Facial Paralysis and Contemporary Management

Michael Hall, MD
PGY-3

Grand Rounds
May 13, 2015
Overview

- Anatomy
- General Concepts
- Causes
- Treatment Options
  - Static
  - Dynamic
- Management of the...
  - Brow
  - Eyelids
  - Mid-Lower Face
- Rehab
- Complications and Management of Synkinesis
- Future Direction and Research
Facial Nerve

- Zygomaticotemporal
- Infraorbital
- Temporal br.
- Zygomatic br.
- Buccal br.
- Mental
- Greater auricular nerve
- Marginal mandibular br.
- External jugular vein
- Cervical br.
- Posterior auricular
General Concepts

- Multiple etiologies
- Diverse presentation
- Not life threatening
- Severe QOL implications and psychological impact
- Prognosis and outcomes variable
Etiology

- Idiopathic
- Infection
- Trauma
- Iatrogenic
- Metabolic
- Toxic
- Vascular
- Neurologic
- Otologic
- Congenital
# Grading Facial Nerve Injury

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Normal</td>
<td>Normal facial function in all areas</td>
</tr>
<tr>
<td>II</td>
<td>Mild dysfunction</td>
<td>Slight weakness noticeable on close inspection; may have very slight synkinesis</td>
</tr>
<tr>
<td>III</td>
<td>Moderate dysfunction</td>
<td>Obvious, but not disfiguring, difference between 2 sides; noticeable, but not severe, synkinesis, contracture, or hemifacial spasm; complete eye closure with effort</td>
</tr>
<tr>
<td>IV</td>
<td>Moderately severe dysfunction</td>
<td>Obvious weakness or disfiguring asymmetry; normal symmetry and tone at rest; incomplete eye closure</td>
</tr>
<tr>
<td>V</td>
<td>Severe dysfunction</td>
<td>Only barely perceptible motion; asymmetry at rest</td>
</tr>
<tr>
<td>VI</td>
<td>Total paralysis</td>
<td>No movement</td>
</tr>
</tbody>
</table>
Sunderland Classification

<table>
<thead>
<tr>
<th>Sunderland</th>
<th>Injury</th>
<th>Degeneration</th>
<th>Regeneration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>First degree</td>
<td>Myelin sheath (M)</td>
<td>Conduction block</td>
<td>Complete recovery</td>
</tr>
<tr>
<td>Second degree</td>
<td>M+Axon (A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third degree</td>
<td>M+A</td>
<td>Wallerian degeneration</td>
<td></td>
</tr>
<tr>
<td>Fourth degree</td>
<td>M+A+E</td>
<td></td>
<td>Incomplete recovery</td>
</tr>
<tr>
<td>Fifth degree</td>
<td>M+A+E+P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Facial Nerve Testing

<table>
<thead>
<tr>
<th>Test</th>
<th>Indication</th>
<th>Results</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromyography (EMG)</td>
<td>Acute paralysis &lt; 1 week</td>
<td>Active motor units</td>
<td>Intact motor axons</td>
</tr>
<tr>
<td></td>
<td>Chronic paralysis &gt; 2 weeks</td>
<td>Polyphasic motor units</td>
<td>Regenerating nerve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motor units + fibrillation potentials</td>
<td>Partial degeneration</td>
</tr>
<tr>
<td>Electroneuronography (ENoG)</td>
<td>Paralysis &lt; 3 weeks</td>
<td>&lt; 90% degeneration</td>
<td>Good likelihood of recovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 90% degeneration</td>
<td>Poor likelihood of recovery</td>
</tr>
<tr>
<td>Nerve excitability test (NET)</td>
<td>Complete paralysis &lt; 3 weeks</td>
<td>&lt; 3 mA threshold</td>
<td>Good prognosis</td>
</tr>
<tr>
<td>Maximal stimulation test (MST)</td>
<td>Complete paralysis &lt; 3 weeks</td>
<td>Marked weakness or no contraction</td>
<td>Advanced degeneration</td>
</tr>
</tbody>
</table>
Treatment Options

- Observation
- Conservative
  - Prednisone: 1mg/kg per day for 7-10 days with slow taper
  - Acyclovir/Valcyclovir

Direct Nerve Repair and Cable Grafting

Static Procedures
  - Facial Sling, Gold Weight

Dynamic Procedures
  - Nerve, muscle or free tissue transfer
Timing and Considerations with Facial Paralysis

- Patient Age
- Onset
  - Immediate
  - Delayed
- Duration
- Involved Branches
- Progression
  - Complete
  - Incomplete
- Patient Expectation
- Status of the Eye
Primary Nerve Repair and Cable Grafting

- Ideal for injuries < 72 hours
- Best functional outcomes
- Epineural vs Perineural repair
- Tension free closure
Cable Grafting

• Great Auricular Nerve
  • 7-10 cm
  • Close proximity

• Sural Nerve
  • 30-75 cm
  • Several branch points for multiple anastomoses

• Medial and Lateral Antebrachial Cutaneous Nerve
  • Good for concomitant RFFF
  • ~20 cm harvest
Cable Grafting Pearls

- Oblique cut to facilitate grafting more than one branch
- Harvest ~25% > defect length
- Graft zygomatic and mandibular branches first
- At least 6 months for recovery but can be up to 1-2 years
- Often times perform static procedures concomitantly
Neural Conduits

- End to end anastomosis not possible
- Good for gaps < 3cm
- Provides support, shape and guidance for axonal regeneration
- Limits fibrosis, neuroma formation and FB reaction
- No donor site morbidity
Nerve Conduits

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Product</th>
<th>Form</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>AxoGen</td>
<td>Avance Nerve Graft</td>
<td></td>
<td>Allograft</td>
</tr>
<tr>
<td></td>
<td>AxoGuard Nerve Connector</td>
<td>Conduit</td>
<td>Porcine material</td>
</tr>
<tr>
<td></td>
<td>AxoGuard Nerve Protector</td>
<td>Wrap</td>
<td>Porcine material</td>
</tr>
<tr>
<td>Stryker</td>
<td>NeuroMend</td>
<td>Wrap</td>
<td>Collagen</td>
</tr>
<tr>
<td></td>
<td>NeuroMatrix</td>
<td>Conduit</td>
<td>Collagen</td>
</tr>
<tr>
<td></td>
<td>NeuroFlex</td>
<td>Conduit</td>
<td>Collagen</td>
</tr>
<tr>
<td>Integra</td>
<td>NeuraGen</td>
<td>Conduit</td>
<td>Collagen</td>
</tr>
<tr>
<td></td>
<td>NeuraWrap</td>
<td>Wrap</td>
<td>Collagen</td>
</tr>
<tr>
<td>Polyganics</td>
<td>Neurolac</td>
<td>Conduit</td>
<td>PLA-CL</td>
</tr>
<tr>
<td>Synovis Micro</td>
<td>NeuroTube</td>
<td>Conduit</td>
<td>PGA</td>
</tr>
</tbody>
</table>
Nerve Transfer

1879: Earliest description of nerve transfer by Drobnick, CN XI->VII

1901: Korte performed first CN XII -> VII transfer

1924: Balance recurrent laryngeal -> VII transfer

1971: Scaramella and Smith reported cross facial nerve grafting

1984: Terzis introduced the “babysitter” procedure which combined CFNG and partial XII-VII transfer

• Keys to success: Strong contraction, harvest should not result in serious deficit, ability to adhere to rigid rehab program
Cross Facial Nerve Grafting

• Contralateral CN VII ideal
• <6 months denervation if used as sole procedure
• Work medially to laterally to find branches
• Map out branches
• Ideally match like to like
• Make tunnels prior to neurorraphy
• Sural Nerve most common
• Disadvantages: donor site deficits, long interval of reinnervation, limited donor axons, two coaptation sites, possible sacrifice of function
Nerve Transfer Options

- XII -> VII transfer
  - Sacrifices ipsilateral XII
  - Hemiglossal dysfunction, lingual atrophy
  - End to side, end to end, interposition graft, partial transfer

- Babysitter procedure
  - Partial CN XII transfer with CFNG
  - Gives immediate motor function while waiting for CFNG reinnervation without ipsilateral tongue paresis
Nerve Transfer Options cont.

- CN V transfer
- CN XI transfer
  - Last resort, Mobius syndrome
  - Less natural result and severe donor site morbidity
- Cervical Roots
A Comparison of Surgical Techniques Used in Dynamic Reanimation of the Paralyzed Face

TABLE 4

<table>
<thead>
<tr>
<th>Technique</th>
<th>HB grade 3 or better (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end coxal Cable nerve graft</td>
<td>0.15</td>
</tr>
<tr>
<td>End-to-end coxal transposition</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Fisher’s exact test

- $p = 0.15$
- $p = 0.03$
- $p = 0.005$
Static Procedures

- Good for temporary paralysis, poor candidates for dynamic procedures, atrophied muscles, failed dynamic procedure
- Facial Slings, Gold weight, Lower lid tightening
Static Treatment of the Eyelid

- Orbicularis Oculi main depressor of upper lid
- Used to treat exposure keratitis
- Tarsorrhaphy
- Lid Loading (Gold vs Platinum weight)
- Lateral Tarsal Strip
- Medial/Lateral Canthopexy
Static Treatment of the Brow

- Browlift
  - Direct
  - Midforehead
  - Coronal
  - Trichophytic
  - Endoscopic
# Static Treatment of the Lower Face - Facial Slings

<table>
<thead>
<tr>
<th>Material</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fascia</td>
<td>Ease of harvest, autologous</td>
<td>Donor site morbidity, tendency of tissue to stretch</td>
</tr>
<tr>
<td>Lyophilized dermis (AlloDerm, ENDURAGen)</td>
<td>No donor site, incorporation into recipient tissue</td>
<td>Unpredictable stretching/elongation</td>
</tr>
<tr>
<td>Expanded Polytetrafluoroethylene (e-PTFE)</td>
<td>Technically easy, local anesthesia, no donor site, ease of revision/reversal</td>
<td>Higher infection and extrusion rates</td>
</tr>
<tr>
<td>Multi-vector suture suspension</td>
<td>Least invasive, local anesthesia, quick healing, easy revision</td>
<td>Unpredictable stretch and relaxation, suture breakage</td>
</tr>
</tbody>
</table>
Facial Slings
Dynamic Muscle Transfer

- Restore oral competence
- Most commonly used for long standing facial paralysis, restoration of neural input not feasible
- Uses functional, innervated and vascular muscle
- 2 options
  - Regional muscle transposition
  - Free muscle transfer
• First described in 1911 by Eden, later popularized in 1977 by Rubin.
• Most commonly used muscles: temporalis, masseter, and digastric.
• Temporalis Muscle Transfer:
  • Innervated by V3, blood supply deep temporal artery.
  • "Temporal Smile".
  • Donor site depression, bulge over zygoma, revision, orthodromic muscle.
Temporalis Tendon Transfer

- Popularized by Labbe
- Coronal and nasolabial incisions
- Slight overcorrection
- Orthodromic muscle contraction, natural vector of pull, less bulky, no donor site depression
- 2 versions of technique
Masseter and Digastric Transfer

- **Masseter**
  - Melolabial incision
  - Less excursion than temporalis

- **Digastric**
  - Injury to the marginal branch -> paralysis of the depressor anguli oris and depressor labii inferioris
  - Anterior belly of digastric
  - Submental incision
Free Tissue Transfer

- Offers possibility of synchronous, mimetic movement
- Muscle alone and muscle + soft tissue
- Gracilis is first choice and most popular
  - Located medially and posteriorly to the adductor longus
  - Attaches to pubic symphysis and medial aspect of tibia
  - Medial femoral circumflex or profunda femoral artery
  - Pedicle length ~ 6-8 cm
  - Anterior branch of obturator nerve
Gracilis Free Tissue Transfer

- 2 stage procedure
  - CFNG
  - Gracilis FFMT
- 1 stage procedure
  - Masseter nerve
- Facial vessels as recipient site
- 1cm and 2cm additional length to avoid lip contracture deformity
- Early training and muscle stimulation

Complications
- Hemorrhage, injury to Stenson’s duct, flap failure, lip contracture, bulkiness, lip asymmetry
Facial Rehab

- Nonspecific light massage, electrical stimulation, and repetitions of common facial expressions in a general exercise regimen
- Facial Neuromuscular re-education
- Enhance desired muscle activity while reducing others
- Surface EMG biofeedback and mirror feedback
- How to measure success?
  - Facial Grading System
  - Facial Disability Index
Management of Synkinesis

- Abnormal involuntary movement that occurs simultaneously during voluntary muscle contraction
- Aberrant nerve regeneration
- Sunderland Class III and above
- ~20% patients
- Treatments include facial neuromuscular retraining, Botox injection, selective neurolysis or myomectomy
Future Direction and Research

- Platelet rich plasma
- Neural tube additives
- Facial Analysis
Platelet Rich Plasma

Effect of Neural-Induced Mesenchymal Stem Cells and Platelet-Rich Plasma on Facial Nerve Regeneration in an Acute Nerve Injury Model

Hyong-Ho Cho, MD; Sujeong Jang, PhD; Sang-Chul Lee, MD; Han-Seong Jeong, MD; Jong-Seong Park, MD; Jae-Young Han, MD; Kyung-Hwa Lee, MD; Yong-Bum Cho, MD

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Axon No. (±2,500 μm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>41.0 ± 4.7</td>
</tr>
<tr>
<td>Control</td>
<td>19.6 ± 0.9</td>
</tr>
<tr>
<td>PRP</td>
<td>29.8 ± 2.5</td>
</tr>
<tr>
<td>nMSC</td>
<td>28.2 ± 1.9</td>
</tr>
<tr>
<td>PRP + nMSC</td>
<td>35.8 ± 2.0</td>
</tr>
</tbody>
</table>

TABLE I
Number of Myelinated Axons in an Area Corresponding to 2,500 μm²

Vibrissae movement

Eye closure movement
Neural Tube Additives

Dorsal root ganglion-derived Schwann cells combined with poly(lactic-co-glycolic acid)/chitosan conduits for the repair of sciatic nerve defects in rats.

Engineered neural tissue with aligned, differentiated adipose-derived stem cells promotes peripheral nerve regeneration across a critical

Use of Natural Neural Scaffolds Consisting of Engineered Vascular Endothelial Growth Factor Immobilized on Ordered Collagen Fibers Filled in a Collagen Tube for Peripheral Nerve Regeneration in Rats

Peripheral nerve reconstruction with epsilon-caprolactone conduits seeded with vasoactive intestinal peptide gene-transfected a mesenchymal stem cells in a rat model

Fabrication of bioactive conduits containing the fibroblast growth factor 1 and neural stem cells for peripheral nerve regeneration across a 15 mm critical gap.

Transplantation of Schwann cells in a collagen tube for the repair of large, segmental peripheral nerve defects in rats.

Berrocal YA, Almeida VW, Gupta R, Levi AD.
Facial Analysis

- Recently, computer analysis has been used to quantitatively measure facial asymmetry and thus synkinesis
- Increased sensitivity and reliability
- Facial Assessment by Computer Evaluation (FACE)
- Peak Motus Motion Measurement System
- Automated Facial Image Analysis (AFA)
- New focus on 3D analysis
**Conclusion**

- Many options to treat facial paralysis from neurorraphy to free muscle transfer
- Onset, timing and duration of paralysis is important
- Must match goals of the patient with goals of surgeon
- New and dynamic field of facial plastic surgery with continual advancements which will allow for objective data and better results
Thank You

- Dr. Heffelfinger
- Dr. Krein
References

- Ni HC, Tsien TC, Chen JR, Hsu SH, Chiu IM. Fabrication of bioactive conduits containing the fibroblast growth factor 1 and neural stem cells for peripheral nerve regeneration across a 15 mm critical gap. Biofabrication, 2013 Sep;5(3):035010