MASM Annual Fall Course: Current Surgical Treatment of OSA

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Single and Multilevel Airway Surgery in OSA

- Review AASM Practice Parameters for Surgical Modification of the Upper Airway in Adult Obstructive Sleep Apnea

- Surgical Treatment
  - (1) Single Level
    - Nasal Surgery
    - Palatal Surgery
  - (2) Multilevel
  - (3) Hypoglossal Nerve Stimulation
Surgical Modifications of the Upper Airway for Obstructive Sleep Apnea in Adults: A Systematic Review and Meta-Analysis

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A substantial portion of patients with obstructive sleep apnea (OSA) seek alternatives to positive airway pressure (PAP), the usual first-line treatment for the disorder. One option is upper airway surgery. As an adjunct to the American Academy of Sleep Medicine (AASM) Standards of Practice paper, we conducted a systematic review and meta-analysis of literature reporting outcomes following various upper airway surgeries for the treatment of OSA in adults, including maxillomandibular advancement (MMA), pharyngeal surgeries such as uvulopalatopharyngoplasty (UPPP), laser assisted uvulopalatoplasty (LAUP), and radiofrequency ablation (RFA), as well as multi-level and multi-phased procedures. We found that the published literature is comprised primarily of case series, with few controlled trials and varying approaches to pre-operative evaluation and post-operative follow-up. We include surgical morbidity and adverse events where reported but these were not systematically analyzed. Utilizing the ratio of means method, we used the change in the apnea-hypopnea index (AHI) as the primary measure of efficacy. Substantial and consistent reductions in the AHI were observed following MMA; adverse events were uncommonly reported. Outcomes following pharyngeal surgeries were less consistent; adverse events were reported more commonly. Papers describing positive outcomes associated with newer pharyngeal techniques and multi-level procedures performed in small samples of patients appear promising. Further research is needed to better clarify patient selection, as well as efficacy and safety of upper airway surgery in those with OSA.

Keywords: Obstructive sleep apnea, surgical modifications, maxillo-mandibular advancement, uvulopalatopharyngoplasty, multi-level surgery

Citation: Caples SM; Rowley JA; Prinsell JR; Pallanch JF; Elamin MB; Katz SG; Harwick JD. Surgical modifications of the upper airway for obstructive sleep apnea in adults: a systematic review and meta-analysis. SLEEP 2010;33(10):1396-1407.
AASM Practice Parameters

- 1383 relevant studies identified and screened for retrieval
  - 1065 excluded after screening of title or abstract
  - 318 eligible studies retrieved for more detailed evaluation
    - 239 excluded after full-text screening for lack of primary outcome measure (before - after AHI)
    - 79 potentially eligible studies to be included in the meta-analysis
      - 4 parallel RCT
        - 2 LAUP
        - 1 temp contr. RFA
        - 1 soft palatal implant
      - 75 case series
        - 9 MMA
        - 13 UPPP
          - 5 extended uvulopalatal flap (EUPF)
        - 31 multi-approach surgery
      - 6 LAUP
      - 2 palatal implants
      - 7 radiofrequency
## AASM Practice Parameters

### Table 1—AASM levels of recommendations

<table>
<thead>
<tr>
<th>Assessment of benefit/harm/burden</th>
<th>Overall quality of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Benefits clearly outweigh harm/burden</td>
<td>Standard</td>
</tr>
<tr>
<td>Benefits closely balanced with harm/burden OR uncertainty in the estimates of benefit/harm/burden</td>
<td>Guideline</td>
</tr>
<tr>
<td>Harm/burden clearly outweighs benefits</td>
<td>Standard</td>
</tr>
</tbody>
</table>
AASM Practice Parameters - 2010

• No surgical alternative was recommended as a standard or guideline – primarily due to low quality of supportive evidence

• All reviewed surgical procedures were labeled as options

• EXCEPT: Laser assisted uvulopalatoplasty (LAUP) was not recommended
Obstructive Sleep Apnea

• Two components
  – 1) Abnormal Upper Airway Structure
  – 2) Muscular Tone
    – State-dependent changes in upper airway dilator muscle activity
    – Genioglossus muscle: primary upper airway dilator
Obstructive Sleep Apnea Surgery

- Two primary limitations of traditional surgical procedures:
  - (1) Decrease in upper airway muscle tone is not addressed
  - (2) Principal improvement is in the A-P diameter
Upper Airway Structure

Normal Subject

Lateral Pharyngeal Wall

Parapharyngeal Fat Pad

Apneic Patient

Lateral Pharyngeal Wall

Parapharyngeal Fat Pad
Upper Airway Structure

- Effect of a 5mm increase in A-P diameter on ellipses of equal area but different orientation:
Single Level Surgery

- Indications, Techniques, Outcomes
- Nasal Surgery
- Isolated Palatal Surgery
Nasal Airway
Nasal Airway

- Effect on Collapsibility ($P_{\text{crit}}$)
Pcrit Values
Nasal Obstruction

• The Effect of Nasal Obstruction on Sleep Disordered Breathing:
  – 1. Starling Resistor Model
  – 2. Naso-pulmonary Reflex
  – 2. Mouth Breathing
Nasal Obstruction

- **Starling Resistor Model**

  - Maximal flow through the resistor depends on:
    - (1) Resistance of the upstream segment
    - (2) Pressure surrounding the collapsible segment
Nasal Obstruction
Nasal Obstruction

• Naso-pulmonary Reflex

  – Increased nasal obstruction results in both obstructive and central apneas

  – Activation of nasal receptors has a direct positive effect on minute ventilation
Nasal Obstruction

• Mouth Breathing
  – Increase in total airway resistance during sleep (2.5x)
  – Decrease in retropalatal and retroglossal area
  – Increase in Pcrit
Nasal Surgery Outcomes

• AHI - No significant change

• O2 Nadir – mild improvement in patients with moderate OSA
Nasal Surgery Outcomes

• Improved CPAP Compliance
  – (1) Decrease in PAP Pressure requirement \( (x=2-3 \text{ cm H}_2\text{O}) \)
  – (2) Increase in PAP mask options and comfort (e.g. nasal pillows, or nasal mask without chin strap)

• Improved daytime energy level
  – Decreased work of breathing
  – Decreased microarousals
Sleep Apnea Surgery

• Primary sites of obstruction in OSA
  – Retropalatal area
  – Retroglossal area
Sleep Apnea Surgery

• Pre-operative assessment: Identification of site(s) of collapse

• Current practice:
  – Muller’s maneuver
  – Drug Induced Sleep Endoscopy
  – **Friedman staging**
  – Cephalometric analysis
  – CT/MRI
Single Level Surgery

• Isolated Palatal Surgery: Indications, Techniques, Outcomes

• Often referred to as Salvage surgery

• Goal: Improvement in disease severity and quality of life
Uvulopalatopharyngoplasty
Single Level Surgery

• Modifications of UP3
  – Uvulopalatoflap
  – Z – palatopharyngoplasty
  – Expansion sphincter pharyngoplasty

• Transpalatal Advancement Pharyngoplasty

• Palatal Stiffening Procedures
  – Radiofrequency Volumetric Reduction
  – Palatal Implants
  – Cautery Assisted Palatal Stiffening Operation
Uvulopalatal Flap
Z-palatopharyngoplasty
Expansion Sphincter Pharyngoplasty
Transpalatal Advancement Pharyngoplasty
Single Level Surgery: Outcomes

• Overall “success” rate in all unselected patients is 40%.

  – Sher et al. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996;19(2):156-177

• AASM meta-analysis reported a 33% reduction in AHI S/P traditional UP3.
Friedman Stage: UP3 Results

Stage I – 80%
  • Tongue position 1-2 + tonsil size 3-4
Stage II – 37%
  • Tongue position 1-2 + tonsil size 0-2
  • Tongue position 3-4 + tonsil size 3-4
Stage III – 8%
  • Tongue position 3-4 + tonsil size 0-2 or BMI > 40
Single Level Surgery Outcomes

Studying Life Effects & Effectiveness of Palatopharyngoplasty (SLEEP) Study: Subjective Outcomes of Isolated Uvulopalatopharyngoplasty

Edward M. Weaver, MD, MPH¹, B. Tucker Woodson, MD², Bevan Yueh, MD, MPH², Timothy Smith, MD, MPH³, Michael G. Stewart, MD, MPH⁴, Maureen Hannley, PhD⁵, Kristine Schulz, MPH⁶, Miles M. Patel, MS⁶, David Witsell, MD, MHS⁷, and the SLEEP Study Investigators
Single Level Surgery Outcomes

• Biomarkers

• Significant reduction in serum levels of hs-CRP six months post-operatively in OSA patients without a pre-existing diagnosis of cardiovascular disease

• Associated with improvement, but not normalization, of AHI

Multilevel Surgery
Multilevel Surgery

• Fujita Upper Airway Classification
  – Type I – Oropharynx only (25%)
  – Type II – Oropharynx and Hypopharynx (55%)
  – Type III – Hypopharynx only (20%)

Fujita S. UPPP for sleep apnea and snoring. Ear Nose Throat J 1984;63:227-235
U. S. Practice Patterns

2006 Nationwide Inpatient Sample, State Ambulatory and Inpatient Surgery Databases

35,000+ surgeries for OSA
>75% isolated palatal surgery
<20% involved hypopharyngeal surgery

Multilevel Surgery: Indications

- Freidman Stage II or IIII

- Mueller’s maneuver > 50% collapse at retoglossal area

- Cephalometric Analysis:
  - PAS < 8 mm
  - SNB > 78 degrees
Multilevel Surgery: Techniques

• Hypopharyngeal Procedures
  – Mandibulotomy with genioglossus muscle advancement
  – Hyoid Suspension
  – Radiofrequency Ablation – Tongue Base
  – Midline glossectomy
  – Tongue base stabilization
  – Transoral Robotic Surgery (TORS)
Genioglossus Muscle Advancement
Hyoid Suspension

Fig. 44.5 (Hyoid 5) The thyrohyoid apposition in place.
Genioglossus muscle advancement + Hyoid Suspension
Radiofrequency Ablation
Tongue Base Stabilization
Midline Glossectomy
Transoral Robotic Glossectomy
Transoral Robotic Glossectomy
Transoral Robotic Glossectomy
Transoral Robotic Glossectomy
Transoral Robotic Glossectomy
Transoral Robotic Glossectomy

• Advantages:
  – Improved visualization
  – Precise, more aggressive tissue resection

• Disadvantages:
  – Lack of tactile sensation
  – Potential difficulty obtaining hemostasis
  – Increased operative time (set-up)
  – Prolonged dysphagia (return to normal diet)
  – ? Need for trach
  – Cost
Multilevel Surgery Outcomes

- AASM reviewed 31 multi-level surgery case series

- Two directly compared single vs. multi-level surgery

- Findings:
  - Greater improvement in post-operative AHI with multi-level vs. single level surgery
  - Largest difference noted in patients with Friedman Stage II and III (i.e. suspected tongue base obstruction)
Multilevel Surgery Outcomes
The Efficacy of Multilevel Surgery of the Upper Airway in Adults With Obstructive Sleep Apnea/Hypopnea Syndrome

Hsin-Ching Lin, MD; Michael Friedman, MD; Hsueh-Wen Chang, PhD; Berk Gurpinar, MD
# Multilevel Surgery Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline Values</th>
<th>Percentage Change</th>
<th>Number of Groups</th>
<th>Total n</th>
<th>Weighted Average %</th>
<th>Range %</th>
<th>Number of Groups</th>
<th>Total n</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>46.2</td>
<td>35.8 to 56.0</td>
<td>41</td>
<td>1,120</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>AI (/hour)</td>
<td>17.3</td>
<td>5.0 to 48.9</td>
<td>17</td>
<td>510</td>
<td>−55.6</td>
<td>−91.7 to −27.0</td>
<td>16</td>
<td>496</td>
<td>.035</td>
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<tr>
<td>AHI (/hour)</td>
<td>48.0</td>
<td>12.9 to 76.2</td>
<td>57</td>
<td>1,962</td>
<td>−60.3</td>
<td>−94.5 to 11.7</td>
<td>54</td>
<td>1,933</td>
<td>&lt;.0001</td>
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<tr>
<td>REM sleep (%)</td>
<td>12.2</td>
<td>8.6 to 16.0</td>
<td>4</td>
<td>329</td>
<td>44.0</td>
<td>23.8 to 48.7</td>
<td>4</td>
<td>329</td>
<td>&lt;.0001</td>
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<tr>
<td>LSAT (mmHg)</td>
<td>75.6</td>
<td>63.5 to 86.3</td>
<td>33</td>
<td>1,376</td>
<td>10.8</td>
<td>−1.85 to 36.3</td>
<td>31</td>
<td>1,189</td>
<td>.028</td>
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<tr>
<td>mO₂ (%)</td>
<td>91.4</td>
<td>77.0 to 93.2</td>
<td>7</td>
<td>213</td>
<td>1.9</td>
<td>0.3 to 17.8</td>
<td>7</td>
<td>213</td>
<td>.655</td>
</tr>
<tr>
<td>Snoring VAS (%)</td>
<td>8.1</td>
<td>7.5 to 9.3</td>
<td>9</td>
<td>328</td>
<td>−65.1</td>
<td>−72.4 to −34.7</td>
<td>9</td>
<td>328</td>
<td>.020</td>
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<tr>
<td>ESS (score)</td>
<td>12.9</td>
<td>7.4 to 18.2</td>
<td>26</td>
<td>806</td>
<td>−43.0</td>
<td>−73.7 to −17.6</td>
<td>26</td>
<td>806</td>
<td>&lt;.0001</td>
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<tr>
<td>QOL (score)</td>
<td>16.3</td>
<td>15.6 to 16.9</td>
<td>3</td>
<td>77</td>
<td>8.8</td>
<td>7.1 to 11.5</td>
<td>3</td>
<td>77</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>29.5</td>
<td>25.9 to 36.0</td>
<td>39</td>
<td>1,343</td>
<td>−1.3</td>
<td>−8.1 to 7.6</td>
<td>25</td>
<td>922</td>
<td>.309</td>
</tr>
</tbody>
</table>

n = number; OSAHS = obstructive sleep apnea/hypopnea syndrome; AI = apnea index; AHI = apnea/hypopnea index; REM = rapid eye movement stage; mO₂ = mean saturation of oxygen; LSAT = lowest oxygen saturation; VAS = visual analogue scale; ESS = Epworth sleepiness scale; QOL = quality of life.
Transoral Robotic Tongue Base Resection in Obstructive Sleep Apnoea-Hypopnoea Syndrome: A Preliminary Report

Claudio Vicini\textsuperscript{a} Iacopo Dallan\textsuperscript{b} Pietro Canzi\textsuperscript{a} Sabrina Frassinetti\textsuperscript{a} Maria Grazia La Pietra\textsuperscript{a} Filippo Montevecchi\textsuperscript{a}

\textsuperscript{a}Department of Special Surgery, ENT and Oral Surgery Unit, Ospedale Morgagni Pietrantoni, University of Pavia, Forli, and \textsuperscript{b}Second ENT Unit, Azienda Ospedaliera Universitaria Pisana, Pisa, Italy
Multilevel Surgery Outcomes

TORS tongue base resection + additional level surgery

“Success” rate (AHI <10): 70%

Pre-op AHI: 36 vs. post-op AHI: 16
Epworth: pre-op 12 vs. post-op 8
Hypoglossal Nerve Stimulation

Original Article

Upper-Airway Stimulation for Obstructive Sleep Apnea

Patrick J. Strollo, Jr., M.D., Ryan J. Soose, M.D., Joachim T. Maurer, M.D.,
Nico de Vries, M.D., Jason Cornelius, M.D., Oleg Froymovich, M.D.,
Ronald D. Hanson, M.D., Tapan A. Padhya, M.D., David L. Steward, M.D.,
M. Boyd Gillespie, M.D., B. Tucker Woodson, M.D., Paul H. Van de Heyning, M.D., Ph.D.,
Mark G. Goetting, M.D., Oliver M. Vanderveken, M.D., Ph.D., Neil Feldman, M.D.,
Lennart Knaack, M.D., and Kingman P. Strohl, M.D., for the STAR Trial Group*
Hypoglossal Nerve Stimulation

Patient Selection

Inclusion criteria:
AHI > 15, < 50
Intolerant of CPAP therapy
> 18 years of age

Exclusion criteria:
BMI > 32
3-4+ tonsillar hypertrophy
Concentric collapse of retropalatal airway on DISE
Severe pulmonary disease
NYHA class III or IV heart failure
Uncontrolled hypertension
Hypoglossal Nerve Stimulation

Human Trials

Arousal threshold and stimulator activity

Location of stimulator placement

Synchronization with inspiration
Hypoglossal Nerve Stimulation

Extrinsic musculature
1) Geinoglossus m – protrusion and tip elevation (ventral nucleus)
2) Styloglossus m – retrusion and elevation (dorsal nucleus)
3) Hyoglossus m – retrusion and depression (dorsal nucleus)

Intrinsic musculature
1) Inf. And sup longitudinal m
2) Transverse m
3) Vertical m
   Elongation, protrusion, fine shaping movements
Hypoglossal Nerve Stimulation

1. The system is programmed to automatically deliver therapy according to the patient’s sleep schedule.

2. When the patient falls asleep, the system monitors breathing using the respiration sensing leads.

3. During each breath, the system delivers a signal to the hypoglossal nerve using the stimulation lead.

4. The hypoglossal nerve activates the genioglossus muscle, which helps keep the airway open during sleep.

5. Therapy stops according to the patient’s programmed schedule. Otherwise, the patient can use the controller to stop therapy.
Hypoglossal Nerve Stimulation

- Mylohyoid retracted
- Digastric Tendon
- Hyoid
- Hypoglossal Nerve
- Internal & External Carotid Arteries
- Ansa cervicalis
- Submandibular Gland
- 0–2cm
- Hyoglossus Muscle
- Cuff Location
- Mylohyoid Muscle
- Digastric Muscle
Hypoglossal Nerve Stimulation
Hypoglossal Nerve Stimulation
Conclusions
Alternatives to CPAP Program

- > 1800 patients
- Mandibular Advancement Device: 45%
- Single or Multilevel Surgery: 39%
- Maxillomandibular Advancement: 15%
- Tracheotomy: < 1%
References


References


References


• 33. Thatcher GW et al. The long-term evaluation of tracheostomy in the management of severe obstructive sleep apnea. Laryngoscope 2003;113:201-204.


## Friedman Tongue Position and Mallampati Classification

<table>
<thead>
<tr>
<th>Friedman Tongue Position</th>
<th>Mallampati Tongue Protruded</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTP I: Allows visualization of the entire uvula and tonsils or pillars</td>
<td>MC I: Allows visualization of faucial pillars, soft palate and uvula</td>
</tr>
<tr>
<td>FTP Ila: Allows visualization of the uvula, but only parts of the tonsils are seen</td>
<td>MC II: Allows visualization of the faucial pillars and soft palate</td>
</tr>
<tr>
<td>FTP Iib: Allows visualization of the complete soft palate down to the base of the uvula, but the uvula and the tonsils are not seen</td>
<td>MC III: Allows only visualization of the soft palate</td>
</tr>
<tr>
<td>FTP III: Allows visualization of some of the soft palate, but the distal soft palate is eclipsed</td>
<td></td>
</tr>
</tbody>
</table>
Friedman Stage

- Friedman Stage I
  - Tongue position 1-2 + tonsil size 3-4

- Friedman Stage II
  - Tongue position 1-2 + tonsil size 0-2
  - Tongue position 3-4 + tonsil size 3-4

- Friedman Stage III
  - Tongue position 3-4 + tonsil size 0-2
  - OR body mass index (BMI) > 40