Reconstruction Following Nerve Injury, Nerve Grafts & Nerve Transfers

John S. Taras, MD
Thomas Jefferson University
Drexel University
The Philadelphia Hand Center

Peripheral Nerve Reconstruction

- Surgical approach to nerve repair is dependent upon type of injury, gap length, nerve type, and surgeon's preference
- Direct repair
- Conduit
- Allograft nerve
- Autograft
- Nerve transfer

New Treatment Options

- Conduits
  - Vein
  - Polyglycolic acid
  - Poly(dl-lactide-e-caprolactone)
  - Collagen
  - Porcine submucosa
  - Allograft

Nerve Conduits

- Advantages
  - Availability
  - No donor site morbidity
  - Tension free repair; mobilize digit
  - Simpler than grafting
  - Control environment
  - Neurotropic factors

Histology at Gap Midpoint

PGA Conduit

- Weber PRS 2000
  - Randomized repair
  - Nerve graft via PGA conduit
  - 56 standard, 46 PGA
  - Moving 2-point 3.7 PGA conduit
  - 6.1 end-to-end repair, 12.9 graft
  - PGA; inflammatory response
Neurolac

- Bertleff JHS ’05
  - Poly(dl-lactide-e-caprolactone)
  - 34 nerve lesions
  - Equivalent to direct repair
  - Not fantastic paper

Waitawinyu, Parisi, Miller, Lauria, Morton, Chin & Trumble
JHS 2007

- Compared autogenous nerve graft vs PGA and collagen conduits
- Rat model
- For 10 mm defect
  - Collagen conduit = nerve graft
  - & better than PGA conduit

Conduit Results - Taras Criteria (JHS 2011)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Moving 2-Point (mm)</th>
<th>Static 2-Point (mm)</th>
<th>Digits (% of 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&lt; 4 or &lt; 6</td>
<td>13 (59%)</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>5 – 7 or 7 – 8</td>
<td>3 (14%)</td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>&gt;8</td>
<td>Protective Sensation 6 (27%)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>&gt;8 and &gt;8</td>
<td>No protective sensation 0 (0%)</td>
<td></td>
</tr>
</tbody>
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Standard Digital Nerve Repair
Results in Adults

- Sullivan 1985
  - 42 digital nerves
  - 17% normal
  - 30% good
  - 53% poor
- Schaffer Surg 1950
  - 10/32 ; 2 point < 10 mm
- Onne Acta Chir Scand 1962
  - 0/13 adult digital nerve repairs with 2-point < 8mm

Standard Digital Nerve Repair
Results

- Poppen J Hand Surg 1979
  - 5/48 digital nerve repairs
  - 2 point < 10 mm
- Moberg 1964
  - Results of digital nerve repair “disappointing”

Survey of ASSH Members (2014):
If you use a hollow tube conduit, do you prefer:

- A. Collagen
- B. PGA
- C. Polyacrylactone
- D. Autologous vein
- E. Porcine submucosa

- 10.3%
- 41.1%
- 49.14%
- 7.2%
Fibrin cable is robust enough to allow regeneration at short gaps.

- Thinning restricts the regenerative space at longer gaps.
- The cable does not form when length limits are exceeded. This can result in:
  - No regeneration
  - Neuroma
- Zhao 1993, Res. Neural Neurosci

Length Limitation of Conduits

- Decreasing efficacy
- Increasing gap length

3 months prior to presentation

Thank you, Milan Stevanovic, MD

Group Fascicular Repair

- Sural nerve graft; acts as a conduit with scaffolding

Auto graft Nerve

Benefits
- 3-D scaffold supports nerve regeneration
- Schwann cells and laminin

Limitations
- Must sacrifice another healthy nerve
- Potential for donor site complications
- Limited availability and sizes
- Increased OR time

Avance Nerve

- Allograft nerve
  - Diameters from 1 to 5 mm
  - Lengths from 15 to 50 mm
- Predegeneration while preserving the 3D scaffold
- Handles similar to autograft nerve
- Requires no immunosuppression

Avance® Preclinical Comparative Study
10mm Gap - Rat Sciatic Nerve Model

Multi-function index comprised of sensory (toe pinch & thermal pain) and motor (foot spread & grip force) tests.

Graham et al, JNDR 2:1, 2009
Allograft Results
Taras et al, JHS 2013

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<th>Digits (% of 18)</th>
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</thead>
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<tr>
<td>Excellent</td>
<td>&lt; 4 or &lt; 6</td>
<td></td>
<td>7 (39%)</td>
</tr>
<tr>
<td>Good</td>
<td>5 – 7 or 7 – 8</td>
<td></td>
<td>7 (39%)</td>
</tr>
<tr>
<td>Fair</td>
<td>&gt;8 or &gt;8</td>
<td>Protective Sensation</td>
<td>4 (22%)</td>
</tr>
<tr>
<td>Poor</td>
<td>&gt;8 and &gt;8</td>
<td>No protective sensation</td>
<td>0 (0%)</td>
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Preclinical Comparative Study
Whitlock, Muscle Nerve 2009

- Isograft
- AxoGen
- NeuraGen®

28mm, 22 weeks (midgraft). Scale bars = 20µm

Allograft Clinical Experience

- Moran S. Early Clinical Outcomes from the Use of Processed Nerve Allograft in the Hand. Hand 2009
- 10 nerve repairs
  - Sensory nerve gaps from 5-30 mm
- Results
  - M2PD 4.4 mm; S2PD 5.2 mm
  - Functional recovery with graft lengths up to 3 cm
  - No recovery failures

Processed Allografts and Type I Collagen Conduits for Repair of Peripheral Nerve

<table>
<thead>
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<th>14mm</th>
<th>28mm</th>
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<tr>
<td>Collagen conduit</td>
<td>1511 ± 349</td>
</tr>
<tr>
<td>AxoGen</td>
<td>5590 ± 2533</td>
</tr>
<tr>
<td>Isograft</td>
<td>13803 ± 3977</td>
</tr>
</tbody>
</table>

Basal lamina
Schwann Cell
Allograft Clinical Experience

- Viola et al AAHS 2010
  - 16 subjects
  - Sensory nerve injuries with 10-30mm gaps

- Results
  - 92% reported recovery of sensation S3+/S4
  - 94% reported resolution of pre-operative pain

Clinical Registry: RANGER Study

- 12 centers, 100+ nerve injuries to date
  - AAHS, Brooks 2011
    - 59 patients
    - 76 injuries with outcomes
    - 23 mm mean gap length

A 42-year-old male sustained a laceration to the radial digital nerve of his dominant index finger that has a 1.5 cm gap with the hand in a neutral position. Your most common method to reconstruct the nerve, which cannot be reapproximated, is:

- A. Placement of a nerve autograft (54%, 13%)
- B. Placement of a processed nerve allograft
- C. Reconstruction with a hollow tube conduit

A 42-year-old male sustained a laceration to the radial digital nerve of his dominant index finger that has 3.0 cm gap with the hand in a neutral position. Your most common method to reconstruct the nerve is:

- A. Reapproximation with a hollow tube conduit (249, 60%)
- B. Placement of a nerve autograft
- C. Placement of a processed nerve allograft

Following 3 months of closed treatment of a humerus fracture with a radial nerve palsy in a 25-year-old female, electrodiagnostic studies confirm no recovery of the radial nerve. After discussion with the patient, operative intervention is pursued. The radial nerve is found to have a 3 cm defect. You proceed with:

- A. Tendon transfers (50, 13%)
- B. Grafting with nerve autograft
- C. Grafting with processed nerve allograft
- D. Nerve transfer
- E. Conduit, hollow (249, 63%)

Thank You