Drug-Induced Sleep Endoscopy in Obstructive Sleep Apnea

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Overview

Techniques for identifying the sites of obstruction

DISE and VOTE Classification

Advantages and Disadvantages

Association with treatment outcomes

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Obstructive Sleep Apnea (OSA)

Symptomatic, repeated upper airway obstruction during sleep

Severity quantified: apnea-hypopnea index (AHI)
- Mild (>5-15), Moderate (>15-30), Severe (>30)

Behavioral: sleep disruption

Health-related: cardiovascular, endocrine

National Institutes of Health
- OSA affects 18-20 million American adults

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Snoring and OSA Treatment

Behavioral measures
- Weight loss
- Avoid supine body position
- Avoid alcohol and sedatives

PAP

Surgery

Oral appliances

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Common Role of OSA Surgery in Adults

Low adherence/benefit from PAP therapy (30%)

In addition to behavioral measures, options:
- No treatment
- Surgery
- Oral appliances

Goal: improve signs/symptoms (AHI too)

PAP may not benefit cardiovascular health

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OSA ≠ OSA ≠ OSA: Patients Are Different

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Goal of Evaluation

Characterize disorder to guide effective treatment

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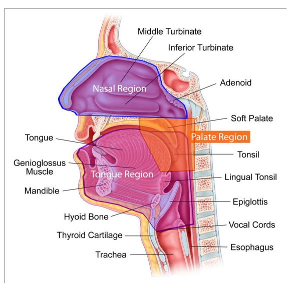
OSA Surgical Procedures and Outcomes

Effective surgery directed at site(s) of obstruction
- Nose
- Palate
- Hypopharynx/
  - Retroglossal/
  - Retrolingual



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OSA Surgical Treatment Options

Uvulopalatopharyngoplasty
Expansion sphincter pharyngoplasty
Uvulopalatal flap
Transpalatal advancement pharyngoplasty
Z-Palatoplasty
Lateral pharyngoplasty
Relocation pharyngoplasty
Barbed reposition pharyngoplasty

Genioglossus advancement
Mortised genioplasty
Tongue radiofrequency
Midline glossectomy
Hyoid suspension
Tongue suspension/stabilization
Partial epiglottectomy

Hypoglossal nerve stimulation
Upper Airway Stimulation (Inspire)

Maxillomandibular advancement

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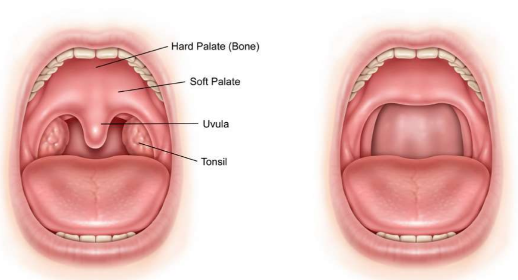
Uvulopalatopharyngoplasty (UPPP)



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OSA surgery review (Sher *et al.* Sleep 1996)
- UPPP "successful" in 41% of all OSA patients
  - 52% Fujita Type I
  - 5% Fujita Types II and III
- Conclusion: failure to identify site(s) of obstruction is principal factor in poor results for surgery

Cochrane Collection 2005 review (evidence-based medicine review database)
- "More research should also be undertaken to identify and standardise techniques to determine the site of airway obstructions."

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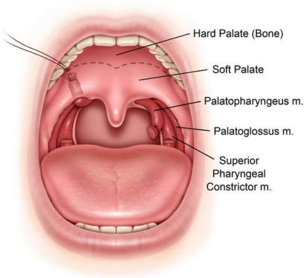
Modified Expansion Sphincter Pharyngoplasty, aka Functional Expansion Pharyngoplasty



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Palate + Hypopharyngeal Surgery

	Success (AHI)		Range	Predictors
Genioglossus Advancement	62%	56/91	39-78%	BMI
Mortised Genioplasty	48%	16/33		BMI, AHI
Tongue Radiofrequency	35%*	95/269	20-75%	Technique, FS; +/- AHI
Tongue Stabilization	35%*	27/77	20-82%	BMI
Midline Glossectomy	50%	37/74	25-83%	
Hyoid Suspension	50%	51/101	17-78%	BMI, LSAT?
GA + HS	55%	180/328	24-78%	BMI, AHI

Kezirian EJ, Goldberg AN. Archives Oto—HNS 2006 Adapted from Table 7

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Identifying the Sites: Ideal Test Characteristics

Easy: technically simple, non-invasive
Low cost
Dynamic assessment while breathing
Sleeping patient
Accurate

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OSA Severity

Premise: region(s) of upper airway obstruction are related to OSA severity (AHI)

Mild-moderate OSA is most likely due to collapse at the level of the palate, whereas moderate to severe OSA most likely includes some component of hypopharyngeal collapse

Advantages: easy, low cost, assessment during sleep

Disadvantage: inaccurate—not supported by the evidence, and refuted in some studies

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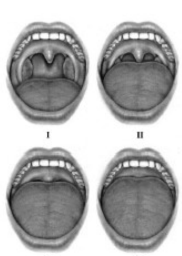
Friedman Stage (Friedman Oto-HNS 2002)



FS	Modified Mallampati	Tonsils
I	1, 2	3+, 4+
II	1, 2	0, 1+, 2+
	3, 4	3+, 4+
III	3, 4	0, 1+, 2+
IV	BMI ≥ 40	

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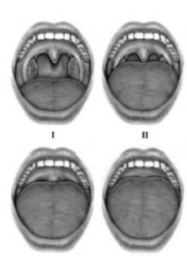
Friedman Stage (Friedman Oto-HNS 2002)



	FS	Modified Mallampati	Tonsils
81%	I	1, 2	3+, 4+
38%	II	1, 2	0, 1+, 2+
		3, 4	3+, 4+
8%	III	3, 4	0, 1+, 2+
	IV	BMI ≥ 40	

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Müller Maneuver

Endoscopic evaluation of awake patient with forced inspiratory effort against closed mouth and nose

Advantages: simple, low cost

Disadvantage: not accurate or useful by itself

- Patients with primarily retropalatal obstruction by MM had only ~40% cure of OSA after UPPP
  - Sher *et al.* 1985, Doghramji *et al.* 1995
- Petri *et al.* 1994: MM no predictive value for palate surgery outcome
- Li *et al.* 2003: MM associated with UPPP outcomes
- No information on selection of procedures

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Imaging (CT, MRI, fluoroscopy)

Advantage: Assessment during sleep possible, improve understanding of abnormal OSA anatomy and changes after certain treatments

Lee Laryngoscope 2012: sleep videofluoroscopy suggested multilevel obstruction common (45%; higher in severe OSA)

Disadvantages

- CT and MRI can be static (although cine-CT)
- Time-consuming and not inexpensive
- Specific equipment and technical assistance
- Radiation exposure (CT, fluoroscopy)
- ? association between static dimensions of airway and surgical outcomes—further research

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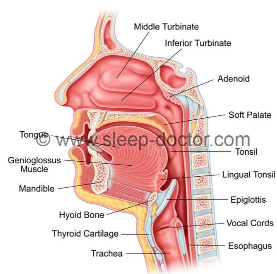
Identifying the Site(s): Natural Sleep Endoscopy

Fiberoptic scope to visualize airway as patient attempts to fall asleep naturally

Borowiecki Laryngoscope 1978

Rojewski Laryngoscope 1982

Marques J Physiol 2019



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Identifying the Sites: Drug-Induced Sleep Endoscopy

Developed in UK in 1991

Pringle MB, Croft CB. Clin Otolaryngol 1991;16:504-9.

Used in several centers around the world but less commonly in U.S.

Fiberoptic endoscopy of sedated, "sleeping" patient

Goal: reproduce SDB seen on sleep study

VOTE Classification system (Kezirian, Hohenhorst, de Vries Eur Arch Oto 2011)

--some standardization and comparison of findings/outcomes across centers

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DISE Technique

Goal: reproduce patterns of SDB seen during natural sleep

Check sleep study (apneas vs. hypopneas)

Transition to loss of consciousness key (avoid oversedation)

Hillman Anesthesiology 2009: genioglossus muscle tone under propofol sedation 10% of maximal wakefulness at loss of consciousness (lower than sleep onset and natural NREM in normals but likely higher than in natural REM)

Oversedation decreases muscle tone (Eastwood Anesthesiology 2005)

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DISE and Transition to Unconsciousness

Propofol decreases upper airway (genioglossus) muscle tone (Eastwood Anesthesiology 2005)

Hillman 2009: genioglossus muscle tone under propofol sedation 10% of maximal wakefulness at transition to unconsciousness

Less than sleep onset in normals (Fogel J Physiol 2005) but higher than REM in normals and OSA (Eckert Chest 2009)

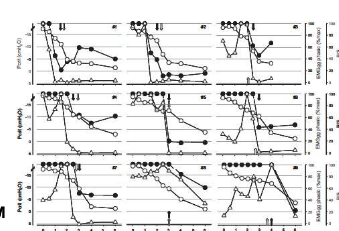

Fig. 1. Relationships among pharyngeal critical closing pressure (Pcrit, cm H_2O; *closed circles*), phasic genioglossus electromyogram activity (EMGgg) recorded at Pcrit (% of maximum value recorded in each subject over the series of measurements; *triangles*), bispectral index score (BIS; *open circles*), and Propofol effect site concentration (µg · ml^{-1}) in each of the nine subjects. Subjects are presented in order of their susceptibility to upper airway collapse with increasing Propofol levels. *Closed arrows* = Propofol dose at which unequivocal loss of consciousness was first noted; *open arrows* = BIS:Propofol inflection point.

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DISE Technique: Anesthesia Team?

OR not required

Required: MD + specialized (CRNA)
2 MDs

Certified facility

Mechanical ventilation (safety)

Europe: Postoperative care unit or procedure suite

US: OR often, but procedure suite an option

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DISE Technique: Preoperative

No preoperative anesthetics (ketamine, etc.)
- Decide on choice of sedation and avoid others

Possible anticholinergic (glycopyrrolate or atropine)
- 0.2-0.4 mg IV
- Reduce secretions; helpful for visualization and avoidance of coughing
- Tachycardia expected (ECG monitoring)

Administer when IV placed, not on way to the OR
- 20-30 minutes for effect on secretions

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DISE Technique: Preoperative

Topical vasoconstrictor and anesthetic

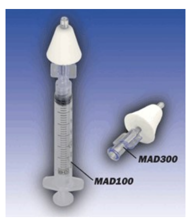
Cotton or spray with
- pontocaine/oxymetazoline

Oxymetazoline in preoperative area

Topical anesthetic (3 cc of lidocaine 2% c 1/100,000 epinephrine) in OR

Beware: coughing with secretions in trachea with pharynx anesthetized

Awake fiberoptic exam in OR (possible)
- Ensure reasonable topical anesthesia
- Level of comfort for Anesthesia team



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DISE Technique: Setup

Patient positioning—Options
- Supine position in all cases
- Supine except cases with worse SDB in lateral position
- Natural sleep position, but may be logistically challenging

Positional OSA very common (Richard Eur Arch Otorhinolaryngol 2006)

As comfortable as possible (pillows, room temp)

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DISE Technique: Setup

Oxygen (options)
- Nasal cannula (4 L/min)
- Face mask on upper chest

Adjust oxygen saturation alarm (80% or lowest saturation on sleep study)

Optional: BIS or other neuromonitor (Hillman 2009—BIS 55-70 range at loss of consciousness)

Lights off, minimize noise

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DISE Technique: Choice of Sedation

Titrate to loss of consciousness (doses widely differ)
- Loss of response to verbal stimulation

Propofol
- Boluses (20-50 mg loading dose)
- Target-controlled infusion (Diprifusor/Astra Zeneca infusion pump system to achieve desired serum concentration more quickly)
- Continuous infusion (50-75 mcg/kg/min; usually sedation at 75-125 mcg/kg/min)

Midazolam

Midazolam (3-5 mg IV)/propofol

Dexmedetomidine

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DISE Technique: VOTE Classification

- Many different classification described
- Wide range of complexity
  - *Palate and/or hypopharynx only*
  - *Seven patterns of collapse described*
- Structure-based assessment
- Structures are key to making individualized treatment decisions

Kezirian, Hohenhorst, de Vries Eur Arch ORL 2011
Hohenhorst, Ravesloot, Kezirian, de Vries Op Tech OHNS 2012

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VOTE: Structures Contributing to Obstruction

Nose/Nasopharynx

Velum (palate, uvula, lateral velopharyngeal walls)

Oropharyngeal lateral walls, tonsils

Tongue base

Epiglottis

Larynx

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VOTE: Configuration of Obstruction

Anteroposterior

Lateral

Concentric

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VOTE Classification

Degree of narrowing: qualitative assessment

0	No obstruction	No vibration
1	Partial obstruction	Vibration
2	Complete obstruction	Obstruction
X	Not visualized	

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VOTE Classification

Table 1 The VOTE classification

STRUCTURE	DEGREE OF OBSTRUCTION[a]	CONFIGURATION[c]		
		A-P	LATERAL	CONCENTRIC
Velum				
Oropharynx lateral walls[b]				
Tongue Base				
Epiglottis				

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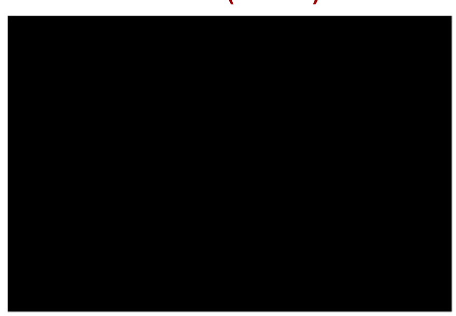
Velum (Palate)



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Oropharyngeal Lateral Walls

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Tongue

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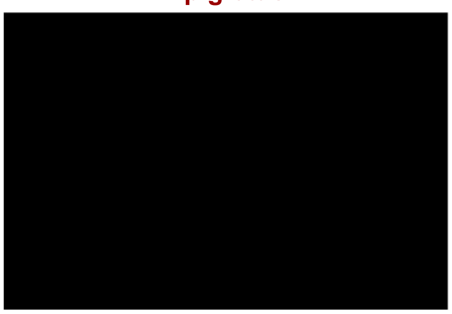
Epiglottis



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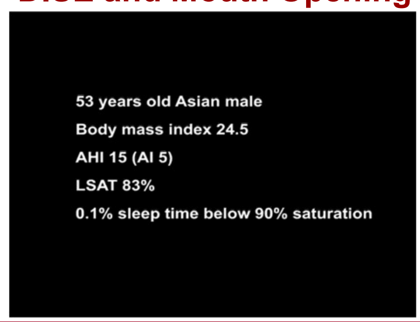
DISE and Mouth Opening



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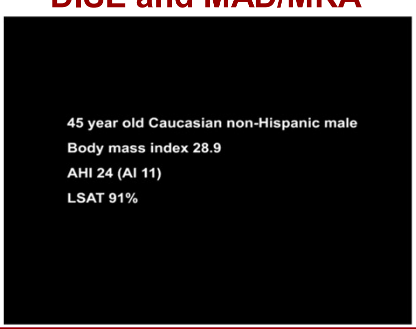
DISE and MAD/MRA



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Drug-Induced Sleep Endoscopy

Advantages: Dynamic assessment of "sleep"
- Directly visualize location of obstruction and involved structures
- Possible quantification of collapse (Borek Oto-HNS 2012)
- Vibration vs. obstruction (Hohenhorst AAO et al.)
- Valid: greater collapsibility in OSA vs. snorers (Steinhart Acta Otolaryngol 2000) and SDB vs. controls (Berry Laryngoscope 2005)
- Reliability: test-retest (Rodriguez-Bruno Oto-HNS 2009) and inter-rater (Kezirian Archives Oto-HNS 2010) moderate to good

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DISE Research

600+ studies

Diversity of obstruction patterns—reassuring

83% HP

Kezirian Archives Oto-HNS 2010 (from Table 1)

	# (%)
Analysis I. Global assessment	
Palate	99 (92)
Hypopharynx	90 (83)
Analysis II. Degree of obstruction	
Palate	
<50%	9 (8)
50-75%	15 (14)
>75%	84 (78)
Hypopharynx	
<50%	18 (17)
50-75%	29 (27)
>75%	61 (57)
Analysis III. Specific structures (primary)	
Velum	99 (92)
Oropharyngeal Lateral Walls	16 (15)
Tongue	60 (56)
Epiglottis	16 (15)

Yalamanchili Laryngoscope 2018

Table 4. Associations of Body Position by VOTE Findings, Analyzed Separately as Overall Group and POSA and N-POSA Subgroups

Independent Variable	Odds Ratio (95% CI) Overall*	POSA (n = 39)*	N-POSA (n = 26)*
Supine (vs lateral)			
Velum AP	7.28 (3.53-15.01)	7.78 (2.99-20.24)	7.29 (2.36-22.51)
Velum lateral	0.54 (0.26-1.12)	0.76 (0.29-2.02)	0.32 (0.10-1.00)
Oropharyngeal lateral walls	0.52 (0.26-1.03)	0.80 (0.34-1.92)	0.22 (0.07-0.70)
Tongue	29.41 (12.10-71.47)	26.06 (7.91-85.90)	44.40 (11.09-177.69)
Epiglottis	11.04 (1.32-92.67)	7.33 (0.80-67.17)	Not estimable

What anatomic mechanisms underlying positional OSA are suggested by DISE?

DISE findings in positional and nonpositional OSA in supine and lateral body position

POSA and NPOSA: supine more Velum AP and Tongue

NPOSA: lateral more Oropharyngeal lateral walls (and maybe more Velum lateral), while not true for POSA

May explain why some surgeries (and oral appliances) work better in POSA

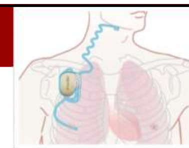
Green Laryngoscope 2018

Are DISE findings associated with surgical outcomes?

Multicenter study of DISE
14 centers, n = 275
Blinded review of DISE videos

Any O: decreased response (OR 0.51; 95% CI 0.27, 0.93)
Complete T: decreased response (OR 0.52; CI 0.28, 0.98)
Complete T: untreated = poorer outcomes
Complete T: tongue resection likely better
V, CCC not associated with outcomes; ?E (sample size)

Huyett AAO-HNS 2019



Are DISE findings associated with Upper Airway Stimulation outcomes?

DISE is required before UAS implantation

Only use is to screen out those with complete concentric collapse (30%)

Approximately 70% efficacy

What if we could identify those with 90% response and those with 50% response?

What if we could identify those who would never be comfortable with stimulation?

DISE and UAS: Huyett AAO-HNS 2019

Overall, 75% response rate (n = 239)

57% response rate on efficacy study (n = 84)

Velum: any vs none (RR 1.1, [0.9-1.2]; p=0.30)

CCC: 7/10 were responders (vs no CCC: RR 0.78, [95%CI 0.21-2.93]; p = 0.48)

Oropharynx: O2 vs O1/none (RR 0.47, [0.22-1.00]; p = 0.049)

T2: 80/99 were responders (vs. T1/none: RR 1.41 [0.94-2.11]; p = 0.076)

Epiglottis: any vs none (RR 0.9, [0.5-1.8]; p=0.77)

Drug-Induced Sleep Endoscopy

Disadvantages

- Not easy: requires sedation, somewhat time-consuming
- Sedatives decrease muscle tone and decrease respiratory drive
  - May artificially worsen OSA and alter pattern of collapse
  - Hillman Anesthesiology 2009
  - Key is avoidance of oversedation (Eastwood Anesthesiology 2005: decreased muscle tone)
  - Propofol has less decrease in respiratory drive

Drug-Induced Sleep Endoscopy: Future Directions

Determining optimal selection of procedures:
CCC, O, complete T

Predicting and/or improving surgical outcomes (accuracy)

Improving our understanding of the airway and changes after surgery

- Possibly, greatest value with selected patients
  Questionable pattern of obstruction
  Previous surgery with persistent OSA

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	PS G	FS	MM	LC	AA	SBT	CT/ MRI	PM	AR	FR	SE
Easy	+	+	+	+	+	-	-	-	+	-	+/-
Low-cost	+	+	+	+	+	+/-	-	+/-	+/-	+/-	-
Dynamic	+	-	+	-	+	+	+	+	+	+	+
Asleep	+	-	-	-	+	+	+/-	+	-	+	+
Accurate	-	+/-	-	?	-	?	?	-	?	?	+/-

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Site of Obstruction and Surgical Options

Past/Current	Current/Future?
Palate/Tonsils	Velum
Hypopharynx/ Retrolingual	Oro Lat Walls
	Tongue
Maxillofacial	Epiglottis
	Maxilllofacial

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Structure-Based Approach for Procedure Selection?

Velum/Palate	Palate surgery
Oro Lat Walls	? (Lateral pharyngoplasty, ESP, hyoid suspension, MAD/MMA)
Tongue	GA Partial Glossectomy Tongue RF Tongue Stabilization Upper Airway Stimulation (multilevel)
Epiglottis	? Hyoid suspension Partial epiglottectomy

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Conclusions

Identifying the site(s) of airway obstruction in OSA is critical

No single ideal method of identifying site of obstruction, although there are some options

Improving our assessment of the airway may enable targeted, more-effective treatment of OSA with surgery and oral appliances

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