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Snoring

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- Most common reason to seek care in the context of sleep disordered breathing.
- Most disruptive aspect of abnormal breathing during sleep.
- Detrimental impact of snoring on bed partner's health ("second-hand snoring") and personal relationships.
- Possible detrimental vascular effects.
- Increased public awareness of OSA and focus on sleep wellness.
- Data from wearable technology.
- Can be classified as: mild (40-50 dB), moderate (50-60 dB) and severe (>60 dB).

Nimrod Maimon, Patrick J. Hanly, Does Snoring Intensity Correlate with the Severity of Obstructive Sleep Apnea? J Clin Sleep Med. 2010 Oct 15; 6(5): 475-478.

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Agenda

- Review of upper airway anatomy, relevant to snoring:
 - Functional nasal, pharyngeal and hypopharyngeal anatomy
 - Mechanisms of snoring
 - Dynamic evaluation: nasal endoscopy and laryngoscopy, Pang-Rotenberg sign, Drug Induced Sleep Endoscopy (DISE)
- Questionnaires and objective testing:
 - Questionnaires, snoring recording apps, SNAP, HST and PSG
 - Limitations and research on snoring recording and interpretation
- AAO-HNS Clinical Consensus Statement on Snoring:
 - Areas of intervention, rationale for treatment
 - Review of literature
- Review of current treatment strategies:
 - Non-invasive, minimally invasive, surgical
- Final thoughts/pearls, Q&A

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Functional Nasal Anatomy

- Primary sites of obstruction are the nasal vestibules, nasal valves, inferior turbinates and nasal septum.
- Nasal resistance tends to be more stable due to bony/cartilaginous framework.
- Contributes to 50% of airway resistance.
- Flow-limiting segments act as Starling resistors at the nose and lower levels of the upper airway.
- Mouth opening secondary to nasal obstruction leads to inferior movement of mandible, backwards movement of tongue and further collapse of pharyngeal structures.
- Increased nasal resistance is more prevalent in patients who snore.
- Correction of nasal airway obstruction improves sleep quality but can lead to paradoxical worsening of AHI and snoring.

Friedman M, Schalch P. Effects of nasal surgery on snoring and sleep apnea. In: Sleep Apnea and Snoring: Surgical and Non-surgical Therapy. Elsevier; 2016.

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Functional Nasal Anatomy

- Nasal exam:
 - Anterior rhinoscopy
 - Nasal endoscopy
 - Nasal airflow evaluation: rhinomanometry, acoustic rhinometry
 - Imaging: CT sinuses

Clement PA, Halowyc S, Gordis F, Michel O. Critical evaluation of different objective techniques of nasal airway assessment: a clinical review. Eur Arch Otorhinolaryngol. 2014 Oct 27;171(10):2617-25.

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Functional Anatomy: Pharynx and Hypopharynx

- Factors that influence upper airway cross-sectional area:
 - Age
 - BMI
 - Regional obesity: neck circumference, parapharyngeal, tongue base.
 - Gender
 - Body posture
 - Lung volumes
 - State of consciousness
 - Repetitive vibratory "trauma", possibly leading to edema and elongation of uvula

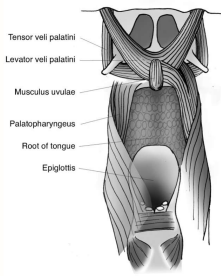


FIGURE 3. Posterior view of nasopharynx and oropharynx that shows levator veli palatini, tensor veli palatini, musculus uvulae, and palatopharyngeus, and the superior constrictor (not shown) wraps superiorly and medially.

Evans A, Ackermann B, Driscoll T. Functional anatomy of the soft palate applied to wind playing. Med Probl Perform Art. 2010 Dec;25(4):183-9. Andrew M, Kim, BS, Brendan T, Keenan, MS, Nicholas Jackson, MPH, Eugenia L, Chan, BA, 1, Anthony Staley, RWST, CRC, 1, Harsh Prasad, PhD, 3, Drew A, Torgiani, MD, MA, Allan I, Pisk, MChD, PhD, Richard J, Schwab, MD, Tongue Fat and its Relationship to Obstructive Sleep Apnea. Sleep. 2014 Oct 1; 37(10): 1639-1648.

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Functional Anatomy: Pharynx and Hypopharynx

Nasopharynx

- Passavant's Ridge: It is a mucosal ridge raised by fibres of palatopharyngeus & Superior constrictor. It encircles the posterior & lateral wall of nasopharyngeal isthmus. During deglutition or speech, soft palate comes in contact with this ridge to cut off nasopharynx from oropharynx.

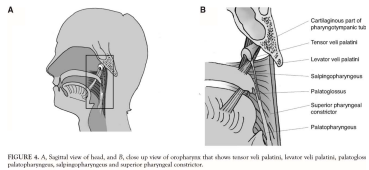
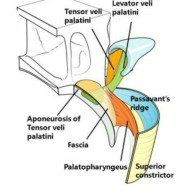


FIGURE 4. A, Sagittal view of head, and B, close up view of oropharynx that shows tensor veli palatini, levator veli palatini, palatoglossus, palatopharyngeus and superior pharyngeal constrictor.



Evans A, Ackermann B, Driscoll T. Functional anatomy of the soft palate applied to wind playing. Med Probl Perform Art. 2010 Dec;25(4):183-9.

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Functional Anatomy: Pharynx and Hypopharynx

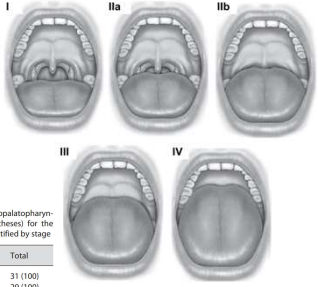
- Stability of airway is determined by:
 - Flow
 - Airway elastance
 - Airway dimensions
- P. crit*: critical negative pressure required for airway to collapse during inspiration.
- During stages N3 (deep) and R sleep, muscle tone decreases: partial or complete collapse of the uvula, soft palate, lateral pharyngeal walls, base of tongue and epiglottis occurs, and airflow decreases/ceases.
- A pressure gradient develops until the airway is forcefully opened by displacing the structures with turbulent air. Resulting vibration = **snoring**.

Hoffstein, V. (1996) Snoring. Chest, 109, 201-22.

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Upper Airway Evaluation

- Friedman tongue position (modified Mallampati):
 - Evaluates oral tongue and base of tongue in relationship with soft palate, uvula, tonsils.
 - Stages: I-IV (updated classification added IIa and IIb), includes size (or presence) of tonsils and BMI.
 - Lower stages: higher success rate (surgical cure of CSA by UPPP).



Stage	PPS	Tonsil size	BMI
I	1-3a, 3b	3 or 4	<40
II	3b, 4a, 4b	3 or 4	<40
III	4a, 4b	0-4	>40
IV	4a, 4b	0-4	>40

Stage	Unsuccessful	Successful	Total
I	6 (19.4)	25 (80.6)	31 (100)
II	18 (62.1)	11 (37.9)	29 (100)
III	68 (91.9)	6 (8.1)	74 (100)

Friedman M, Ibrahim H, Joseph NJ. Staging of obstructive sleep apnea/hypopnea syndrome: a guide to appropriate treatment. Laryngoscope. 2004 Mar; 114(3):454-9.

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Upper Airway Evaluation

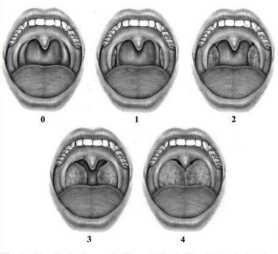
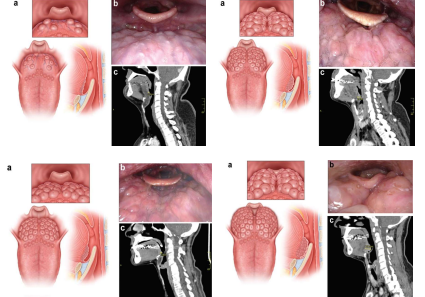


Fig. 2. Tonsil size is graded from 0 to 4. Tonsil size 0 denotes surgically removed tonsils. Size 1 implies tonsils hidden within the pillars. Tonsil size 2 implies the tonsils extending to the pillars. Size 3 tonsils are beyond the pillars but not to the midline. Tonsil size 4 implies tonsils extend to the midline.

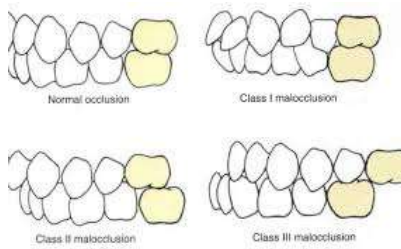
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Upper Airway Evaluation



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Upper Airway Evaluation: Angle's Classification



Class I: The mesiobuccal cusp of the maxillary first molar is in occlusion with the mesiobuccal groove of the mandibular first molar.



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Upper Airway Evaluation

- **Mueller Maneuver:**
 - Assessment of collapsibility of the velum, lateral pharyngeal walls, base of tongue and epiglottis during maximum inspiratory effort with a closed mouth and sealed nose (reverse Valsalva). Scale 0-4 (0, 25, 50, 75 and 100% collapse).
- **Pang-Rotenberg sign:**
 - Patient opens mouth slightly to produce palatal flutter (snoring sound) on inhalation through mouth) followed by an attempt to re-produce palatal flutter with mouth closed. Patient instructed to avoid creating "snorting" sound through nose. A positive sign is when patients are unable to re-create sound with mouth closed. Positive patients have better prognosis for snoring reduction after surgery.

Terris, D.J., Hanasono, M.M. and Liu, Y.C. (2000), Reliability of the Muller Maneuver and Its Association With Sleep-Disordered Breathing. *The Laryngoscope*, 110: 1819-1823.
Pang KP, Kishore S, Kit JC, Pang EB, Chan YH, Keat SJ, Rotenberg B.
Pang-Rotenberg sign--snoring surgery prognosticator: A prospective clinical trial of 153 patients. *Laryngoscope*. 2016 Jan;126(1):260-5.



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Drug-induced Sleep Endoscopy



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Snoring Evaluation: Questionnaires and Tests

- OSA and Snoring Questionnaires, Visual Analog Scales: most questionnaires include at least one item related to snoring (example: Berlin Sleep Questionnaire).
- Acoustic pharyngometry and SNAP testing: limited studies that show accuracy and reliability, but maybe useful and determining "type" of snoring (palatal vs. BOT).
- Snoring Apps: along w video recordings from smart phones (by bed partner), most popular (e.g. SnoreLab).
- Snoring Recording during HST and PSG: all sleep studies have recording capabilities. Confirm presence of snoring, frequency, severity, correlation with arousals, positional component.

Weingarten CZ, Raviv G. Evaluation of criteria for uvulopalatoplasty (UPPP) patient selection using acoustic analysis of oronasal respiration (SNAP testing). *J Otolaryngol*. 1995;24(6):352-357.
Su S, Baroody FM, Kohrman M, Suskind D. A comparison of polysomnography and a portable home sleep study in the diagnosis of obstructive sleep apnea syndrome. *Otolaryngol Head Neck Surg*. 2004 Dec;131(6):844-50.



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Snoring Evaluation: Limitations

- Snoring sound analysis has been inconsistent in locating site(s) of obstruction.
- Theoretical advantages: non-invasive, obtained during physiologic (not pharmacologic) sleep.
- Technology to obtain real time video and sound recordings in development.
- Main issue: perception of snoring is largely subjective, in the "ear of the beholder", thus, difficult to analyze objectively.
- Older studies reveal inconsistencies between self-reported and bed partner reported snoring. No gold standard to compare questionnaires against.

Hoffstein, V., S. Mateika & D. Anderson (1994) Snoring: is it in the ear of the beholder? *Sleep*, 17, 522-6.
Hoffstein, V. & J. Szalai (1993) Predictive value of clinical features in diagnosing obstructive sleep apnea. *Sleep*, 16, 118-22.
Jones, T., A. Swift, P. Calverley, M. Ho & J. Earis (2005) Acoustic analysis of snoring before and after palatal surgery. *Eur Respir J*, 25, 1044-9.



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Snoring: Background Info for Clinical Consensus Statement

- Prevalence: in adults, 10-20% (likely higher in middle aged and older adults).
- National Sleep Foundation (2002): 37% of adults report snoring more than one night per week, 27% almost every night.
- More common in men (42%) vs. women (31%).
- Snorers have higher healthcare utilization than non-snorers (Danish patient registry).
- Carotid artery atherosclerosis: present in 20% of mild, 32% moderate and 64% of severe snorers, after adjusting for other risk factors.
- Significant impact in quality of life and personal relationships.


Submitted by:
AAOHN's Sleep Disorders Committee
Scott Brietzke, Stacey Ichman, Derek Lam, Cristina Baldassari, Paul Schalkch Lupe



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Snoring: Need for Clinical Consensus Statement


- Clarify existing knowledge base and establish gaps in knowledge.
- Recommend studies in high-impact areas.
- Provide guidance for management of primary snoring, from conservative to more invasive therapies.
- Offer support for insurance authorization for recommended treatments.



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Snoring: Most Pressing Aspects of Care


- What are the implications of snoring in adults in terms of both medical comorbidities such as increased risk of cardiovascular sequelae and quality of life?
- What is the optimal method for evaluation of snoring? Is there a role for wearable and personal device-based technology (apps in iPhone or Android devices) for characterization of snoring and assessing response to therapy?
- What are the outcomes to assess in patients seeking treatment for snoring?
- How do outcomes of non-surgical therapies such as oral appliances and over-the-counter-products compare with outcomes of surgical interventions for snoring?
- Does the treatment of snoring result in improvement in cardiovascular sequelae and quality of life?



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Treatment Strategies

- Non-invasive, over the counter, medical
- Minimally invasive/office based
- Surgical
- Combination




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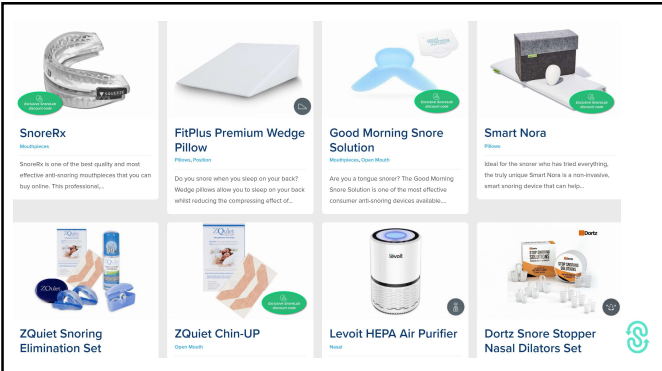
Treatment Strategies

- Non-invasive, over the counter, medical:
 - Patient will seek care after they have tried some of these if results were insufficient.
 - Important to at least know about them.
 - Oftentimes there is not much scientific literature to support efficacy, but they can be useful adjuncts to other treatment strategies.
 - Typically not covered by insurance.
 - Possible sequelae or complications (e.g. from oral appliances).
 - Simplest solution: ear plugs!

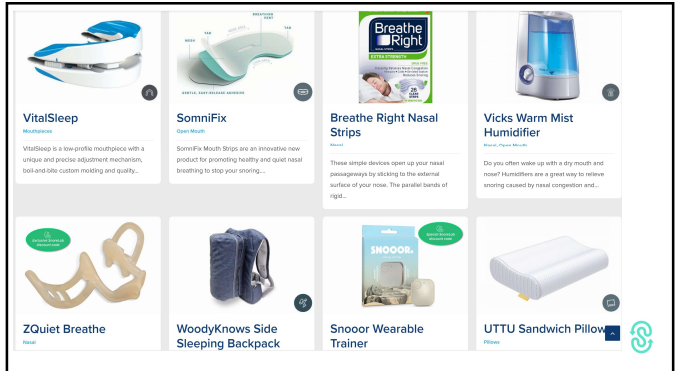
Robertson S, Loughran S, MacKenzie K. Ear protection as a treatment for disruptive snoring: do ear plugs really work? J Laryngol Otol. 2006 May;120(5):381-4.



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Positional Therapy

- Effective adjunct in managing patients with a significant positional component during PSG or HST (very important to look at positional data).
- Also effective for snoring.
- Several devices available: help re-train preferred sleep position (from supine to lateral).
- Adverse effect: may result in disrupted sleep architecture (keeps waking patient up).



L. B. L. Benoist, A. M. E. H. Beelen, B. Toressma, N. de Wries. Subjective effects of the sleep position trainer on snoring outcomes in position-dependent non-apneic snorers. *Eur Arch Otorhinolaryngol*. 2018; 275(8): 2169-2176.



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Oral Appliances

- Over the counter, DDS (ideally, dental sleep medicine board certified), or MD prescribed.
- Indicated for mild to moderate OSA: AASM Guideline.
- Common scenario in the ENT office:
 - Patient has tried an oral appliance: could not get used to it, it never worked, it worked but patient does not want to use forever.
 - Cost was too high, and patient is reluctant to pay if there is uncertainty if it will work.
 - Patient experienced issues with it: dental pain, dental movement or malocclusion, TMJ issues. Did not get proper follow up or care by dentist.
 - Lost it, the dog ate it, left it in the car and it melted, or it is just nasty after using for several years and doesn't want to pay for another one.
- Otolaryngologist can offer trial, "entry level" appliance (easy to fit, affordable, adjustable), good way to try oral appliance therapy without incurring in the cost.
- Good "trial run" for other, more invasive procedures.
- Affordable (usually not covered by insurance if indication is primary snoring).
- Consent process: VERY IMPORTANT, patient needs to be established with dentist during oral appliance therapy. Set realistic expectations and explain possible complications.



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Oral Appliances



MyTAP3



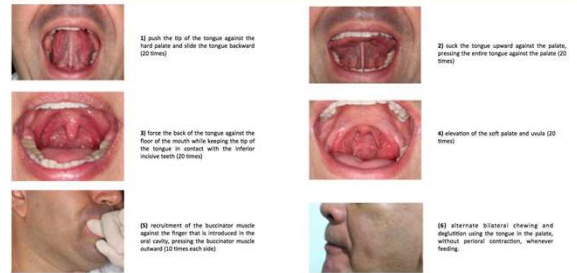
SomnoGuard



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Oropharyngeal Exercises and Myofunctional Therapy

Effects of Oropharyngeal Exercises on Snoring: a Randomized Trial
Youssef Attia, Fakhri Karamour, Maria I. Morais, Raquel F. Morais, Marcelo G. Gregório, Adriano M. Alencar, Luciano F. Drager, Pedro A. Costa, Genivaldo Lorenzi-Filho



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Treatment Strategies

- Minimally invasive/office based:
 - From the rudimentary to the technologically advanced:
 - Injection snoreplasty (using diluted alcohol, Everclear, other sclerosing agents).
 - Radiofrequency ablation of soft palate and base of tongue: CELON (Olympus).
 - Cautery-assisted palatoplasty (CAPSO): limited uvulopalatal flap.
 - All these techniques rely on controlled scar formation and stiffening of soft palate. Fairly painful in the short term. Steroids help but impair scar formation.
 - Palatal implants:
 - Fairly effective, well tolerated. NO LONGER AVAILABLE.
 - Short term: might not work or worsen snoring (swelling always causes transient worsening).
 - Long term: U-shape curve, improvement in snoring followed by relapse.
 - Some techniques can be useful as "touch up" after OSA surgery (if persistent snoring).

Friedman M, Schalkh P, Lin HC, Kakodkar KA, Joseph NJ, Mazloom N. Palatal implants for the treatment of snoring and obstructive sleep apnea/hypopnea syndrome. *Otolaryngol Head Neck Surg*. 2008 Feb;138(2):209-16.
Friedman M, Schalkh P, Joseph NJ. Palatal stiffening after failed uvulopalatopharyngoplasty with the Pillar Implant System. *Laryngoscope*. 2006 Nov;116(11):1956-64.



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Uvulectomy

- Helpful if uvula > 15 mm.
- Tissue welding technology (similar to harmonic scalpel).

Alpiner ME, Yigit O, Kocak I, Altundag A. Does the length of uvula affect the palatal implant outcome in the management of habitual snoring? Laryngoscope. 2011 May;121(5):1112-6.

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S.I.Le.N.C.E. Clinica Trial

- Multi-center, open label, prospective, single-arm cohort study.
- 52 adults with chronic, disruptive snoring.
- Baseline: HST to rule out OSA and to objectively document severity and type of snoring (SNAP, I: mostly palatal, II: palate + tongue, III: no particular pattern, IV: high-pitched, diffuse, WL: wheezing-like).
- Questionnaires filled out by patients and bed partners: VAS, ESS, PSQI at baseline, 30, 90 and 180 days.
- Statistically significant decrease in VAS (primary endpoint) as well as QOL-indicators at all time points.
- No significant improvement in HST-obtained snoring sound signals.

Michael Friedman, MD, Boyd Gillespie, MD, MSc, Faramarz A. Shabdz, MD, David H. Hiltzik, MD, Ted A. Meyer, MD, PhD, Jeffrey Ahn, MD, Peter J. Catalano, MD, Ninos J. Joseph, BS
A new office-based procedure for treatment of snoring: The S.I.Le.N.C.E. study
Laryngoscope Investig Otolaryngol. 2020 Feb; 5(1): 24-30.

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Treatment Strategies

- Surgical:
 - Multi-level, upper airway modification surgery usually indicated in the setting of OSA
 - Addressing the nasal airway is critical:
 - Can be performed as first stage, and then reevaluate effect on snoring: may improve, or may cause "paradoxical snoring"
 - Many office-based options to address nasal valves, inferior turbinates, septal swell bodies and septum.
 - Enlarged tonsils usually require tonsillectomy: conventional (extracapsular), intracapsular (Coblation) or RF tonsillar reduction (works better for smaller tonsils).
 - Palatal relocation procedures and uvulectomy can also be done in the office, but more commonly in the OR.
 - Oropharyngeal procedures hurt, be careful with post-op pain management, as well as risk of bleeding, globus sensation, dysphagia, excessive scarring leading to nasopharyngeal stenosis or over resection leading to velopharyngeal insufficiency.

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Tonsillectomy with tissue welding

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Relocation palatoplasty with reabsorbable barbed suture

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Pearls

- 50% of snorers have at least mild OSA; establish precise diagnosis and avoid creating silent OSA.
- Nasal surgery alone usually not effective in treating snoring, but it is a critical component.
- Steroids can decrease scar formation; scarring is your ally in snoring procedures.
- Set realistic expectations; sometimes you are "moving the dial" towards less snoring, but NO snoring at all is hard to achieve.
- Smartphone apps work well to establish baseline and then compare after procedure.
- Primary snoring indication usually not covered by insurance.
- Lifestyle modifications are critical: BMI, body position, alcohol at night.
- Excellent opportunity for office-based ENT practice.

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Good breathing,
better life.

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