incision

• Straightforward Technique
  – Easier Tensioning

• Strong Fixation
  – Direct Tendon-to-Bone Fixation
FDL Transfer

- 50% failure rate in Stage II PTTD (when used alone)
  - Sobel 1993
- Must correct all the deformities; medial calc slide needed to preserve FDL transfer
  - Mann, Myerson
- Fixation options:
  - Side to side
  - Loop thru drill hole/notch
  - Soft tissue anchors
  - Interference screw
    - Best tendon to bone construct
    - Smaller incision
    - Easier Tensioning
Thank You ASPS!
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