Facial Reanimation

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Facial function plays an integral part in our everyday lives
  - Smile; nonverbal communication, etc.

Facial paralysis is devastating on many levels
  - Functional
  - Cosmetic

Fortunately, a plethora of techniques are available to reanimate the paralyzed face.
Facial Nerve Anatomy

- Intracranial segment
  - Originates in pons
  - 23-24mm segment within CPA to IAC
- Intratemporal
  - Meatal
    - From IAC to fundus
    - Anterior/superior portion of IAC (7-UP, Coke down)
    - 8-10mm
  - Labyrinthine
    - From fundus to geniculate ganglion (narrowest portion)
    - 3-5mm segment
    - Makes 1st genu prior to entering tympanic cavity
- Tympanic/horizontal segment
  - From geniculate ganglion to 2nd genu
  - 8-11mm
  - Superior to oval window/stapes
- Mastoid/vertical segment
  - 2nd genu to stylomastoid foramen
  - Anterior/caudal to lateral SCC
  - Lateral to sinus tympani and stapedius muscle
  - 10-14mm
Anatomy

Extratemporal Segments
- Postauricular Nerve
- Nerve to stylohyoid
- Nerve to posterior digastric

Pes Anserinus
1. Temporal
   a. Frontalis
   b. Corrugator
   c. Procerus
   d. Upper orbicularis oculi
2. Zygomatic
   a. Lower orbicularis oculi
   b. Anastomose with buccal
3. Buccal
   a. Zygomaticus mm
   b. Levator anguli oris
   c. Buccinator
   d. Upper orbicularis oris
4. Mandibular
   a. Lower orbicularis oris
   b. Depressor anguli oris
   c. Depressor labii inferioris
   d. Mentalis
5. Cervical
   a. platysma
Nerve Fiber Components

- **Endoneurium**
  - Surrounds each axon
  - Adherent to Schwann cell layer
  - Vital for regeneration

- **Perineurium**
  - Encases endoneural tubules
  - Tensile strength
  - Barrier to infection

- **Epineurium (nerve sheath)**
  - Outermost layer
  - Houses vasa nervorum for nutrition
**Neuropraxia:**
Conduction block
Complete recovery expected.

**Axonotmesis:**
Axon disrupted
Endoneurium preserved
1mm/day regeneration

**Neurotmesis:**
Neural tube disruption
Slow, often
incomplete recovery
Risk of synkinesis

**Neurotmesis:**
III + perineural disruption
Synkinesis at best

**Neurotmesis**
Complete disruption
of all nerve layers
Synkinesis
Risk of neuroma formation
Anatomy

- 18 paired muscles participate in facial expression
- Major muscles involved in clinical assessment
  - Frontalis
  - Orbicularis oculi
  - Zygomaticus major
  - Orbicularis oris
  - Lip depressors
- Functional elements
  - Nasolabial fold (NLF)
  - Smile dynamics
**Nasolabial Fold**

- **Components**
  - Dense fibrous tissue
  - Upper lip levators
  - Bundles of striated muscle originating in the fold’s fascia

- **Appearance**
  - Variable shape/depth
  - Can assume straight, convex, or concave contour.
Dynamics of Smile

- Primarily performed by the levators of the upper lip
- 2 stages:
  - Contraction of levators and NLF muscles elevating upper lip to NLF against cheek resistance
  - Levator superior, zygomaticus major, caninus muscles raise lip and NLF upward.
Dynamics of Smile

- **3 basic smile patterns**
  - **Zygomaticus major smile**
    - Most common type (67%)
    - Dominated by zygomaticus major and buccinator muscle
      - Corners of the mouth elevate first
  - **Canine smile**
    - 2nd most common (31%)
    - Mainly controlled by levator labii superioris contracting prior to zygomaticus major and buccinator
      - Dominant upward elevation of lip followed by elevation of corners of the mouth
  - **Full-denture smile**
    - Least common (2%)
    - Due to contraction of elevator and depressors of the lips and angles of the mouth
    - Maxillary and mandibular teeth displayed
Basic Smile Patterns

Full Denture Smile: 3%

Canine Smile: 31%

Zygomaticus major smile: 67%
WHO ARE CANDIDATES?

- Those with nerve transection injury
- > 1 yr of facial paralysis
- No physical or electrical signs of recovery
- Congenital facial dysfunction
- Hyperkinetic syndromes
  - Hemifacial spasm
  - blepharospasm

PRIMARY GOALS

- Corneal protection
- Symmetry of face at rest
- Restore symmetry of the smile
Reinnervation of facial muscles should occur as early as possible

Upper and lower face should be reanimated separately
  - Avoids mass movement

Both static and dynamic procedures can be employed

Procedure tailored to patient’s needs
Assessment and Planning

- Cause of facial paralysis
- Functional deficit/extent of paralysis
- Time course/duration of paralysis
  - Likelihood of recovery
- Other cranial nerve deficits
- Patient’s life expectancy
- Patient’s needs/expectations
## House-Brackmann Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>At Rest</th>
<th>Forehead</th>
<th>Eyelid</th>
<th>Mouth</th>
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<tbody>
<tr>
<td>I</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>II</td>
<td>Slight</td>
<td>Normal</td>
<td>Moderate-good</td>
<td>complete w/ minimal effort</td>
<td>slight asymmetry</td>
</tr>
<tr>
<td>III</td>
<td>Moderate</td>
<td>Normal</td>
<td>slight-moderate</td>
<td>complete w/ maximal effort</td>
<td>slightly weak w/ max effort</td>
</tr>
<tr>
<td>IV</td>
<td>Moderately</td>
<td>Normal</td>
<td>none</td>
<td>incomplete</td>
<td>asymmetric w/ max effort</td>
</tr>
<tr>
<td>V</td>
<td>Severe</td>
<td>asymmetric</td>
<td>none</td>
<td>incomplete</td>
<td>slight mvmt</td>
</tr>
<tr>
<td>VI</td>
<td>Total paralysis</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
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</tbody>
</table>
2 systems, 4 scenarios

Facial nerve nucleus (proximal system)
Mimetic musculature (distal system)

Proximal and Distal Systems Intact
Proximal system intact, Distal unavailable
Both systems unavailable
Proximal system unavailable and Distal system intact
Scenario 1: Proximal & Distal System Intact

- Case: 33 yo M suffers nerve injury during mastoidectomy for chronic middle ear disease

- Preferred Options
  - Primary neurorraphy
  - Nerve graft
Primary Nerve Repair

- End-to-end anastomosis preferred
  - No tension
- Can be performed with defect ≤ 17mm
- Extratemporal repair performed ≤ 72 hrs of injury
- Most common methods
  - Group fascicular repair
  - Epineural repair
Primary Nerve Repair

- Severed ends of nerve exposed
  - Devitalized tissue/debris removed with fine scalpel
  - Small bites of epineurium

- Epineural sheath approximated with 9-0 nonabsorbable suture
  - Epineural repair recommended for injury proximal to pes anserinus and intratemporal
    - Horizontal segment rarely accessible to suture repair
Primary Repair

Before

2 years after direct anastomosis
Interposition Grafting

- **Cable grafts**
  - Used when defect > 17mm; nerve cannot be reapproximated w/o tension
  - Most common
    - Greater Auricular Nerve
    - Sensory nerves from superficial cervical plexus
    - Sural nerve
    - Medial antebrachial cutaneous nerve

- **Recovery**
  - Movement first noticed 6 months after surgery
    - Tinel’s sign heralds recovery
    - Muscle tone precedes voluntary movement
    - Mid 1/3 of face usually recovers first, then spreads superiorly toward eye
  - Expect 12-18 months
  - Variable degree of synkinesis
  - Majority of cases reach House-Brackmann III
Interposition Grafting
Greater Auricular Nerve

- Harvesting
  - Located on lateral surface of SCM at the midpoint of a line drawn between mastoid tip and mandibular angle
  - May extend postauricular incision or use separate neck incision

- Useful features
  - Proximity to facial nerve
  - Cross-sectional area
  - Limited morbidity

- Limitations
  - Reconstruction of long defects and/or branching nerve gaps
  - Ideal for defects < 6cm in length
Greater Auricular Nerve
Anatomy

- Formed by union of medial sural cutaneous nerve and lateral sural cutaneous branch of peroneal nerve.
- Pierces fascia of gastrocnemius and runs in lateral compartment in association w/ saphenous vein.
- Distally, located between lateral malleolus and tendon of the calcaneus.
Harvest

- Multiple transverse incisions v. longitudinal incision.
- Longitudinal incision made posterior to the lateral malleolus and then extended upwards depending on length needed
  - Nerve dissected proximally to desired length
Sural Nerve

- **Pros:**
  - Length (40cm)
  - Accessibility
  - Low morbidity associated with sacrifice
  - Two team approach
    - Reduced surgical time

- **Cons:**
  - Variable caliber
    - Often too large
      - Difficult to make graft approximation
  - Unsightly scar
Anatomy

- Arises from medial cord of brachial plexus, adjacent to ulnar nerve
- Medial to axillary artery
- Anterior and medial to brachial artery
- Distally, it is closely associated with basilic vein
MACN

- **Harvest**
  - Important landmarks:
    - Medial epicondyle of humerus
    - Biceps tendon
    - Basilic and medial cubital veins
    - Fascial plane separating bicep from tricep
  - **Tips**
    - Use of sterile, proximal tourniquet
      - Facilitates basilic vein identification
    - Upper extremity can be prepped from axilla to wrist or continuous with the head/neck.
    - May employ 2-team approach
MACN Harvest Technique

- Longitudinal “lazy S” incision made from mid arm to mid forearm
  - Medial to the midsagittal plane
- Begin dissection superiorly through subcutaneous tissue
  - Identify basilic vein as it pierces the brachial fascia and travels superficially
    - *50% of people have MACN traveling superficial to medial cubital vein at the elbow
- Once nerve identified, trace anterior branches distally until adequate length of nerve and branches are obtained.
Usually yields a nerve graft 18.7cm
- Potential length of 24-26cm
- Proximal diameter of graft = 3-4mm
- Graft diameters similar to facial nerve and its branches

Donor site
- Incision well concealed on medial aspect of the arm
- Area of forearm sensory deficit limited to 6x6 cm
  - Decreases over 6-12 mo period
  - Majority fully recover by 3 years
Case: 59 yo M with loss of facial function after acoustic neuroma resection

Reinnervation options

- Hypoglossal-to-facial (most popular)
- Spinal accessory-to-facial
  - Largely abandoned due to donor site morbidity
- Facial-to-facial
Scenarios for use:
- Irreversible facial nerve injury
- Intact facial musculature/distal facial nerve
- Intact motor endplates
- Intact proximal donor nerve

Ideal if performed within a year of facial paralysis
- Prior to distal muscle/facial nerve atrophy

Pros
- Low level of difficulty
- Time interval until movement
  - 4-6 months
- Avoid multiple sites of anastomosis
- Mimetic-like function achievable with practice

Cons
- Donor site morbidity
- Some degree of synkinesis
1. Parotidectomy incision extended into cervical crease ~ 2-3 cm below inferior border of mandible
2. Facial nerve identified and dissected distal to pes anserinus
3. Identify hypoglossal nerve
   a. SCM retracted posteriorly
   b. Dissect superiorly until posterior belly of digastic is identified
   c. Retract digastric superiorly and CN XII is found traveling inferiorly.
   d. Hypoglossal is within 2-3 cm of main trunk of the facial nerve
4. Hypoglossal nerve is dissected anteriorly and medially into the tongue.
   1. Transect distal to ansa hypoglossis
5. Facial nerve transected at the stylomastoid foramen
6. Anastomose nerves using 9-0 epineural suture.
Hypoglossal-Facial

- Technique modification aka partial XII-VII transfer
  - Donor nerve harvested
  - One end of donor nerve is sutured to severed main trunk of CN VII; other end hooked up to proximal segment of partially severed CN XII
  - Limits tongue dysfunction and atrophy
- CN XII-CN VII anastomosis contraindicated with ipsilateral vagal paralysis
  - Swallow dysfunction
- Improved facial tone/symmetry in ~ 6 months
- Pt learns to smile by moving the tongue
  - Exercise/biofeedback training
- Adjunctive lid procedures usually required
Contralateral CN VII used to reinnervate paralyzed side using a nerve graft
- Sural nerve often employed
- ~25-30cm of graft needed

Restitution of smile and eye blinking when successful

Disadvantage
- 2nd surgical site
- Violation of the normal facial nerve
4 techniques

- Sural nerve graft routed from buccal branch of normal CN VII to stump of paralyzed CN VII
- Zygomaticus and buccal branch of normal CN VII used to reinnervate zygomatic and marginal mandibular portions respectively
- 4 separate grafts from temporal, zygomatic, buccal and marginal mandibular divisions of normal CN VII to corresponding divisions on paralyzed side.
- Entire lower division of normal side grafted to main trunk on paralyzed side.
CN VII-XII Crossover

Before

1 year later
Scenario #3: Distal and Proximal Systems Unavailable

- Example case: Pt with congenital facial paralysis (Mobius syndrome)
- Reanimation options
  - Muscle transposition techniques
    - Temporalis
    - Masseter
  - Free muscle transfer
Muscle Transposition (aka “Dynamic Sling”)

- When to use:
  - Facial neuromuscular system absent
    - Neural techniques unsuitable
    - i.e. congenital facial paralysis
  - Facial nerve interruption of at least 3 years
    - Loss of motor endplates
  - Crossover techniques not possible due to donor nerve sacrifice
- **Temporalsis**

- Fan-shaped muscle
  - Radiates from coronoid process to temporal fossa
  - Vascular supply by IMAX
  - Innervated by trigeminal (V2)

- Often used for reanimation of the oral commissure but has been used for orbital rehabilitation

- Contractile capabilities of 1-1.5cm.

- Middle 1/3 of muscle is best for transfer (Sherris, 2004)
Temporalis Transfer

1. Incision in preauricular crease extending to superior temporal line
2. Obtain wide exposure of temporalis muscle by dissecting above the SMAS
3. Incise down on periosteum to elevate muscle fibers
   1. Harvest middle 1/3
4. Large tunnel created over zygomatic arch
5. Orbicularis oris muscle exposed via vermilion border incision at oral commissure
6. Large tunnel over zygomatic arch used to connect oral commisure to zygomatic arch/superior incision.
7. Temporalis flap detached and elevated from its origin and tunneled to the oral commissure.
8. 3-0 prolene used to suture orbicularis to temporalis at oral commissure
9. Overcorrection of nasolabial fold and oral commissure
- Overcorrection at oral commissure is critical
  - 2nd or 3rd molar of upper dental arch should be exposed when procedure is finished
- Harvest and placement of temporoparietal facial flap recommended to fill donor site
- Oral support possible within 6 weeks
  - Movement achieved by clenching the jaws
    - Unnatural contraction requiring rehabilitation/PT
Temporalis Transfer

Before

1 year later
Masseter

- Used when temporalis muscle is not available
- May be preferred due to avoidance of large facial incision
- Disadvantage:
  - Less available muscle compared to temporalis
  - Vector of pull on oral commissure is more horizontal than superior/oblique like temporalis
Masseter Transfer

1. Expose muscle with gingival incision along mandibular sulcus
2. Dissection carried out in a plane between mucosa and muscle.
3. Muscle freed off of mandible medially and laterally with periosteal elevators and freed from the inferiolateral edge of mandible with curved right-angle scissors.
4. Vertical incision made in inferior portion of muscle
5. Anterior half of muscle is split into 2 divisions.
6. The 2 anterior slips of muscle are tunneled anteriorly to reach the oral commissure via external vermillion border incisions
7. The tunnel is dissected in a plane superficial to masseteric fascia and medial to the soft tissue of the face.
8. Muscle slips are attached to lips and oral commissure in the deep dermal layer using permanent suture
Microneurovascular Transfer
Free Muscle Flaps

- Created based on the potential of achieving individual segmental contractions
  - Reduction of mass movement/synkinesis
- Numerous muscle flaps used thus far:
  - Gracilis
  - Latissimus dorsi
  - Inferior rectus abdominus
Requires viable muscle and nerve innervation
- Proximal stump of facial nerve
- Contralateral facial nerve
- V3, CN XII, ansa as alternatives

Traditionally done in 2 stages
- 1st: Cross-face nerve graft ~ 1 yr prior to muscle transfer
- 2nd: Muscle transfer performed after neural ingrowth of graft

One-stage procedures are growing in popularity
- Comparable outcomes to 2-stage procedures
  - (Kumar et al, 2002)

Intramuscular stimulators for muscle preservation under investigation
- (Nicolaidis et al, 2001)
**Gracilis**

1. “Workhorse” for free muscle transfer
2. Long, thin muscle in medial thigh
   1. Good neurovasular pedicle
      1. Adductor artery and vein
      2. Anterior obturator nerve
3. 2–team approach may be used
4. 2 stages involved:
   1. Sural nerve employed for cross-face graft
   2. Gracilis muscle transferred after 6-12 months
5. Vascular anastomosis to the facial artery and vein or to superficial temporal vessels.
6. Obturator nerve of gracilis connected to distal end of sural nerve graft.
7. Movement detected by 6 months-1 year (Chuang, 2008)
Addressing Paralytic Eyelids

- Consequences of orbicularis oculi paresis
  - Delayed blinking and lagophthalmos
  - Impairment of nasolacrimal system
  - Dry eye
  - Risk of exposure keratitis, corneal ulceration and blindness
- Aim of surgery is to maintain normal corneal epithelium

- Options
  - Lateral tarsorrhaphy
  - Lateral tarsal strip
  - Gold weight/spring implants
  - Open v. endoscopic brow lifts for significant brow ptosis
Pre-op assessment by ophthalmology

- Complete eye exam including:
  - Visual acuity assessment
  - Lower lip laxity (snap test)
  - Tear production (Schirmer test)
  - Lacrimal system integrity (Jones test)
  - Measurement of the distance between upper and lower eyelids upon closure (margin gap)
Gold Weight Implantation

1. Small incision made several millimeters above the upper eyelid margin.
2. Tarsal plate exposed with sharp dissection.
3. Gold weight secured to tarsus using 8-0 nylon.
Indicated for selected group of patients:
- Debilitated individuals; poor prognosis
- Nerve or muscle not available for dynamic procedures
- Adjunct procedure with dynamic techniques to provide immediate benefit

Major benefits
- Immediate restoration of facial symmetry at rest
- Less complaints regarding oral commisure ptosis
  - Drooling, disarticulation, mastication difficulties
- Relief of nasal obstruction caused by alar collapse
Variety of materials used
- PTFE (Gor-Tex)
- Alloderm
- Fascia lata

Gor-Tex and alloderm have advantage of no donor site morbidity but higher risk of infection (9%)
- (Konior, 1992)
Static facial Sling Technique

1. Preauricular, temporal or nasolabial fold incision may be used
2. Additional incisions made adjacent to oral commissure at vermillion border of upper and lower lip
3. Subcutaneous tunnel dissected to connect temporal to oral commissure incisions
4. Dissection may be carried out in midface adjacent to nasal ala, if needed (for alar collapse)
5. Implant strip is split distally to connect to the upper/lower lips
6. Implant secured to orbicularis oris/commissure using permanent suture
7. Implant is suspended and anchored superiorly to superficial layer of deep temporal fascia, or zygomatic arch periosteum, using permanent suture.
8. May also secure to malar eminence using small miniplate or bone anchoring screw
Facial Paralysis

(Acute < 3 wks)
- CN VII decompression
- Nerve repair
  - Primary
  - Cable graft
    - G. auricular
    - Sural
    - MACN

Intermediate (3 wks-2 years)
- Nerve transfer
  - hypoglossal
  - masseteric
  - spinal acc.
- Cross-facial Graft

Chronic (>2 years)
- Regional Muscle Transfer
  - Temporalis
  - Masseter
  - Digastric
- Free Muscle Transfer
  - Gracilis
  - Serratus
  - L. dorsi
  - Pec minor

+/− Static Techniques: Slings, Gold weight/Lid procedures, etc

Reanimation
References

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