S117: Trigeminal Nerve Injuries
Dr. Michael Miloro
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Trigeminal Nerve Disorders
Diagnosis

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Program Outline
• Etiology of nerve injuries
• Radiographic evaluation
• Nerve anatomy and physiology
• Clinical neurosensory testing
• Classification of nerve injuries
• Management
Top Malpractice Claims

J Calif Dental Assoc, 1996

1. Extract wrong tooth
2. Dental implant failure
3. Nerve damage
4. Postop TMJ dysfunction
5. Postop infection
6. Postop sinus problems

Legal Involvement

OMSNIC estimates 10-15% of nerve-injured patients seek legal counsel

Lydiatt D. Litigation and the lingual nerve. JOMS 61: 197, 2003

33 suits in 12 states (42% California)
Allegations
- 52% lack of informed consent
- 15% inadequate 3rd molar training
- 15% wrong surgical approach
- 12% failure to refer
58% defense verdicts, 39% plaintiff verdicts
3% settled (mean settlement: $150,000)
Average award = $306,737

Diagnosis Caveats

Spontaneous recovery occurs in most but not all patients
Nerves in soft tissue (LN) have lower recovery rate than in bony canals (IAN)
Documentation with nerve testing and classification is mandatory
Timely referral for microsurgery provides best chance for recovery

Deficit > 1 month indicates high grade injury with uncertain recovery
Continued improvement may be followed, but if improvement stops, it usually does not start again
Most injuries resolve in 3-9 months, but only if improvement began before 3 months
Patients anesthetic at 3 months usually do not achieve recovery without microsurgery

Diagnosis Caveats

Patients with sensation that they find unacceptable may be considered for microsurgery
Microsurgical delay decreases success
Late painful neuropathies are managed nonsurgically by a neurologist
Early pain may indicate neuroma formation and warrant early surgery
Management Caveats

- A timely referral must be provided
- Angry, uninformed patients don’t improve with any treatment
- Surgery at 3-6 months is more likely to be successful than surgery > 12 months
- Surgery may improve objective function
- Surgery may not reduce subjective pain

Medico-Legal “Damage Control”

- “My lip/tongue is still numb”
- Surgeon speaks with patient
  - Reassurance, recall prep discussions
  - Dictate details now (LA, flap, suture, nerve visualized) as addendum
  - Don’t alter medical record
- Schedule follow-up (1-2 days)
  - Brief nerve exam (gross sensation)
  - Consider: Medrol® dose-pak
  - Sensory reeducation exercises

Medico-Legal “Damage Control”

- 1 week postop visit
  - Nerve testing (light touch, two-point)
  - Subjective (VAS)
  - Panorex (retained root, foreign body)
  - Photographs for comparison?
- 1 month visit
  - No change, or severe deficit: referral
  - Improvement, follow every 2 weeks
Referral to Microsurgeon?

1. Observed nerve transection
2. Complete postop anesthesia (‘unobserved’ nerve injury)
3. No improvement at 1 month
4. Residual subjective-only complaints
5. 2nd opinion to confirm OMS findings

Why Refer To Microsurgeon?

- Serial examinations by experienced surgeon
- Trial of medications
- Prompt microsurgery, if indicated

To Whom Do You Refer?

- Bruce Donoff, Boston, MA
- Salvatore Ruggiero, New Hyde Park, NY
- John Zuniga, Dallas, TX
- John Gregg, Blacksburg, VA
- Jim Green, Gainesville, FL
- Michael Miloro, Chicago, IL
- Tony Pogrel, San Francisco, CA
- Regional Academic OMS Training Program
Terminology

- **Paresthesia**: abnormal sensation, spontaneous or evoked, no pain
  - range: hypoesthesia to anesthesia
- **Dysesthesia**: abnormal sensation, spontaneous or evoked, unpleasant
  - range: hyperesthesia to dysesthesia
- **Dysesthesia**
- **Hyperpathia**, **Hyperalgesia**
- **Causalgia**: burning pain
- **Anesthesia dolorosa**: pain in area of anesthesia
- **Alloynia**: pain to non-painful stimulus
- **Neuralgia**: pain in distribution of nerve

Etiology of Nerve Injury

- 3rd molar removal
- Maxillofacial trauma
- Orthognathic surgery
- Dental implants
- Salivary gland surgery
- Pathology
- Preprosthetic surgery
- Endodontic treatment

Incidence of Nerve Injury

- **3rd molar surgery** (1-5% overall)
  - IAN: 0.26 - 8.4%
  - LN: 0.1 - 22.0%
- **Orthognathic surgery (SSO)**
  - IAN: 0.025 - 84.6%
  - LN: rare (screws)

- Questionnaire to CAAOMS (n=535)
- 12 month period
  - 95% had an IAN injury, 53% had a LN injury
  - In OMS lifetime of practice
    - 78% had a permanent IAN injury
    - 46% had a permanent LN injury
- Temporary: IAN 0.4%, LN 0.1%
- Permanent: IAN 0.04%, LN 0.01%
- Correlation with years of experience

Queral-Godoy E. Frequency of LN lesions after 3rd molars. JOMS 64:402, 2006
- n = 4,995 lower 3rd molar extractions (Spain)
- 0.5% overall incidence of LN injury
  - 17 women, 6 men, mean age = 25.8 yrs
  - 14 left, 10 right, 1 bilateral
  - 100% had bone removal
  - 20/24 had tooth sectioning
  - Most recovered in 3 months

Cheung LK. Incidence of neurosensory deficits after 3rd molars. IJOMS 39:320, 2010
- n = 4,338 cases
  - 61% female, 39% male, ages 14-82
  - 0.35% IAN deficit, 0.69% LN deficit
  - Most recovery occurs within 3-6 months
  - LN risk: distoangular
  - IAN risk: depth of impaction
  - Experience is significant
  - Not significant: sex, age, lingual flap, removal of distolingual bone, tooth sectioning
Jerjes W. Risk factors associated with injury to IAN and LN after 3rd Molar EOE 109: 335, 2010

- n=3,236 patients
- 1 month
  - 1.5% IAN paresthesia
  - 1.8% LN paresthesia
- 24 months
  - 0.6% IAN
  - 1.1% LN

IAN risks: age (26-30), horizontal impaction, radiographic proximity to IAC, trainee surgeon
LN risks: males, distoangular impaction, radiographic proximity to IAC, trainee surgeons

3rd Molar Nerve Injury

Temporary
- IAN: 0.5-7.5%
- LN: 0.1-5.0%

Permanent
- IAN: 0.05-1.0%
- LN: 0.01-0.5%

Risk Factors For Nerve Injury

1. Advanced age (>25 years)
2. Female gender
3. Depth of impaction
4. Angulation (horizontal-IAN, distoangular-LN)
5. Lingual orientation with loss of lingual cortex (LN)
6. Bone removal, tooth sectioning
7. Surgeon experience, duration of surgery
8. Radiographic predictors

Female Predilection

Pogrel MA. The etiology of altered sensation of the IAN, LN nerves as a result of dental treatment. J Calif Dent Assoc 27: 531, 1999
- Female: Male = 3.3:1

Coyle DE. Female rats are more susceptible to development of neuropathic pain using partial sciatic nerve ligation. Neurosci Lett 17: 186, 1995
- Rat sciatic nerve ligation, measure paw withdrawal (alodynia)
- 65% female, only 29% male, withdrew to noxious stimulus
- Male rat nerves recovered better than female

3rd Molar Surgery Etiology

LA injection
- Incision
- Flap reflection
- Bone removal
- Lingual plate
- IA canal
- Tooth sectioning
- Tooth elevation with nerve stretching
- Socket curettage
- “Follicle” removal
- Suture placement
- Dry socket medicaments
Pogrel MA. Etiology of LN injuries in 3rd molar region. JOMS 64: 1790, 2006

- 16 cadaver LN injured, examined histologically
  1. Scalpel: minimal fascicular damage, spontaneous recovery likely
  2. Hemostats: crush injury, fascicular disruption, but limited extent; resection and early repair
  3. 702 fissure bur: ragged fascicular injury, delayed repair, possible graft
  4. Stretch > 120% of length: diffuse fascicular disruption, delayed repair, graft likely

Radiology of the Nerve

- A. To assess risk of nerve injury
  - Panorex
  - CT (limited use), 3DCT (cone-beam)
  - MRI
- B. To assess existing nerve injury
  - HR-MRI
  - MRN (magnetic resonance neurography)
  - Magnetic source imaging

7 Panoramic Predictors of IAN Risk

1. Root Darkening
2. Root Deflection
3. Interruption of White Line of Canal
4. Root Narrowing
5. Dark & Bifid Root Apex
6. Canal Diversion
7. Canal Narrowing

1. Root darkening (radiolucent band across the roots continuous with the white lines of IAC)
2. Interruption of white lines of IAC
3. Canal narrowing

Radiographic Predictors

• Blaeser BF, August MA. Panoramic risk factors for IAN injury after 3rd molars. JOMS 61: 417, 2003
• No radiographic findings = minimal risk (<1%)
• 1 or more findings = increased risk (1.7-12%)

8th Radiographic Predictor

• Periapical radiolucency
• Loss of cortical integrity between IAC and root PDL space
Ueda M. Clinical significance of CT assessment and anatomic features of the IAC as risk factors for IAN injury at 3rd molar surgery. JOMS 70: 514, 2012
- 99 pts (145 teeth) CTs reviewed
- 3 canal shapes: round/oval, teardrop, dumbbell
- 7/145 IAN injuries (4.8%)
- All 7 lacked cortication
- 3/7 dumbell, 4/7 round/oval

Garcia, GS, Valmaseda-Castellon E, Gay-Escoda C. Does CT prevent IAN injuries caused by lower 3rd molar removal? JOMS 70: 5, 2011
- Retrospective cohort study of 150 extractions
- Most common indications for CBCT = patient age and Rood predictors on pano
- CT group (95) – pano + CT, Control (55) – pano
- 15 (10%) in CT, 6 (4%) in Control had IAN impairment
- Logistic regression models indicate that CBCT does NOT decrease risk of IAN injury

Miloro M. Radiographic proximity of 3rd molar to IAC. OOOOE 100: 545, 2005
- 560 lower 3rds on panorex
- Tooth-to-canal distance
- Mean distance of erupted: 0.88 mm
- Unerupted (all below canal, neg)
  - Mesioangular: - 0.97 mm (p<.05)
  - Vertical: - 0.61 mm
  - Distoangular: - 0.31 mm
  - Horizontal: - 0.24 mm
Miloro, OOOE 2005
- Temp IAN paresthesia = 3.33% (18)
- More common with mesioangular impactions (mean: -0.66 mm)
- More common in females (13/18)
- Mean age: 23.2 yrs

Tay ABG. Effect of exposed IAN during removal of 3rd molars. JOMS 62: 592, 2004
- n=192 nerves seen in 170 pts over 5 yrs
- 20% paresthesia @ 1 week
  - 43% recovered by 3 months
  - 65% recovered by 6 months
  - 71% recovered by 1 year
  - 6% long-term paresthesia > 1 year

Forced Orthodontic Eruption
- n=18, 0% IAN injury
- Avg 2nd molar probing depths: 7.9 to 1.8 mm

17.6% LN in soft tissue over impacted tooth


LN Above Lingual Crest

LN Contact Lingual Plate
McDonald, Fogrel. Noninvasive somatosensory monitoring of the injured IAN using Magnetic Source Imaging. JOMS 54: 1068, 1996

Filler AG. MRN. J Neurosurg 1996

Coronectomy
- Advanced age, mandibular atrophy
- Proximity to canal
- High risk of nerve injury, jaw fracture

Coronectomy
- 45 degree cut
- > 3mm below alveolar crest
- No pulp treatment
- Protect LN
- Not for horizontal impactions
Coronectomy Literature

O’Kirdon BC. OOOO 98: 274, 2004
- n=52 teeth in 10 yrs, 3 removed for infection, most roots migrate 2-3 mm, 1 pt (1.8%) IAN injury

Pogrel MA. JOMS 62: 1447, 2004
- n=50 teeth, 2 removed for infection (same pt), 1 for migration, 30% showed migration 2-3 mm

Renton T. Br J OMS 43: 7, 2005
- n=120, 50/50 randomized extraction vs. coronectomy, 1% paresthesia with extractions, 0% with coronectomy, failed coronectomy (8%)

Goto S. Clinical and dental CT evaluation 1 year after coronectomy. JOMS 70: 1023, 2012
- N=116 teeth (3/06-12/09)
- Only 1 root erupted into soft tissue
- 8 teeth extracted in 1-6 mos due to dehiscence
- No nerve injuries
- Average root migration = 3 mm
  - Females, <20 yrs age, conical roots

Risk Factors For LN Injury

- Distoangular impaction
- Superficial position of LN
- Chronic pericoronitis
- Scarring of LN toward surface
- Lingual version of tooth
- Roots overlap 2nd molar roots
- Missing lingual plate
- Right side (#32)
  - Right-handed surgeon can’t see lingual region

Lingual Nerve Retraction

Beirne, OOOO 91:395, 2001
- Review of 8 articles
- BA+ (buccal approach + LNR), BA- (BA - LNR), LS (lingual split + LNR)
  - Temp: LS (9.8%), BA+ (6.4%), BA- (6.6%)
  - Perm: LS (1.1%), BA+ (6.6%), BA- (2.2%)
  - LNR: higher temporary, same permanent rates
Mandibular Block Injury

- Incidence?, unreported injuries
  - Pogrel MA. Permanent nerve involvement resulting from IAN blocks. JADA 131: 901, 2000
  - n = 83 pts, 79% LN, 21% IAN
  - 36% dysesthesia
  - Estimate: 1:26,762-1:160,571
  - High incidence: 4% prilocaine

Injection Injury Trends

- Electric shock on injection is uncommon
- High proportion of dysesthesia
- Non-anatomic pattern of nerve involvement
  - Demyelination to trigeminal ganglion
  - Adjacent nerve recruitment (V1V2)
- More common in females
- LN much more common than IAN

Why Lingual Nerve?

- Mouth opening stretches LN toward surface
- Multiple needle redirection
  - May cause direct injury, but no ‘shock’ since LN numb already
  - Less fascicles in 3rd molar region (3), more damage

Lingual N in 3rd Molar Region

- Smith E. Presence of nerve cell bodies in LN in 3rd molar area. JOMS 47: 931, 1989
- 44 cadaver halves
- 40/44 (91%) had cell bodies or ganglia along the LN in 3rd molar region
- Damage to cell body is irreversible vs. axonal injury

Block Injury Mechanisms

1. Direct neural trauma
   - Needle barb
   - Multiple redirections
2. Local anesthetic toxicity (%)
   - Epinephrine - local ischemia
3. Epineurial hematoma
### Direct Neural Trauma

- Occurs commonly but low % paresthesia
- If polyfascicular, trigeminal has interfascicular tissue
- If 1-3 fascicles, minor injury may have major effect
- May be “needle barb” or “multiple redirection” injury

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### Local Anesthetic Toxicity

- More likely if intraneuronal
- Dysesthesia common
- 4% prilocaine > 2% lidocaine = 3% mepivacaine
- 4% articaine (concentration gradient)
  - Amide-ester combination
  - Contraindicated for blocks
- Epinephrine may exacerbate damage through ischemia

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### Frequency Distribution of Paresthesia 1993 Only

<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Cartridges Used</th>
<th>No. Paresthesias</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articaine</td>
<td>4,378,970</td>
<td>15</td>
<td>77.4</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>201,679</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>3,062,913</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>1,549,037</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>2,532,615</td>
<td>4</td>
<td>38.7</td>
</tr>
<tr>
<td>Total</td>
<td>11,424,914</td>
<td>18</td>
<td>100</td>
</tr>
</tbody>
</table>

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### Pogrel MA. Nerve damage associated with IAN blocks, JADA 126: 1150, 1995

- Ontario’s prof liability program ‘73-’93
- n=143 injection injuries
- Age, gender, needle ga. not significant
- LN most frequently affected
- 1993, 14 cases of paresthesia-10 articaine 4%, 4 prilocaine 4%
- Paresthesia for 4% articaine (p<.002), 4% prilocaine (p<.025) greater than expected based on sales and distribution in 1993

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### Haas and Lennon, 1995

- 1984, Articaine introduced in Canada
### Frequency Distribution ‘73-’93

<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articaine</td>
<td>50</td>
<td>33.6</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>4</td>
<td>3.4</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>43</td>
<td>26.9</td>
</tr>
<tr>
<td>Unknown (2+)</td>
<td>47</td>
<td>31.5</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>100</td>
</tr>
</tbody>
</table>

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*Garisto G, Haas DA. Occurrence of paresthesia after dental LA in the USA. JADA 141: 836, 2010*

- 1997-2008 FDA Adverse Event Reports
- n=248, 95% mandibular blocks
- 89% LN
- Reports using 4% prilocaine (4% articaine) were 7.3 x (3.6 x) greater than expected based on use
- Caution: 4% solutions for mand blocks

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**Figure 3.** U.S. local anesthetic sales percentages from November 1997 through 2008. Source: Strategies Data Marketing, unpublished data, 2005.

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**Table 1.** Observed and expected* frequencies of paresthesia as reported to the Adverse Event Reporting System involving dental local anesthetics from 1997 through 2008 in the United States.†

<table>
<thead>
<tr>
<th>Local Anesthetic</th>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
<th>Articaine Comparison‡</th>
<th>Prilocaine Comparison§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articaine</td>
<td>116</td>
<td>31.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other anesthetics</td>
<td>110</td>
<td>194.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>226</td>
<td>226</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prilocaine</td>
<td>97</td>
<td>18.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other anesthetics</td>
<td>129</td>
<td>212.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>228</td>
<td>228</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Observed Frequency: Number of cases. Expected Frequency: Total number of cases x Proportion of use of local anesthetic.
† Does not include cases involving the use of more than one anesthetic.
‡ This difference was statistically significant (χ² = 38.81, P < 0.001).
§ This difference was statistically significant (χ² = 28.97, P < 0.001).
Epineurial Hematoma Theory
- Transient, localized paresthesia from focal hematoma
- Lymphatic absorption, spontaneous resolution

Injection Injury Prognosis
- 85% of cases resolve in 8 weeks
- Of the 15% that persist, less than 1/3 resolve completely
- No microneurosurgery (access)
- Drugs if dysesthesia

3rd Molar vs. Block Injury?
Pogrel. Trigeminal nerve chemical neurotrauma from injectable materials. OMFS Clin NA 2001
Orthognathic Surgery

- Triplett G. LN injury due to overpenetration of bicortical screws for SSO. JOMS 54: 1451, 1996

SSO Nerve Injury Risk Factors

1. Advanced age
2. Increased length of surgery, surgeon experience
3. Presence of 3rd molars
4. “Bad splits”
5. Nerve manipulation
   - Medial retraction (decreased SSEPs)
   - Within osteotomy
6. Low corpus height (class II high MP angle)
7. Canal close to inferior border

Al-Bishri. On neurosensory disturbance after SSO. JOMS 62: 1472, 2004

- n=43 questionnaires, > 1 yr after SSO
- 11.6% long-term subjective NSD
- Mostly women, over age 40
- Corticosteroid use
  - 15% with steroids reported long-term NSD
  - 30% without steroids
  - Not statistically significant

Dental Implants

- Nerve injury common
- Lack of literature
- No consensus on care
- Pilot drill through canal
- Compartment syndrome
  - Venous bleeding
  - Pressure in canal
Some Consensus

Numb + implant in canal (panorex or CBCT) = implant removal, or shorter

No Consensus

- Numb + implant in canal = implant removal, or shorter
- Numb – implant in canal:
  - Etiology? (block?)
  - Observation
  - Steroids
  - Remove implant
  - Shorter implant

TABLE 1: Algorithm for management of patient with paresthesia after implant placement.

Patient s/p implant c/o sensory dysfunction, verified by NST

Imaging study (panor or CT scan)

- Implant encroachment on IAN, MN
  - Remove or reposition implant
  - Expectant observation, serial NSTs

- No improvement
  - Consider microsurgery
  - Anesthesia>3mos
  - Or
  - Hypoesthesia>4mos

- Improvement
  - No further Rx

No further Rx

Endodontic Injury

- Louis P. OMS
- Clinics of NA.
- May 2001

30-40% permanent altered sensation

Advanced age
Endodontic Nerve Injury

A. Physical compression
B. Neurotoxicity
   - Paraformaldehyde pastes
     - Sargenti, N2, AH26
   - Eugenol-containing cements
     - ZOE, PCS
   - Prompt exploration and debridement (12-24 hrs)

Scolozzi. Successful IAN decompression for dysesthesia following endodontic treatment. GOOO 97: 625, 2004

Chemical Injury

- Caution: terra-cotril for dry socket

- Tetracycline: direct neurotoxicity
- Rat saphenous nerve
  1. BIPP paste (bismuth iodoform paraffin): no effect
  2. Whitehead’s varnish: some effect
  3. Surgical (oxidized cellulose): acidic environment, potential neurotoxicity
  4. Carnoy’s (FACE): < 5 min, reversible

Katre C. IAN damage caused by bone wax in 3rd molar. JOMS 39: 511, 2010
- Developed paresthesia 11 years later after 3rds and bone wax

Intraoral Bone Graft Harvest
**Distraction Osteogenesis**
- Axoplasmic edema
- No fascicular injury
- Neurapraxia: transient conduction block
- Prompt recovery

**Meyer. Effect of DO on IAN function. JOMS 62: 292, 2004**
- 5 advancements of 10-14 mm
- Age: 22-32 yrs, 4 F, 1 M
- Testing: preop, postop, 7d, 3m, 6m, 9m, 12m
- All 10 nerves normal by 12m
  - 100% BSD
  - 4/10 S4+ (2PD = 2-6 mm)
  - 6/10 S3+ (2PD = 7-15 mm)
  - 10/10 subjective hypoesthesia

**Trigeminal Nerve Anatomy**

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Size (μ)</th>
<th>Cond. Vel (m/s)</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-alpha (myelin)</td>
<td>12-20</td>
<td>70-120</td>
<td>Position/Fine Touch</td>
</tr>
<tr>
<td>A-beta (myelin)</td>
<td>6.0-12</td>
<td>35-170</td>
<td>Proprioception</td>
</tr>
<tr>
<td>A-delta (thin myelin)</td>
<td>1.0-6.0</td>
<td>2.5-3.5</td>
<td>Superficial Pain/T*</td>
</tr>
<tr>
<td>C (unmyelinated)</td>
<td>0.5-1.0</td>
<td>0.7-1.5</td>
<td>Deep Pain/T*</td>
</tr>
</tbody>
</table>

**Fascicular Patterns**
- Monofascicular (1 fascicle)
- Oligofascicular (2-10 fascicles)
- Polyfascicular (>10 fascicles = Trigeminal)

LN in 3rd molar region may have fewer (1-3) fascicles
- May explain paresthesia following minor trauma
Trigeminal Nerve Anatomy
- Mesoneurium
- Epineurium
- Perineurium
- Endoneurium

Nerve Healing
- Cellular regeneration
  - Not tissue regeneration
  - No nerve cell mitoses
  - No increase in number of nerve cells, but axonal sprouting
  - Neurotropic and neurotrophic factors

50+ Axonal Sprouts
Schwann cells (NGF)
RER (Rough endoplasmic reticulum)
Cell Body
Microtubule
Schwann Cell
Axon
Chromatolysis (cell body edema)
Nissl substance
Protein synthesis
Schwann Tubulin
Bungner Band
Axonal Sprout
Basal Lamina Tube

2012 ANNUAL MEETING
Neuroma:
accumulation of neuropeptides

**Neuroma Formation**
- Amputation (stump) neuroma
- Neuroma-in-continuity (fusiform, central neuroma)
- Lateral neuromas
  - Exophytic-type
  - Adhesive-type

**Patient Assessment**
- History
- Clinical examination
  - Subjective (VAS)
  - Objective
    - Clinical neurosensory test
- Radiographs
- Nerve injury classification

**Seddon Classification**
- Neurapraxia
- Axonotmesis
- Neurotmesis
Sunderland Classification

Sunderland S. A classification of peripheral nerve injuries produced by loss of function. Brain 74: 491, 1951

- First-degree Injury (Grade I)
  - Types I, II, III
- Second-degree Injury (Grade II)
- Third-degree Injury (Grade III)
- Fourth-degree Injury (Grade IV)
- Fifth-degree Injury (Grade V)

Seddon vs. Sunderland

- Neurapraxia   Grade I (Types 1, 2, 3)
- Axonotmesis   Grades II, III, IV
- Neurotmesis   Grade V

Sunderland vs. Recovery

<table>
<thead>
<tr>
<th>Recovery</th>
<th>Rate of Recovery</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>complete</td>
<td>fast (dys-wks)</td>
</tr>
<tr>
<td>II</td>
<td>complete</td>
<td>slow (wks)</td>
</tr>
<tr>
<td>III</td>
<td>variable</td>
<td>slow (wks-mos)</td>
</tr>
<tr>
<td>IV</td>
<td>poor/none</td>
<td>little/none</td>
</tr>
<tr>
<td>V</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

History of Present Illness

- Etiology
- Onset of symptoms
- Progression of symptoms
- Any treatment (meds)
- Response to treatment
- Present symptoms
Visual Analog Scale
• 10 cm line, 5 degrees every 2.5 cm
• 1. Complete absence of sensation
• 2. Almost no sensation
• 3. Reduced sensation
• 4. Almost normal sensation
• 5. Fully normal sensation

Clinical Examination
• Inspection
  • 3rd molar site
  • Lingual scar
  • Self-induced trauma
  • Atrophic papillae
• Palpation
  • Tinel’s sign

Tinel’s Sign
• “Provocative test of regenerating nerve sprouts”
• Palpation of injury site elicits distal tingling sensation
• Sign of small fiber recovery
• Poorly correlated with functional recovery
• May be confused with neuroma

Post-Extraction Radiographs
• To confirm presence of Rood predictors before bony healing
• Rule out roots, foreign body

Clinical Neurosensory Test
• Level A Testing
  • Brush stroke directional discrimination
  • Two-point discrimination
• Level B Testing
  • Contact detection
• Level C Testing
  • Pin prick nociception
  • Thermal discrimination
Zuniga, Meyer, Gregg, Miloro. Accuracy of clinical neurosensory test for nerve injury diagnosis. JOMS 56: 2, 1998

- Multisite, randomized, prospective, blinded
- n = 130 patients: 60 IAN, 70 LN
- Clinical neurosensory test
  - Normal (I), Mild (II), Moderate (III), Severe (IV), Complete (V)
- Comparisons to nerve findings
  - Normal/intact (I), compressed/intact (II), N-I-C (III), partial transection (IV), complete transection (V)

IAN PPV = 77%
IAN NPV = 60%
IAN Sensitivity = 85%
IAN Specificity = 47%
IAN Accuracy = 68%

LN PPV = 95%
LN NPV = 100%
LN Sensitivity = 100%
LN Specificity = 62.5%
LN Accuracy = 94%
What about the evaluation of dysesthesia?

- Use same Levels A, B, C
- Increased subjectivity
- May be difficult to complete tests
- Most are Sunderland I or II with pain

Clinical Neurosensory Testing

Brush Stroke Direction (Level A)

- Brush from R to L, L to R
- Number correct of 10: > 80% normal
- Alternate with control side

Clinical Neurosensory Testing

- Allodynia: pain due to a nonpainful stimulus
- Hyperpathia: increased reaction to a stimulus, esp. repetitive
- Hyperalgesia: increased response to a stimulus that is normally painful
Two-Point Discrimination (Level A)

- Closest distance (mm) to discern 2 points
- Use blunt tips
- Compare to control side (individual norms)

No sharp points

Contact Detection (Level B)

- Semmes-Weinstein monofilaments, *von frey hairs*
- Acrylic rods with plastic fibers that bends with different pressures (gm of force)

Stick

Fishing Line
Pin Prick Nociception
- 30 ga. needle, all/none response

Thermal Discrimination
- Ice cold and hot water
- Minnesota thermal disks
- RollTemp® (25/40 deg C)

Thermotester®

Stereognosis Testing
- Grids, Letters, Numbers
- van Boven domes
Clinical Taste Testing

- Whole-mouth taste testing
- Localized taste testing
- 1 M sodium chloride (salt)
- 1 M sucrose (sweet)
- 0.4 M acetic acid (sour)
- 0.1 M quinine (bitter)

Problems With Taste Testing

- Significant difference at 4 years of subjective and objective findings
- Wide variation in taste loss and recovery
- Poor correlation of taste (VII) and sensation (V3) recovery
Problem with “Objective Tests”

- Levels A, B, C (2PD, BSD, CD, Temp, PP) are “objective”
- Not objective since a patient response is “subjective”
- The only 100% objective test is SSEP

Somatosensory Evoked Potentials

Management Options

- Observation
- Nonsurgical (drugs)
- Low-level (soft) laser therapy
- Sensory re-education exercises
- Microneurosurgery

Trigeminal Nerve Disorders Management

Michael Miloro, D.M.D., M.D., F.A.C.S.
Professor
Department Head & Program Director
Oral & Maxillofacial Surgery
University of Illinois at Chicago
Chicago, Illinois
Treatment Planning Considerations
- Sunderland grade I, II, III, IV, V
- Observed vs. unobserved injury
- Time from injury to repair
- Mechanism of injury
- Presence of dysesthesia
- ASA physical status

Nerve Injury Treatment Planning
- Increased sensation
  - Drugs
- Decreased sensation
  - Wait
- Anesthesia = surgery
  - LN in 1-3 months
  - IAN in 3-6 months

Clinical Scenarios
- Painless anesthesia
- Nonpainful hypoesthesia
- Nonpainful hyperesthesia
- Surgery
- Painful anesthesia (anesthesia dolorosa)
- Painful hypoesthesia
- Painful hyperesthesia

The Hypoesthetic Patient
- Etiology
  - 3rd, SSO, needle-stick
- Neurosensory testing
  - Should be < 50% for surgery
  - Successful improvement: 80-85%
- Time from injury to repair
  - Early (< 6 months): drugs, consider microsurgery for neuroma
  - Late (> 6 months): drugs

The Dysesthetic Patient
- Etiology
  - 3rd, needle-stick, SSO-rare
  - Implant: removal?
- Neurosensory testing
  - Usually 90-100%. microsurgery not indicated
- Time from injury to repair
  - Early (< 6 months): drugs, consider microsurgery for neuroma
  - Late (> 6 months): drugs
Pharmacotherapy for Neuropathic Pain

1. Membrane stabilizing drugs to prevent ectopic neural discharges
   - Antidepressants, anticonvulsants
   - Elavil, dilantin

2. Dorsal horn inhibitors (GABA agonists)
   - Muscle relaxants, benzodiazepines
   - Neurontin

3. Topical agents

Pharmacotherapy

- Local anesthetic nerve blocks
- Corticosteroids (medrol dose-pak)
- B-complex vitamins (B1, B6, B12)
- NSAIDs (ibuprofen, tylenol)

Antidepressants
- Tricyclics: amitryptyline (elavil)
- Tetracyclics: doxepin (sinequan)
- Serotonin antagonists: fluoxetine (prozac) and duloxetine (cymbalta)

Pharmacologic Therapy

- Topical crèmes: capsaicin (zostrix)
- Eutectic mixtures of topical crèmes
  - Ketoprofen 10%/tegretol 2%/lidocaine 10%
  - Elavil 2%/capsaicin .075%/lidocaine 5%/clonidine 2%
  - Ketoprofen 10%/gualenesin 10%/capsaicin .075%/lidocaine 4%
  - Neurontin 6%/clonidine .02%
  - Ketoprofen 10%/baclofen5%/lidocaine 5%
  - Ketamine 10%/neurontin 6%/clonidine .2%

Current Pharmacologic Options

- Neurologist consultation
- Steroids, B-complex vitamins
- Capsaicin crème 0.075% HP tid
- Neurontin (gabapentin) 300 mg tid
- Lyrica (pregabalin) 100 mg tid
- Baclofen (lioresal) 10 mg tid
- Clonopin (clonezepan) 1.0 mg tid
- Elavil (nortryptaline) 25 mg tid

Anticonvulsants
- Phenytoin (dilantin)
- Carbamazepine (tegretol)
- Gabapentin (neurontin)
- Levetiracetam (lyrica)
- Levetiracetam (keppra)

Muscle relaxants: baclofen (lioresal)
Benzodiazepines: clonazepan (klonopin)
Antisympathetics (SMP)
- Propranolol, guanethidine, phenoxybenzamine, prazosin, clonidine
Corticosteroids

- Evidence to support use, spinal cord injury, orthognathics (SSO)
- Decrease perineurial edema, especially in immediate postoperative period
- Medrol Dose-Pack (contains 21 4 mg pills)
  - Methylprednisolone 4 mg
  - Begin with 6 pills (24 mg)
  - Take one less each day for 6 days

B-Complex (B1/B6/B12) Vitamins

- B1 (thiamine), B6 (pyridoxine), B12 (cyanocobalamin)
- Analgesic role in neuropathic pain
- Rat studies show benefit in experimental hyperalgesia (spinal cord compression)
  - Song, Anesthesiology, 2009
  - Wang, Pain, 2005

Acetyl-L-carnitine (ALCAR)

- Amino acid nutritional supplement
- Alzheimer’s disease
- Wilson A. Acetyl-L-carnitine increases nerve regeneration and target organ reinnervation. JPRAS 63: 1186, 2010
- Rat sciatic nerve model
- ALCAR 50 mg/kg/day IV
  - Increased number of regenerating nerve fibers and target organ reinnervation (gastrocnemius muscle bulk)

Capsaicin Crème (Zostrix)

- Chili pepper extract
- Chew chili peppers
- Decreases substance P
- Apply to area tid prn
- Skin, mucous irritation
  - 0.025% LP, 0.075% HP

Capsaicin Crème
Gabapentin (Neurontin)
- Anti-epileptic drug
- Exact mechanism unknown
- Mimics GABA (inhibitory neurotransmitter)
- Begin 300 mg po tid, then taper
  - 200/300/300, 200/200/200, 100/200/200, 100/100/200, ...
- Max: 3600 mg/day
- Side effects: mild drowsiness

Lyrica (Pregabalin)
- Anti-epileptic drug
- For fibromyalgia
- Similar mechanism to gabapentin
- Used for DM neuropathy
- Increases GABA (inhibitory)
- 75-100 mg po tid (max: 600 mg/day)

Keppra (Levetiracetam)
- Anti-epileptic drug
- Used for partial seizures
- 500 mg po bid
- Max: 3000 mg/day

Carbamazepine (Tegretol)
- Anti-convulsant drug
- 100-300 mg po tid
- Therapeutic dose: 900-1200 mg/dl
- Monitor blood levels: 4-12 mcg/ml
- Hepatotoxicity (LFT)
- Agranulocytosis (CBC)
- No longer a first-line agent

Clonazepam (Klonopin)
- Benzodiazepine (GABAₐ agonist)
- Suppresses spike and wave seizure foci
- 1.0 mg po tid
- Maximum dose: 20 mg/day

Amitryptaline (Elavil)
- Antidepressant
- Blocks 5-HT and NE reuptake
- 50 mg po qhs
- Max: 300 mg/day
Other Methods

- Classically for trigeminal neuralgia
- Nerve injections
  - Alcohol
  - Glycerol
- Radiofrequency thermal neurolysis
- Cryotherapy

Other Methods

- Gregg JM, Small EW. Surgical management of trigeminal pain with radiofrequency lesions of peripheral nerves. JOMS 44: 122, 1986.  
  - 68% recurrence of pain at one year

Low Level Laser ("Soft Laser")

- Wound healing capabilities (all tissues)
- Direct effect on injured axons and NGF production
- Mechanism: rhodopsin-kinase enzyme
  - Active at 820nm wavelength (Ga-Al-Ar)
  - NF-kappa B translocation into nucleus
  - Transcription of neural repair elements
- No FDA approval, yet

LLL Nerve Studies

- Khullar. Effect of LLL on neurosensory deficits subsequent to SSO. OOOO 82: 132, 1996
- Khullar. Preliminary study of LLL for treatment of long-standing (> 2 years) sensory aberrations of the IAN. JOMS 54: 2, 1996
- Miloro M. LLL effect on neurosensory recovery after SSO. OOOO 89: 2000
  - n=6 BSSO
  - Bilateral LLL 6.0 joules x 4 sites
  - Preop, 6 hrs, 24 hrs, days 2, 3, 4, 7
  - CNT and VAS: preop, 6 hrs, 24 hrs, days 2, 3, 4, 7, 14, 28, 56
Miloro, 2000

- BSD normal by 2 weeks
- 2PD and CD normal by 8 weeks
- Temp and PP minimally affected, but remained deficient at 2 months
- VAS
  - 50% reported deficit at 2 days
  - Only 15% deficit at 8 weeks

Microneurosurgery Indications

- Complete anesthesia (0%)
- Less than 50% residual sensation
- Sunderland III, IV, V
- Observed nerve transection
- Early dysesthesia (neuroma formation)

Microneurosurgery Not Indicated

- Sensation improves at each visit
- Late dysesthesia (esp IAN)
- Other contraindications
  - Anesthesia dolorosa
  - Sympathetic-mediated pain (CRPS)
  - Deafferentation pain
  - Trigeminal neuralgia
  - Atypical facial pain

AAOMS Nerve CIG, 1996

- Microsurgery, when indicated should be considered (time after injury):
  - Lingual Nerve 1-3 months
  - Inferior Alveolar Nerve 3-6 months

Unobserved Injury Algorithm

- Monitor with clinical NS testing
- If 0-50% sensation:
  - LN repair: 1-3 months
  - IAN repair: 3-6 months

Observed Injury Algorithm

- Sunderland I, II, III (nerve visualized)
- Compression (root, implant, jaw fracture)
- Immediate decompression
- Chemical (RCT, tetracycline)
- Immediate debridement
- Sunderland IV, V
- Clean, immediate repair
- Avulsive: delayed primary repair (21d)
Meyer RA, AAOMS, Chicago, 1991

- **Success after repair of severed IAN, LN nerves**
  - 90% if repaired by 3 months
  - 80% if repaired by 6 months
  - 10% if repaired at 12 months

---

### Why Does Time Matter?


### Published Success of Microsurgery

- **30-50% "success***
  - Few multicenter trials (1 surgeon)
  - Patient age
  - Etiology of injury
  - Delay from injury to repair
  - Surgical technique
  - Clinical NS exam
  - Follow-up period
  - "Success" criteria

### Leung, 2012

Treatment modalities of neurosensory deficit after lower third molar surgery: A systematic review. *JOMS* 70: 748, 2012

- Systematic literature review identified 10 articles (of 1112 returned)
- 4 surgical, 2 nonsurgical options
- Total surgical: 164 LN, 23 IAN
  - External neurolysis, 29 LN, 3 IAN
  - Direct suturing, 21 LN, 1 IAN
  - Vein graft, 14 LN, 14 IAN
  - Gore-Tex Tube, 14 LN, 14 IAN
- "Significant improvement" in surgical ranged from 25-66.7%
- Acupuncture and low-level laser showed "significant improvement" in 100%
- Any treatment option rarely produces complete recovery
- Timing too variable to determine optimal repair time
- No standardized assessment criteria for success

### Leung, 2012 Treatment Study Nerve, n Outcomes (Complete, Significant, Some Improvement, No Improvement)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Study</th>
<th>N</th>
<th>Outcome</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>IAN 7</td>
<td>0-0-0-0</td>
</tr>
<tr>
<td>Vein graft</td>
<td>Pogrel, 2001</td>
<td>LN 14, IAN 14</td>
<td>0-0-0-0</td>
</tr>
<tr>
<td>Gore-Tex Tube</td>
<td>Pogrel, 1998</td>
<td>LN 21, IAN 21</td>
<td>0-0-0-0</td>
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<tr>
<td>Acupuncture</td>
<td>Koj 2004 [Japanese]</td>
<td>LN 12</td>
<td>0-0-0-0</td>
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<tr>
<td>STS</td>
<td>Tsukamoto, Hashizume, 1993</td>
<td>LN 22</td>
<td>12-13-13-0</td>
</tr>
<tr>
<td>LLL</td>
<td>Midamba, Haanes, 1993</td>
<td>LN 22</td>
<td>12-13-13-0</td>
</tr>
</tbody>
</table>

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Normal Recovery Stages Following Sensory Trigeminal Nerve Injury (Mackinnon SE, 1988)

Stage 0. No sensibility or response in primary injury zone
Stage 1. Recovery of deep pain sense & response
Stage 1+. Recovery of superficial pain sense & response
Stage 2. Recovery of superficial pain & crude touch sense
Stage 2+. Stage 2 with over-response
Stage 3. Recovery of pain, abn touch with no over-response
Stage 4. Complete recovery of control level sense, response
Stage 5. Control level sense-responses, subjective normality

Pogrel MA. Results of repair of IAN and LN. JOMS, 2000

- 1994-1999, n=880 patients
- 51/880 (6%) had surgery: 34LN, 17IAN
- Direct repair: 16LN, 10IAN
- Graft repair: 13LN, 7IAN (16 vein, 2 nerve, 2 gore-tex)
- 10 “good improvement” (1 normal)
- 18 “some improvement”
- 22 “no improvement”
- 1 “worse”


- 53 pts, 1990-1998, most 3rds
- Delay: 4-47 months (mean=15 months)
- Excised neuroma: 4-14 mm (mean=9.4 mm)
- CD: improved 0 to 51%, PP: improved 34 to 77% (43%)
- No correlation with delay from injury
- No reduction in pain (dysesthesia)
- No patient became completely normal
- Most patients considered surgery worthwhile


- n=64 LN repairs
- Early (<90 days), late (90 days)
- Mean repair time: 153 days (5 months) (31-1606)
- 22% had early repair (<90 days)
- 93% of early vs. 63% of late repairs returned to FSR within 1 year (p=.05)


- 1986-2006 (20 years)
- n=222, 171 women, 51 men
- Mean age: 31.1 years (15-61)
- > 1 year followup
- 90% 3rds, 6% 5SO, 5% local anesthetic
- 55% numbness, 42% numbness + pain
- Mean injury to repair: 8.5 months (1.5-96)
Meyer, 2010

69% neurorrhaphy, 13% decompression, 8% nerve graft (gr. auric. or sural)

Results used the Medical Research Council Scale of neurosensory function

90.5%: 146 "complete recovery," 55 "useful sensory function"
9.5%: 21 patients "no or inadequate improvement"

Meyer, 2010

- Shorter delay = improved outcome
- With each month, odds of improvement decreased by 5.8%
- 9 months is a critical time point
- Increased age = worse outcome
- 5.5% decrease in chance of recovery for every year over 45
- Pain improved more than numbness

Bagheri SC, Meyer RA. Microsurgical repair of the IAN: Success rate and factors that adversely affect outcome. JOMS 2012

n=167 pts by one surgeon, 1986-2005
At least 1 year fu
41 male, 126 female, mean age: 38.7 yrs
Mean time injury-repair = 10.7 mo (0-72 mo)
FSR (via MRCS) in 152 (81.7%)
Linear correlation of repair time and success (11% drop per month), significant drop after 12 mos
Patient age significant, threshold drop at 51 yrs
Etiology, operative findings, surgery done-no effect
Presence of pain not significant in achieving FSR (p=.08)

Trigeminal Nerve Injury.
OMS Clinics North America, 1992

- Multi-site, retrospective study of 521 pts
- 192 IAN hypoesthesia
- 131 LN hypoesthesia
- 124 IAN hyperesthesia
- 74 LN hyperesthesia

"Success" criteria
1. Light touch detected > 80% of the time
2. Postoperative pain ≥ 30% reduction

OMS Clinics NA, 1992 Study

- Overall success = 76.2%
- Hypos (85%) better than hypers (62%)
- Hypo-LN (87%) = Hypo-IAN (85.4%)
- Hyper-LN (67.5%) > hyper-IAN (55.6%)

Worst results for hyper-IAN (55.6%)
Decreased success after 6 months

Microneurosurgery

- Magnification (3.5x, 12x)
- Surgical access
- Neurolysis
- Nerve stump preparation
- Neurorrhaphy
Surgical Access
- Transoral
- Transfacial
  - IAN (posterior to 3rd)
  - Need for greater auricular graft
  - Extraoral approach to fracture or bony reconstruction

Extraoral approach to fracture or bony reconstruction

‘External’ Neurolysis
- Nerve decompression
  - Release nerve from surrounding tissues (root, implant, jaw, ZMC fracture)

‘Internal’ Neurolysis
- Not done for polyfascicular nerve

Nerve Stump Preparation
- 1.0 mm resections
  - Mushrooming fascicles

Coaptation
- Align fascicles for direct repair
- Not for polyfascicular nerve
‘Direct’ Neurorrhaphy

Epineurial repair

Perineurial repair

7-0, 8-0, 9-0
Scar Reduction at Neurorrhaphy

- Laser welding (CO₂, argon, Nd-YAG)
- Additives (experimental)
  - Anti-inflammatories, to inhibit of collagen synthesis
  - Corticosteroids (triamcinolone, methylprednisolone)
  - Glycosaminoglycans (OTR4120, ADCON-T/N)
  - Aprotinin, cis-hydroxyproline, human amniotic fluid, hyaluronic acid, tissue plasminogen activator (tPA)
  - Low-dose external beam XRT (700 cGy)

Ngeow WC. Scar less: Methods of scar reduction at sites of peripheral nerve repair. OOOE 109: 357, 2010

‘Indirect’ Neurorrhaphy

- Interpositional nerve graft
- Autogenous
  - Sural
  - Greater auricular
- Allogeneic
  - Cadaveric
- Conduit (gap) repair

Nerve Graft Indications

- Any significant tension
- IAN gaps > 5-10 mm
- LN gaps > 10-15 mm

Sural Nerve

- Medial sural cutaneous nerve
- Sacral plexus S1S2
- Sensory innervation
  - Posterior leg
  - Dorso-lateral foot
- First choice for trigeminal grafts
- Harvest ≥ 20 cm, if necessary
- No repair of sural nerve defect in leg
Area of Donor Site Deficit
Miloro M. Subjective outcomes following sural nerve repair. JOMS 63: 1150, 2005

- n = 42 sural grafts
- Follow-up > 20 months
- Questionnaire study
- Compared immed post-surgery to current
  Numbness score (3-10): 5.46 to 1.31
  Pain score (0-6): 2.15 to 0
  Cold sensitivity score (0-2): 0.50 to 0

Miloro M, JOMS 2005

- Final size of deficit area
  - < quarter (1\textdegree): 58\%
  - Quarter: 39\%
  - Tennis ball/orange: 4\%
  - Softball/grapefruit: 0\%
  - Larger: 0\%

Positive correlation between trigeminal and sural recovery

<table>
<thead>
<tr>
<th></th>
<th>Sural (2.1 mm)</th>
<th>Gr. Auric (1.5 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAN (2.4 mm)</td>
<td>83%</td>
<td>42%</td>
</tr>
<tr>
<td>LN (2.6 mm)</td>
<td>63%</td>
<td>47%</td>
</tr>
</tbody>
</table>
Greater Auricular Nerve

Cervical plexus C2C3
- Poor choice
  - Small diameter
  - Facial scar
  - Sensory deficit on face
    - Inferior ear, angle of jaw

Indications
- Same surgical site
- Cable graft
- Nerve transfer
IAN Repair with Greater Auricular Nerve Graft

Nerve Transfer

Conduit Repair
- Gap repair
- Entubulation repair

Conduits: Alloplastic
- Polyglycolic acid
- Polyester
- Gore-tex (e-PTFE)
- Silastic tube

Greater Auricular–Sural–Mental
Neurotube®

- Bioabsorbable nerve conduit
- Polyglycolic acid (PGA)
- Porous
- Flexible
- Corrugated
- 2.3 mm diameter
- 4 cm length
- www.neurotube.com

Nerve Connector/Protector

- 3D extracellular matrix
- Resorbable
- Conduit repair
- Protection of anastomosis site

Conduits: Autogenous

- Collagen
- Muscle
- Fascia
- Dura mater
  - No longer used
  - Jacob-Creutzfeldt disease, MMWR 1996
- Vein
  - Abundant, no morbidity
  - NGF on endothelial, advential surfaces
Gore-tex conduit and Tibial nerve grafts

Cadaveric Nerve Graft (Axogen)
- Decellularized allogeneic graft
- Green J. Use of decellularized human nerve grafts for IAN and LN. JOMS Suppl 2009
- 8 pts (5LN, 3 IAN)
- 4 pts, some recovery (50% success)
- 1 pt, minimal recovery
- 3 pts, no recovery
**Nerve Redirection Procedures**

A. Excise painful neuroma and ‘bury’ into muscle or bone

B. Suture mental nerve into orbicularis oris for collateral axonal sprouting

**Neurosensoric Recovery**

- Nerve regeneration
  - 1 mm/day
  - 1 inch/month
  - From cell body (ganglion) to lip or tongue

- Direct repair
  - Ganglion to lip=10 cm (100 days)

- Slower thru nerve graft repair (3-6 months)

**Sensory Re-education Exercises**

- Biofeedback
Miloro M. Surgical access for inferior alveolar nerve repair. JOMS 53: 1224, 1995
22 yom 6 months s/p 3rds
Complete anesthesia R tongue
Loss of taste R tongue
Infraorbital Nerve Repair
- Multiple small (0.5-1.0 mm) branches
- Rarely transected, or in need of repair

Long Buccal Nerve
- Small nerve diameter (0.5-1.0 mm)
- Commonly injured
- Minimal sensory deficit
- Uncommonly repaired

Patient Scenarios
Patient One
- 21 year old man
- 3rds 6 months ago
- ‘Decreased sensation lip/chin’
- VAS = 2/10
- CNT = Sunderland IV (~10%)

Patient Two
- 45 year old woman
- Implant #19 6 months ago
- Not in canal on radiograph
- Developing hypersensitivity LLC
- VAS = 9/10 with pain
- CNT = Sunderland I (100%)

Patient Three
- 39 year old man
- Occlusal amalgam #30 2 months ago
- Numbness, pain of R lower lip, not chin
- VAS = 4/10
- CNT = Sunderland IV focal at vermilion
- CNT = Sunderland I most of LLC

Patient Four
- 27 year old woman
- 3rds removed 8 months ago
- Immediate anesthesia, improved for 1st 3 months only, now left with ‘decreased feeling LLC’
- VAS = 6/10
- CNT = Sunderland II (85%)

Patient Five
- 31 year old woman
- 3rds removed 3 weeks ago
- Hypersensitive LLC to lipstick
- VAS = 10/10
- CNT = Sunderland I (100%)