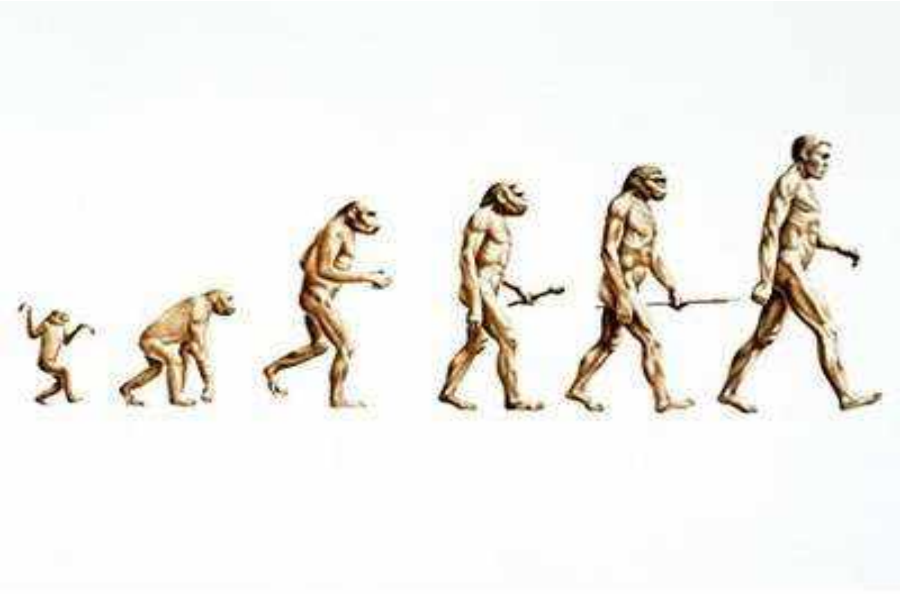
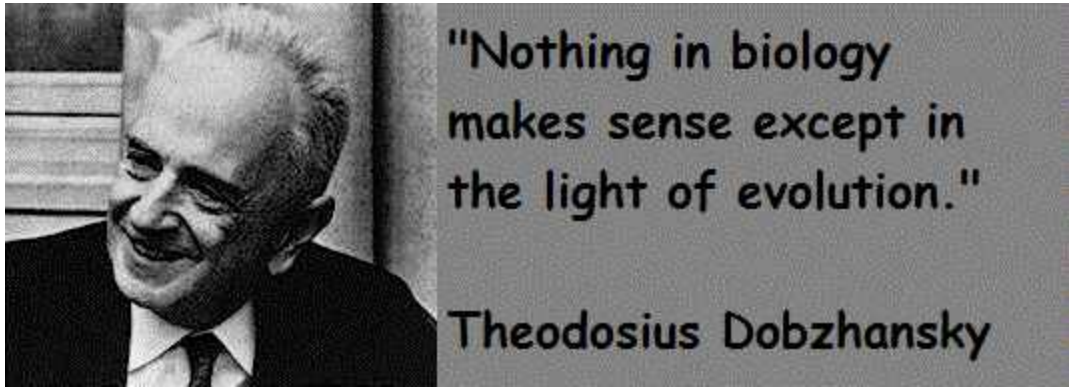
Nasal Obstruction From a Developmental and Evolutionary Perspective





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This talk presents material that is related to one or more of these potential conflicts, and the following objective references are provided as support for this lecture:

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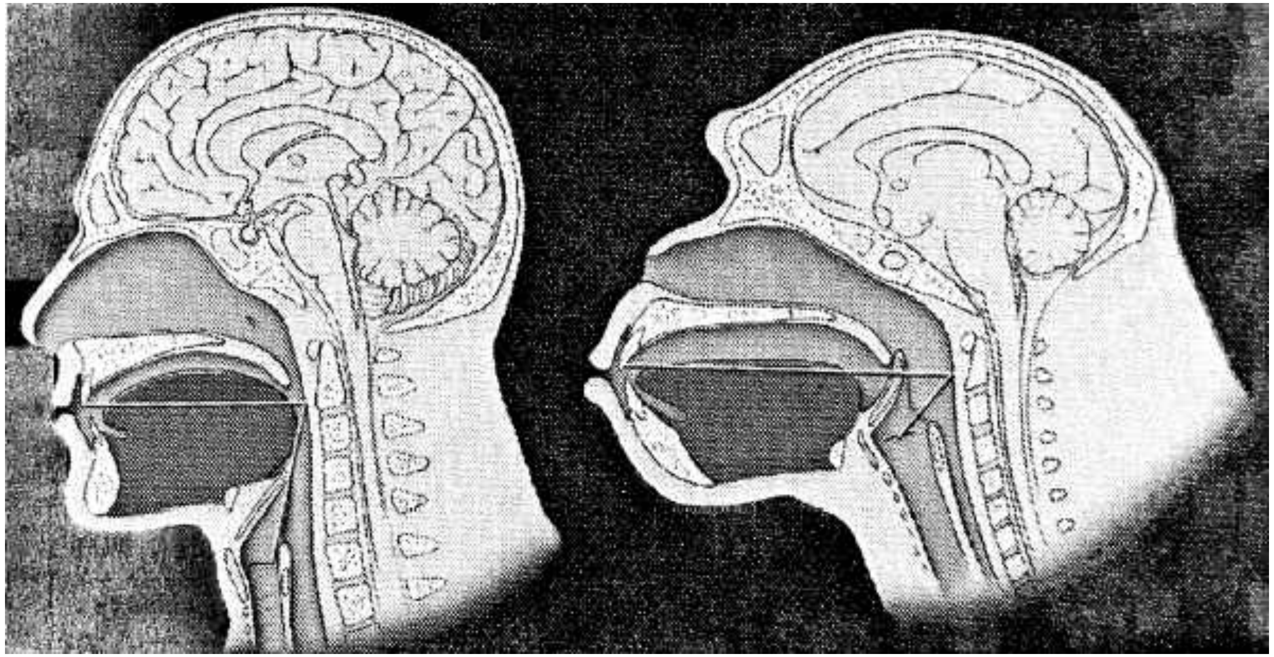
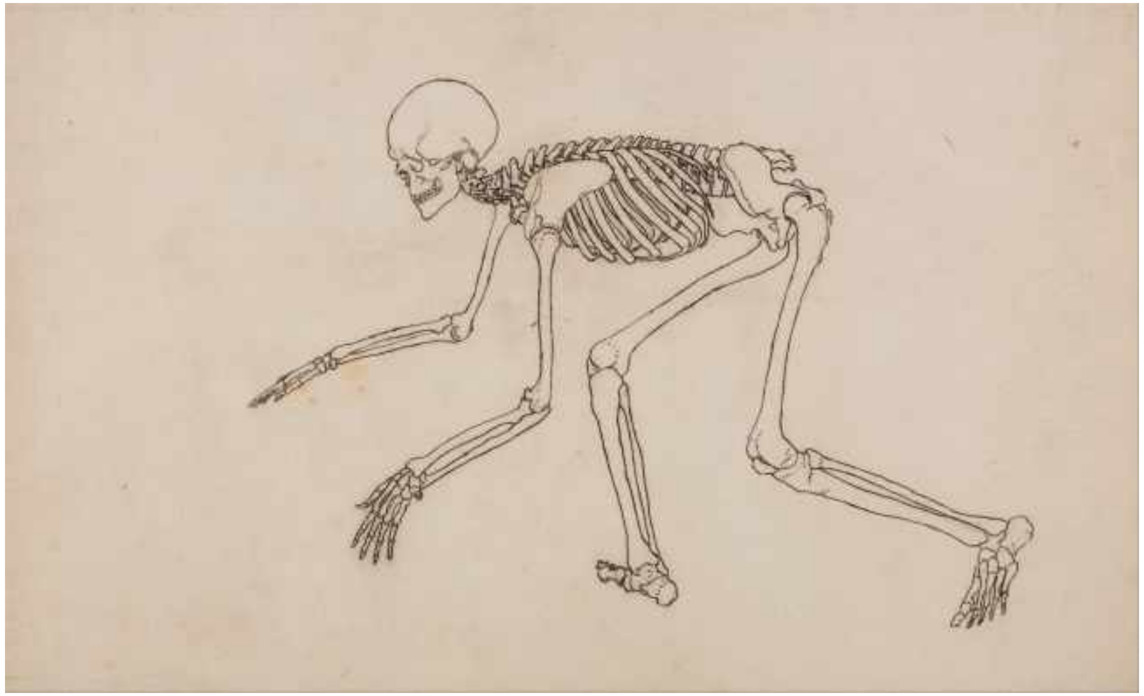
Evolutionary Anatomic Changes



- Facts about the Homo Sapiens:
  - Only animal with an oropharynx
  - Only animal with complex speech
- Potential theories to explain these anatomical changes:
  - Bipedalism
  - Binocularism
  - 1:1 Superior Vocal Cord Tract

An Evolutionary Perspective



Evolutionary Anatomic Changes

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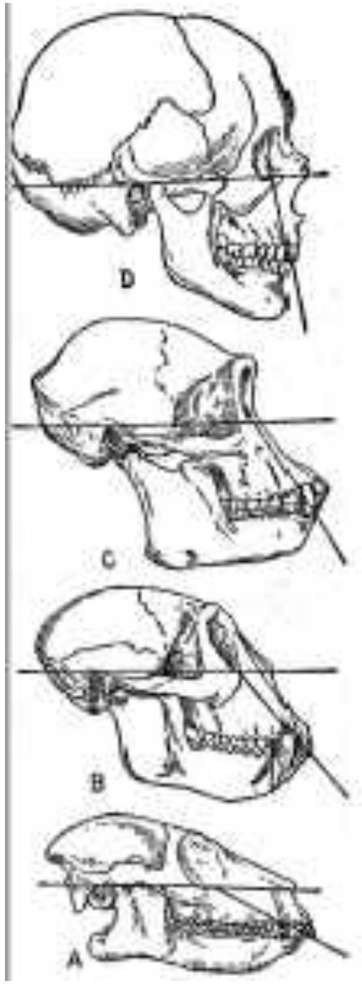

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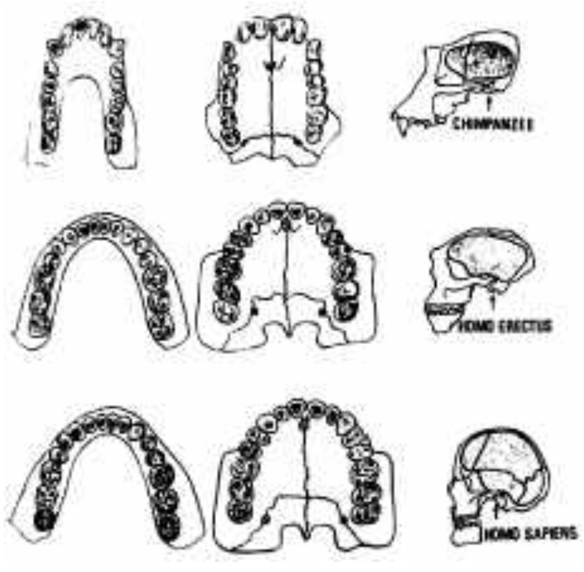

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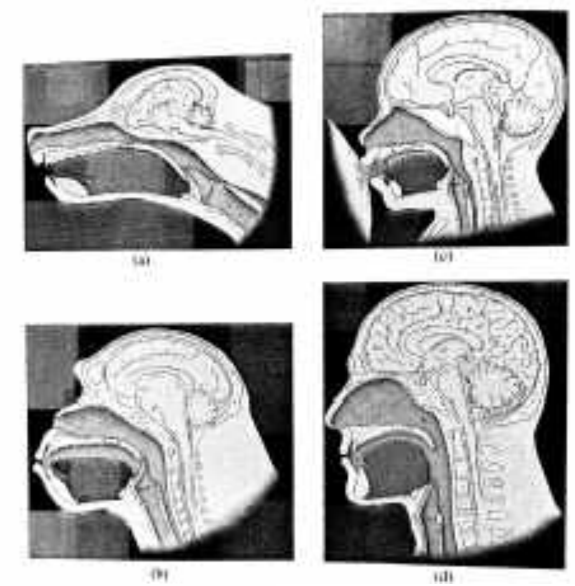

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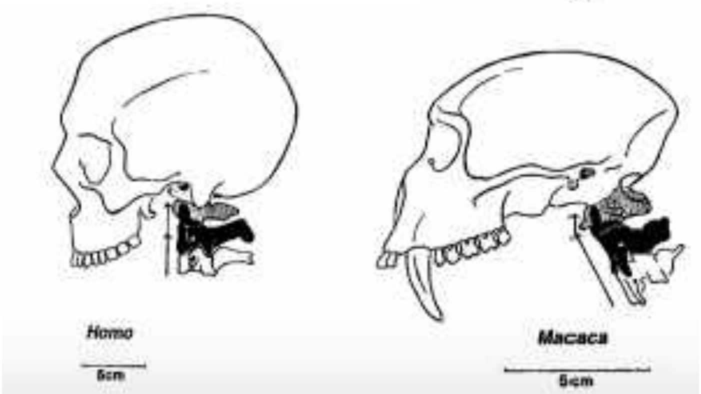
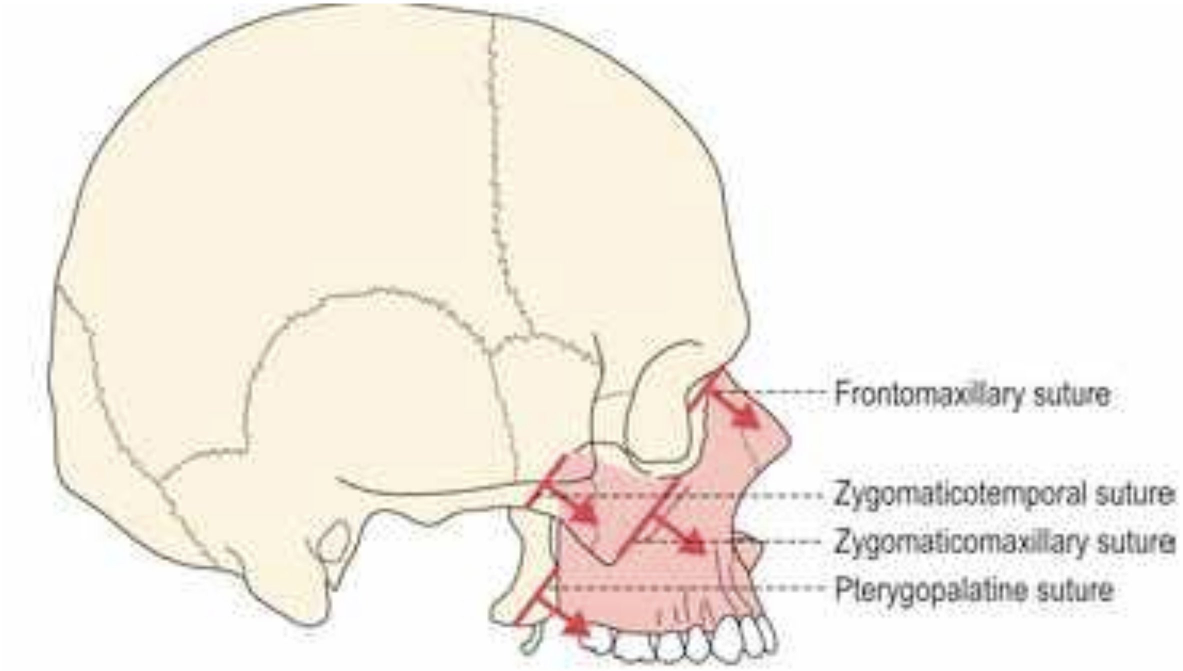


A Developmental Perspective

- Nasomaxillary complex and the mandible are key in determining the size of the upper airway.

  - Infancy until toddler → 1 mm/yr.
  - Prepubertal period (5 - 11 y) → 0.25 mm/yr.
  - 12 - 17 y/o → 1.5 mm/yr.



A Developmental Perspective

-Significant **reduction of PAS of 2.3 ± 0.4mm** at a mean age of 14 y/o compared to 11y/o ***Guilleminault et al,*** 2013 Sleep Med.

	Initial diagnosis	Post-treatment T and A	Post-treatment orthodontics+	Post treatment final evaluation
Number of subjects	29	29	29	29
Number of boys	20	20	8	20
Age (y) mean ± SD	7.6 ± 1.7	7.8 ± 1.8	7.10 ± 2.0	8.6 ± 2.8
AHI mean ± SD	9 ± 5	3 ± 4	0.5 ± 0.2	0.4 ± 0.4
RDI mean ± SD	15 ± 6.4	7 ± 6	0.8 ± 0.2	0.6 ± 0.5
Lowest SaO2-% mean ± SD	91 ± 2.5	94 ± 3	97 ± 1	98 ± 1.5

Recording results in mean age 14 years teen-agers.

Pubertal teen-agers $N = 29$	No clinical complaints	With clinical complaints
Number of subjects	9	20
Number of boys	2	18
BMI (kg/m^2)	15.9 ± 1.9	15.7 ± 2.1
Age (y) mean ± SD	13.8 ± .9	14.2 ± 1
AHI** mean ± SD	0.5 ± 0.2*	3.1 ± 1.0
RDI** mean ± SD	1.5 ± 1.2*	7 ± 1.2
Lowest SaO2-% mean ± SD	97 ± 1%	92.5 ± 1.5

Selected measures from cephalometrics, before puberty and at investigation during puberty.

Cephalometrics	Mean age 11 years	Mean age 14 years
SNA	84.7(1.7)	85.1(2.4)
SNB	79.4(2.65)	79.85(2.65)
H-MP	10.1(3.75)	11.8(9.25)
PAS*	9.0(1.85)	6.6(1.85)*
BL	76.4 (5.5)	83.2 (5.1)

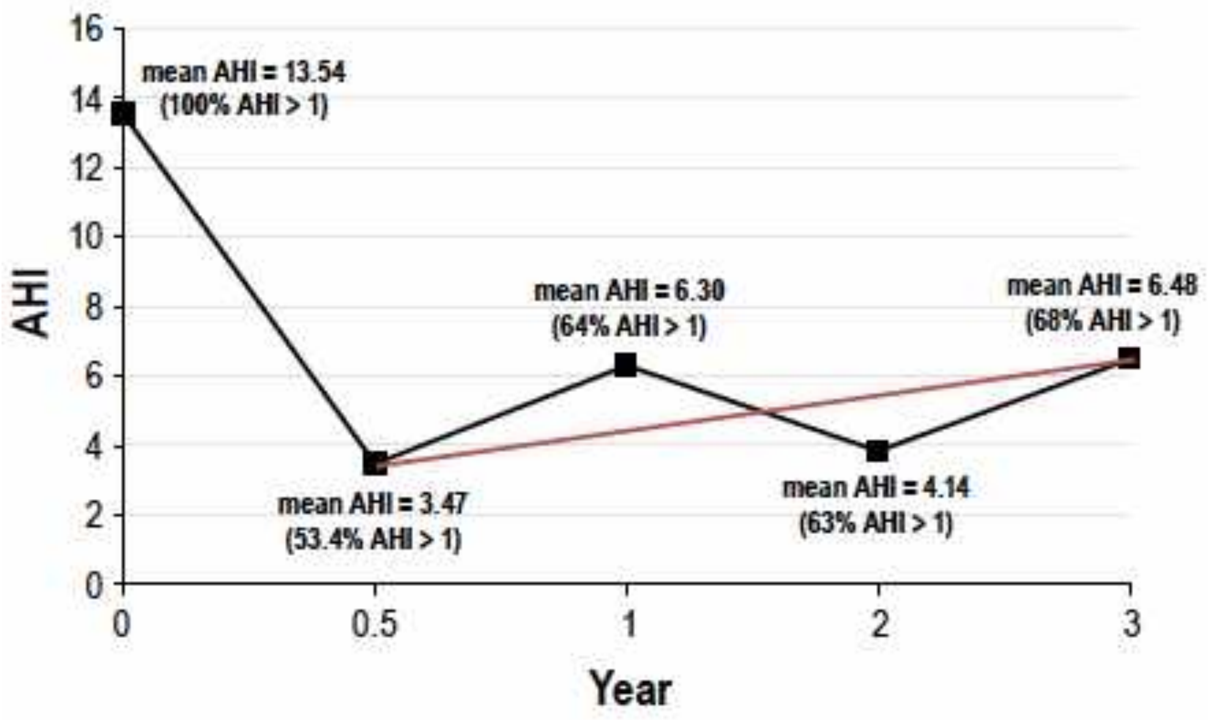
Treatment Outcomes of Adenotonsillectomy

- **Huang et al. (Sleep 2014)**

  -68% of the children - abnormal AHI at 36 months.

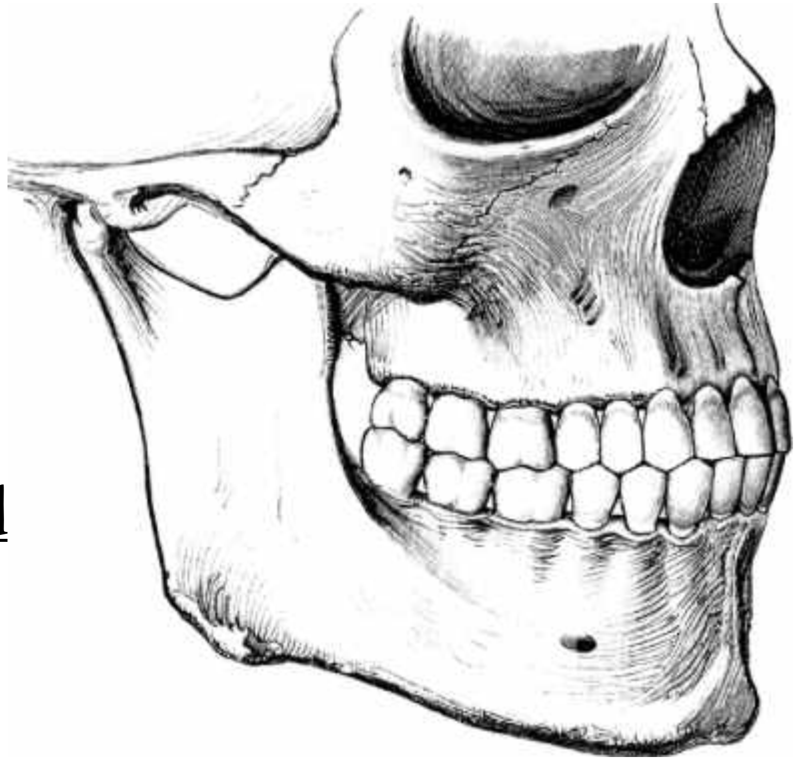
  -Mean AHI @ 36months was 6.48 ± 5.57events/h.

  -Age was a risk factor for recurrence



Nasomaxillary and Mandibular Development

Nasomaxillary complex and mandible interaction guides facial-skeletal growth in a <u>forward</u> and <u>horizontal</u> orientation.



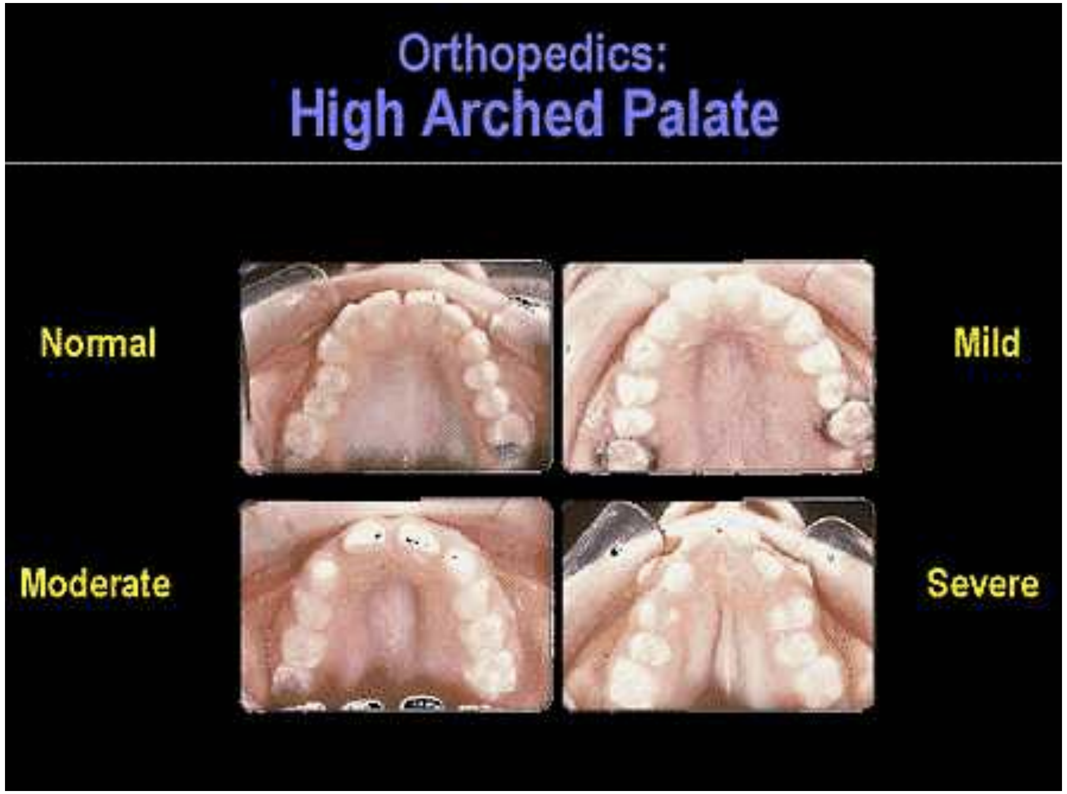
Nasal Breathing and Airway Development

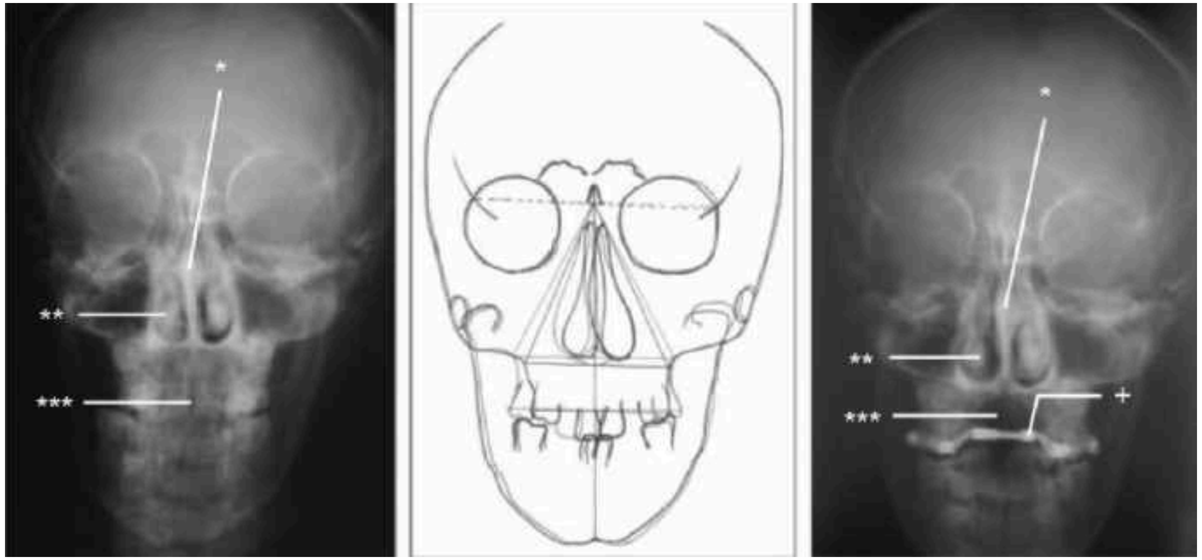
- Essential to maximize the interaction between the nasomaxillary complex and the mandible.

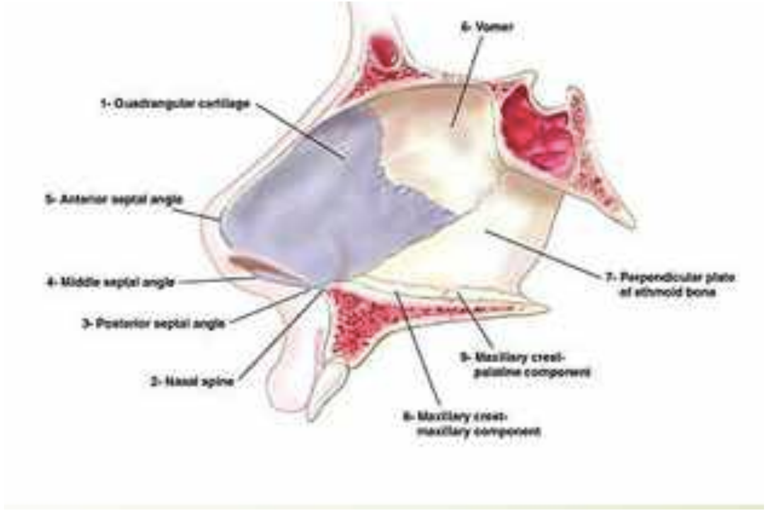
- Establishing proper nasal breathing early in life optimizes craniofacial growth.
  - Consider time sleeping as child

- Nasal disuse leads to other problems that further compromise nasal breathing

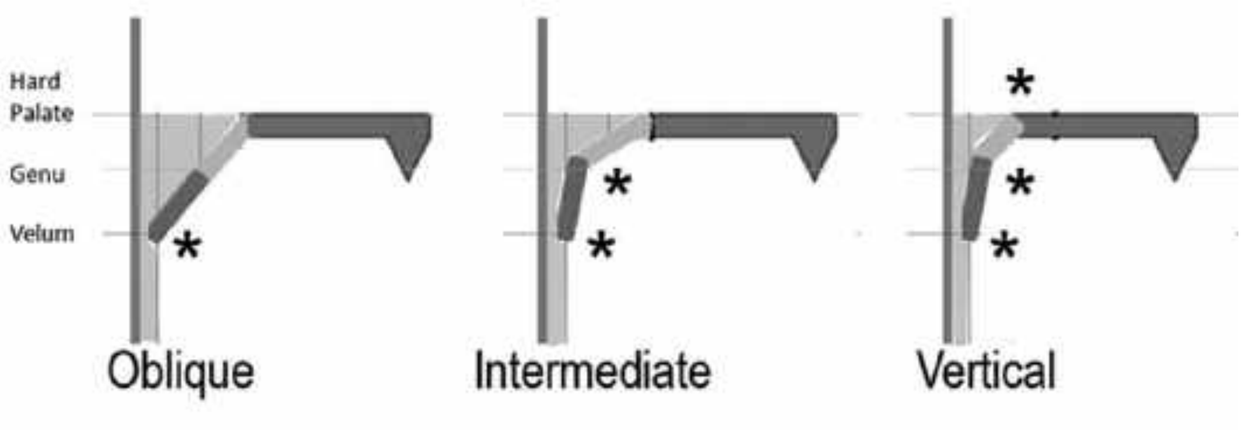
Consequences of Chronic Mouth Breathing

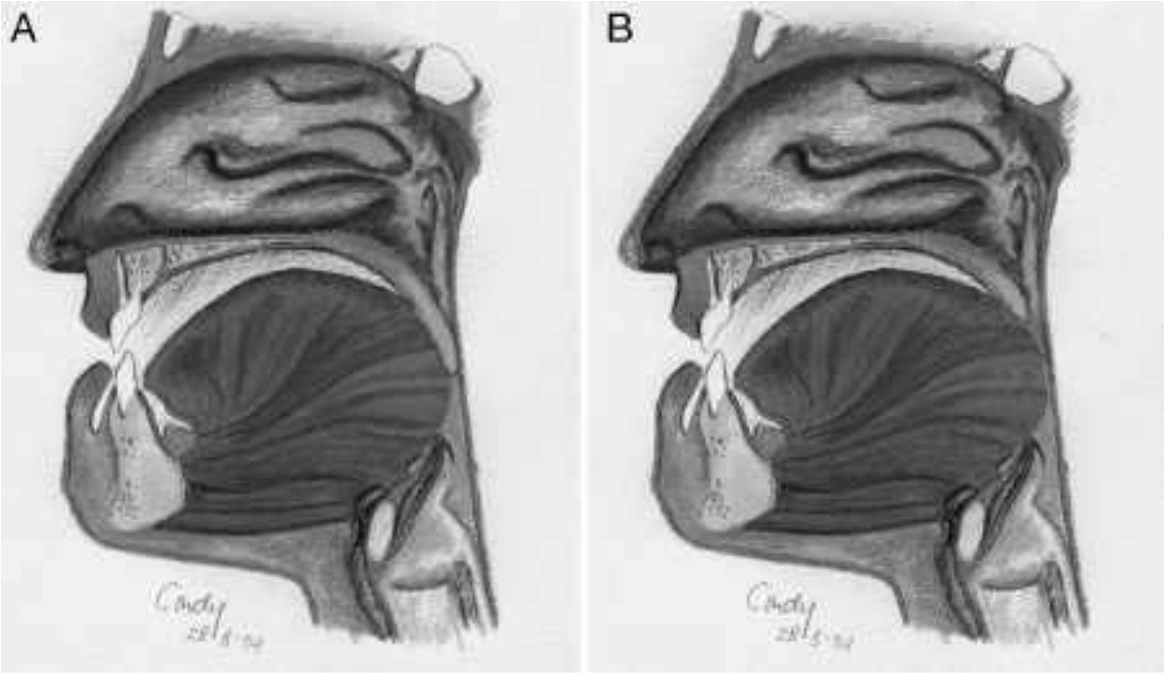




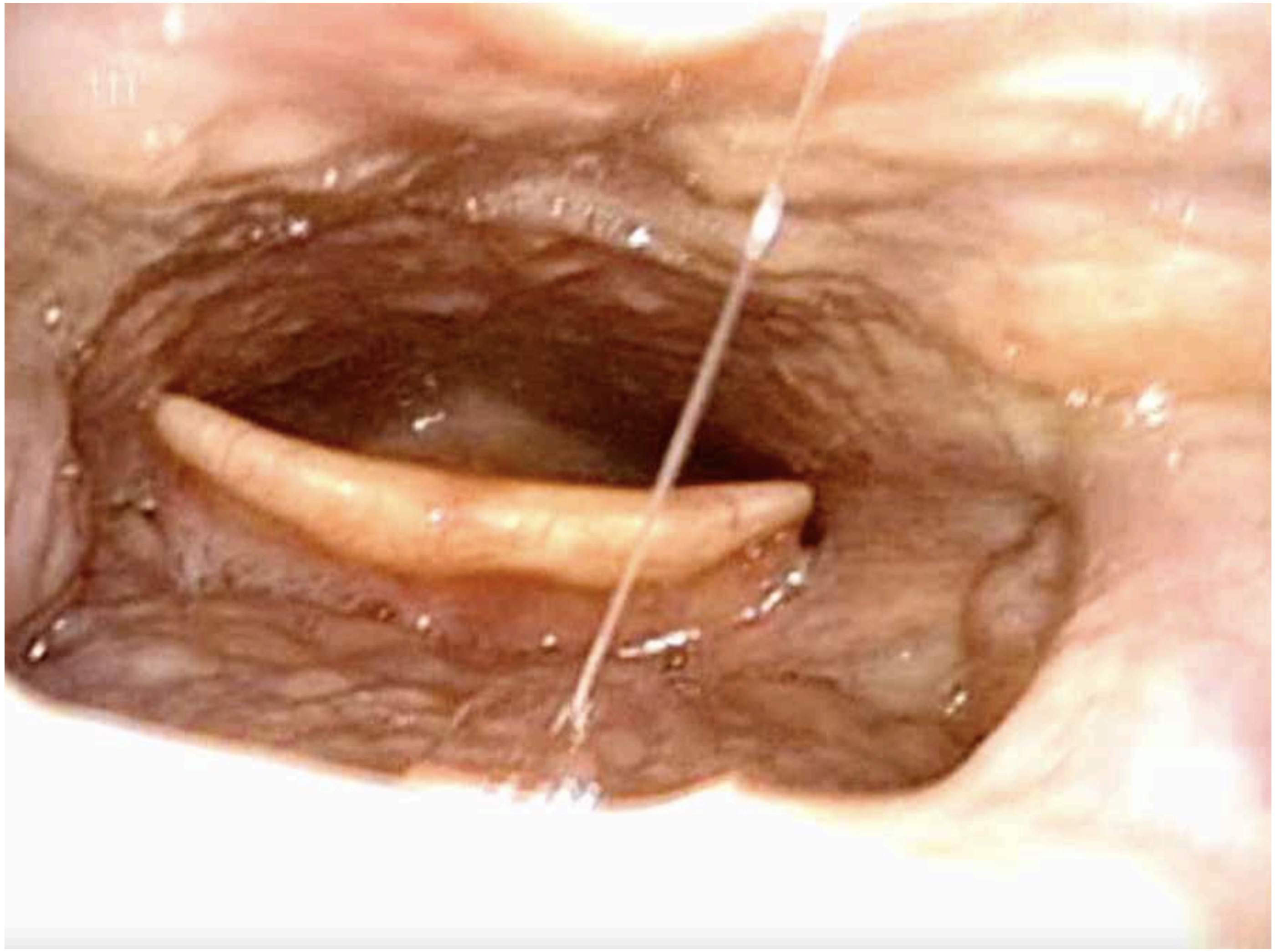


Soft Palate Elongation



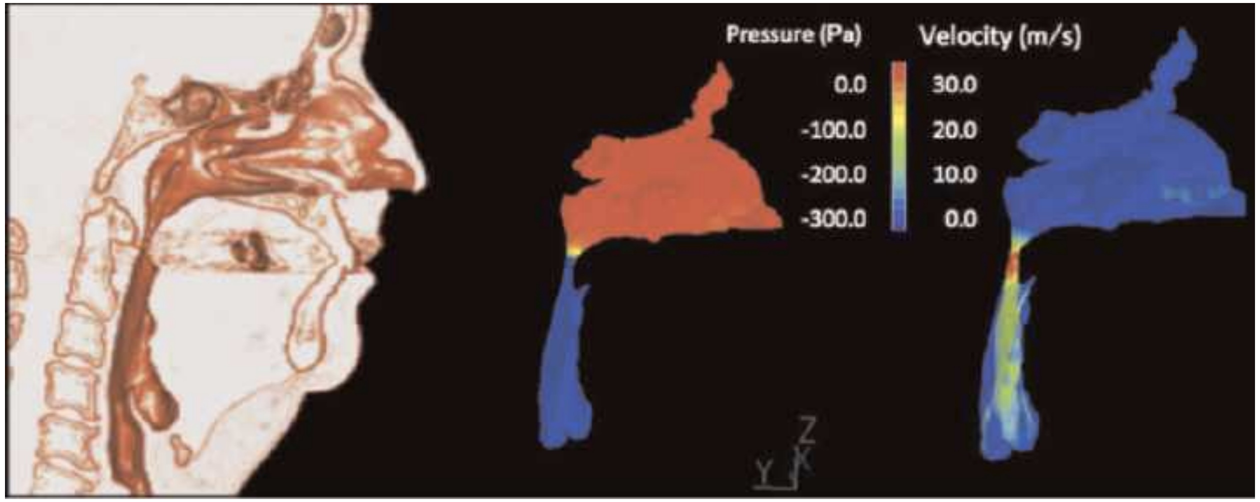


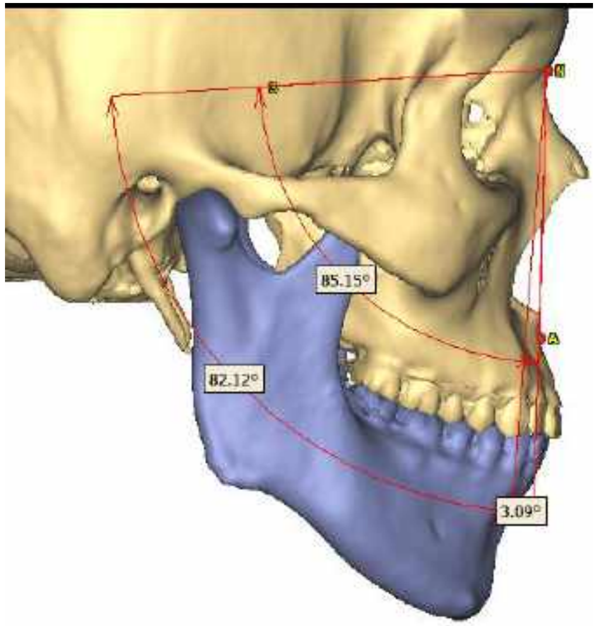
Pseudomacroglossia



Epiglottis Collapse

Anatomic Variables Associated with OSA





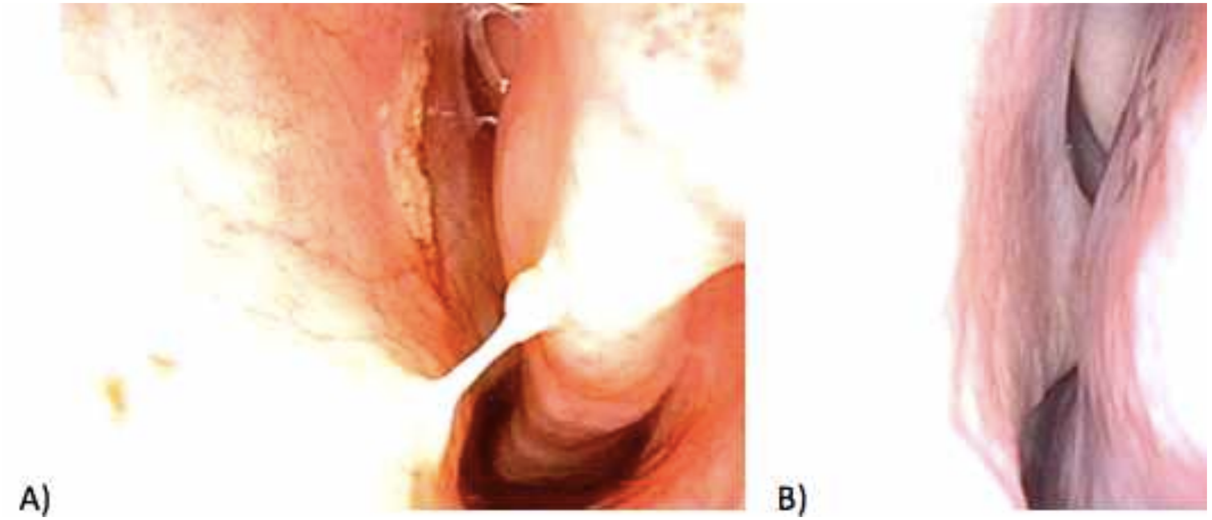
1) Decreased mandibular and maxillary projection

2) Downward and posterior rotation of facial development

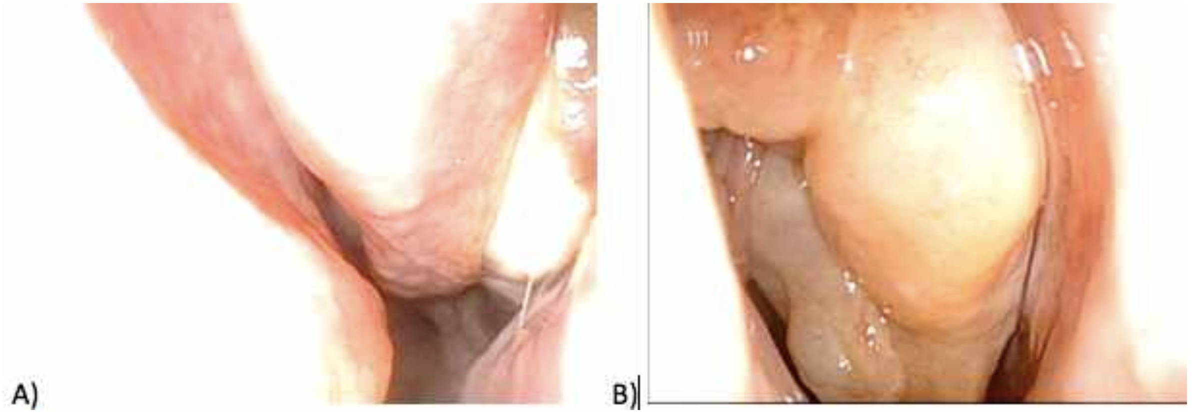
3) Increased vertical length of the upper airway

4)Increased distance of the hyoid bone from the mandibular plane

Consequences of Chronic Mouth Breathing



Cephalocaudal compression of the septum



Nasal under-ventilation causes inflammation

Torre et al. Sleep Science and Practice (2017) 1:8

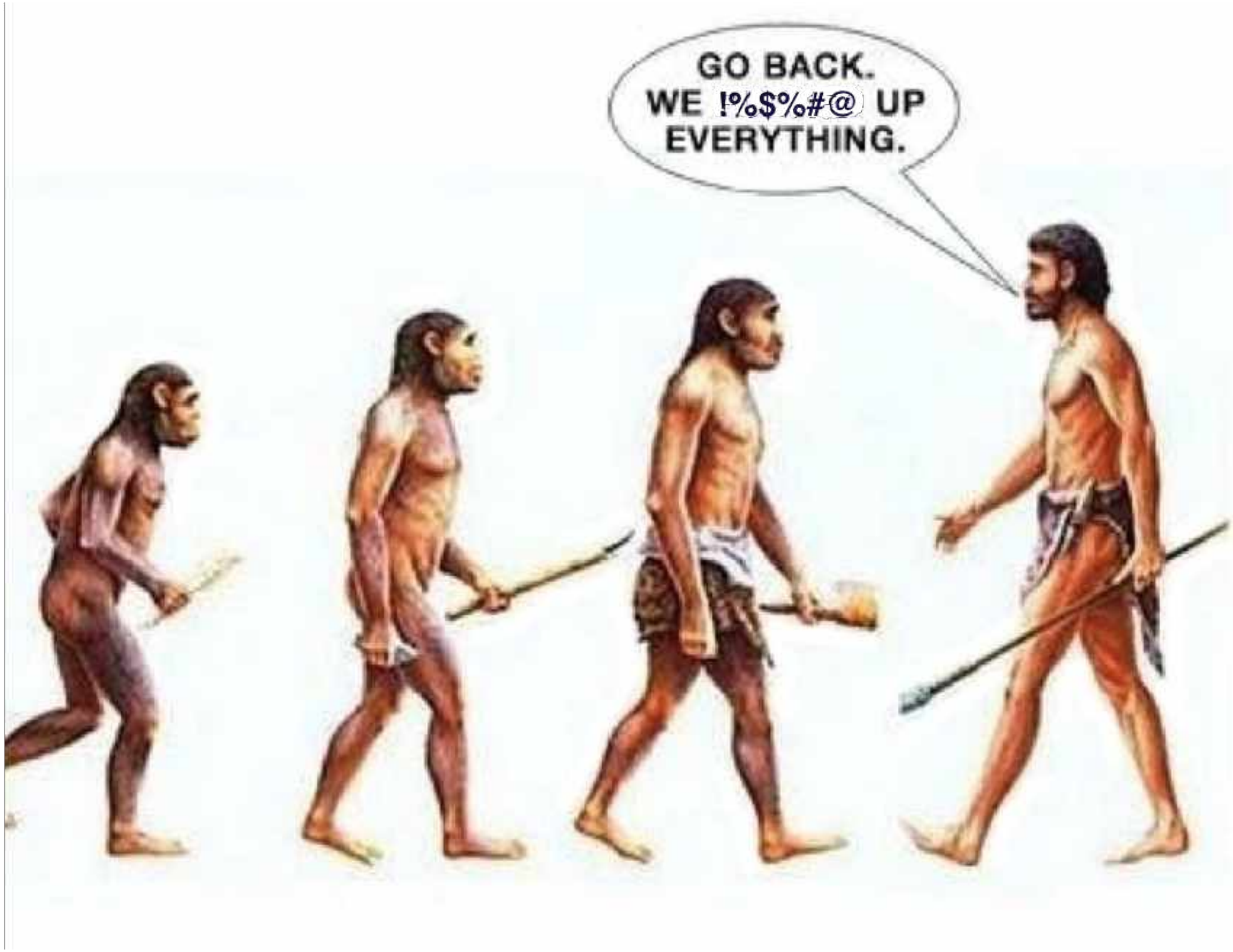
Importance of Nasal Breathing During Sleep

- Activate reflexes that help maintain the tonicity of the muscles that stabilize the upper airway

- Mouth breathing has up to 2.5 times higher total resistance

- Delivers Nitric Oxide to the lungs to improve gas exchange capability – maximizes tidal volume

The Solution…..



Nobody can go back and start a new beginning, but anyone can start today and make a new ending.

Increasing Airway Space

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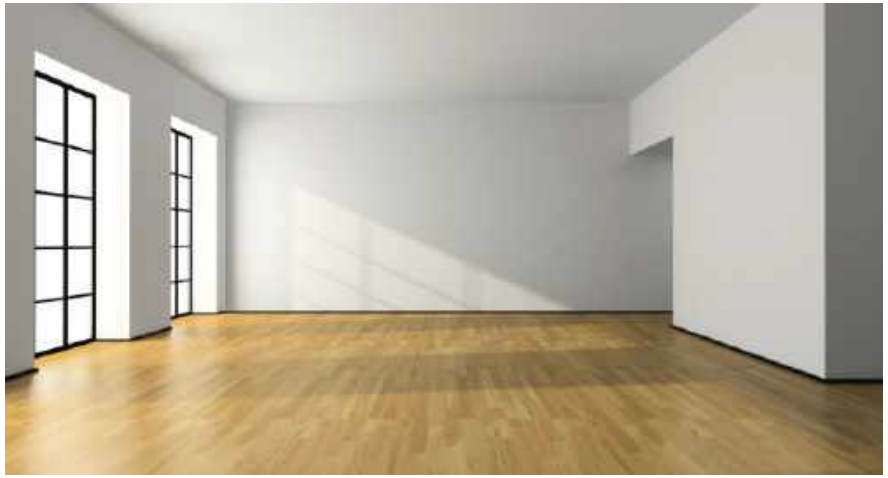

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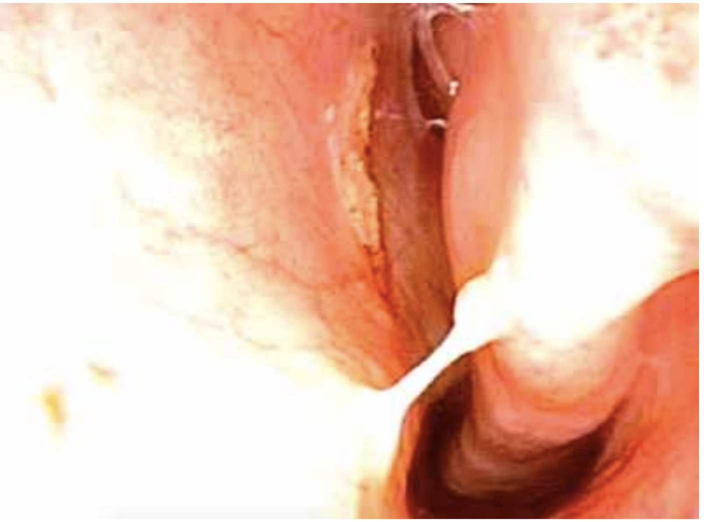
Early Interventions that Target Evolutionary and Developmental Issues

- **Addressing Nasal Obstruction**
- **Rapid Maxillary Expansion**
- **Myofunctional Therapy +/- Frenuloplasty**

Common Causes of Nasal Obstruction

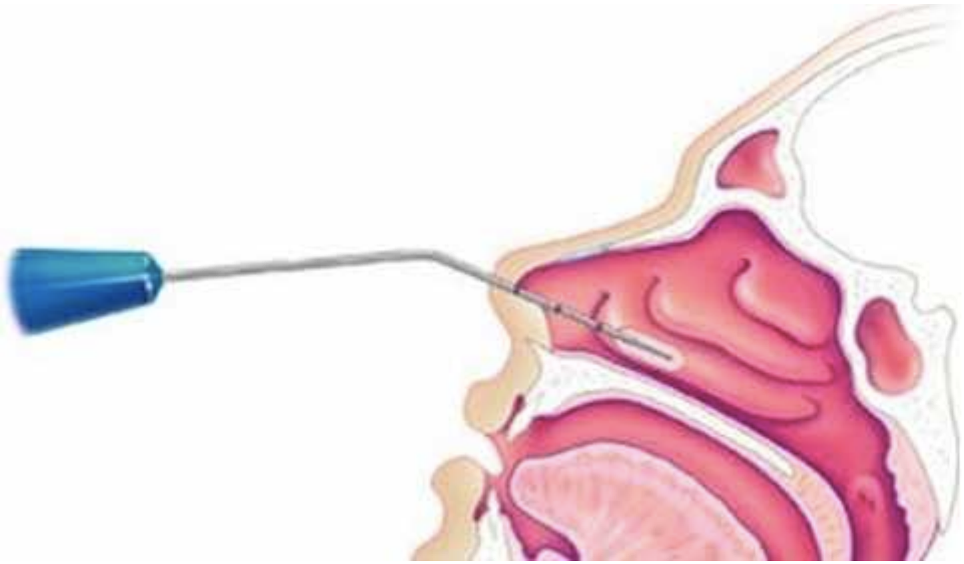


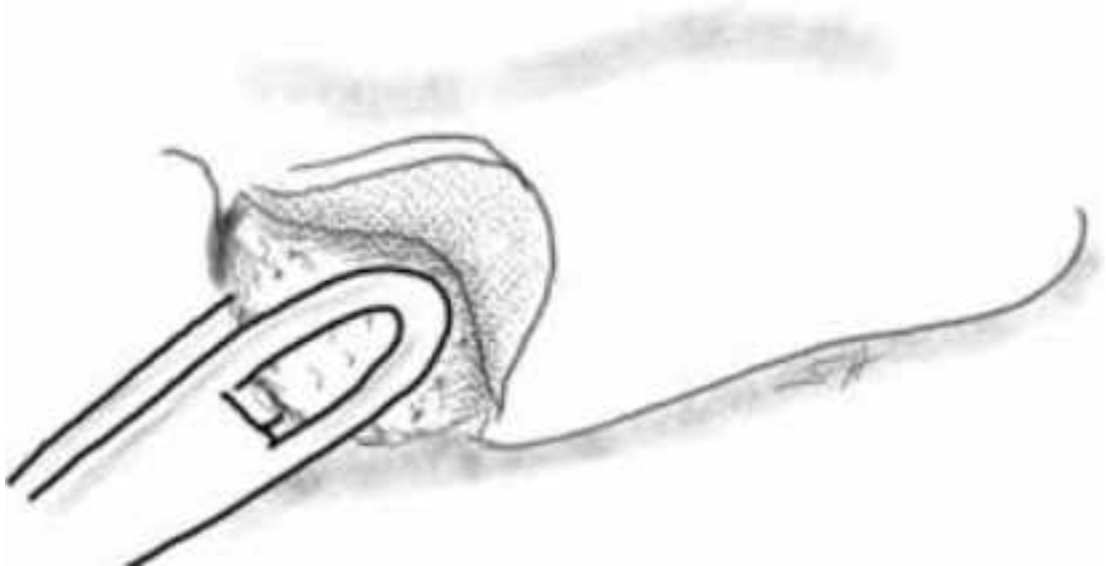
ALLERGIC RHINITIS: TREATMENT

Pharmacotherapy

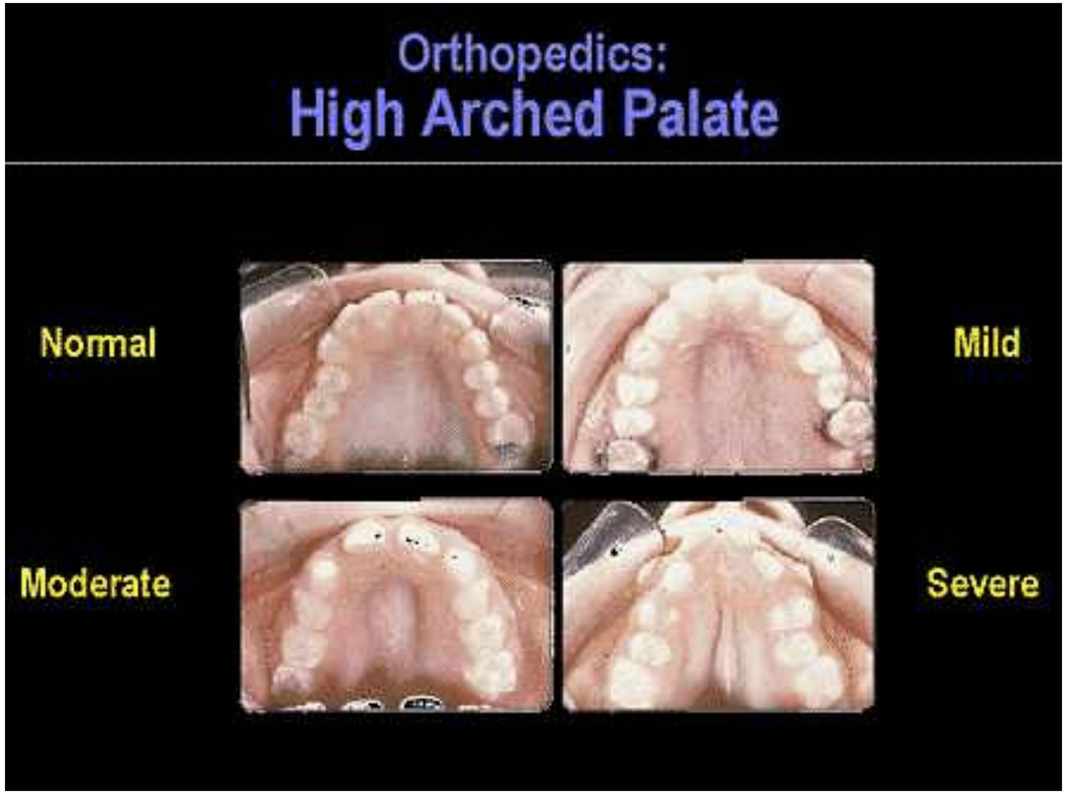
Medication	Strengths	Weaknesses
Oral antihistamines	Fast onset Sneezing, itching, rhinorrhea Ocular symptoms Safe	Nasal congestion Sedation with 1st Generation
Nasal antihistamines	Fast Onset Sneezing, itching, rhinorrhea Helps some with congestion Useful in Nonallergic rhinitis Safe	Taste Some sedation
Intranasal corticosteroids	Very effective for allergic rhinitis Nasal congestion, Sneezing, itching, rhinorrhea Useful in sinusitis	Nasal irritation Epistaxis Rare systemic steroid effects Slower onset
Leukotriene modifiers	Treats allergic rhinitis and asthma Lesser rhinitis efficacy	Behavioral changes Some require monitoring liver enzymes
Oral decongestants	Fast onset Nasal congestion, rhinorrhea	Sleep disturbance Hypertension
Mast cell stabilizers	Safety Few side effects	Frequent dosing Lesser efficacy
Topical anticholinergics	Watery rhinorrhea Helps with nonallergic rhinitis Helps in viral rhinitis	Nasal congestion Sneezing, itching

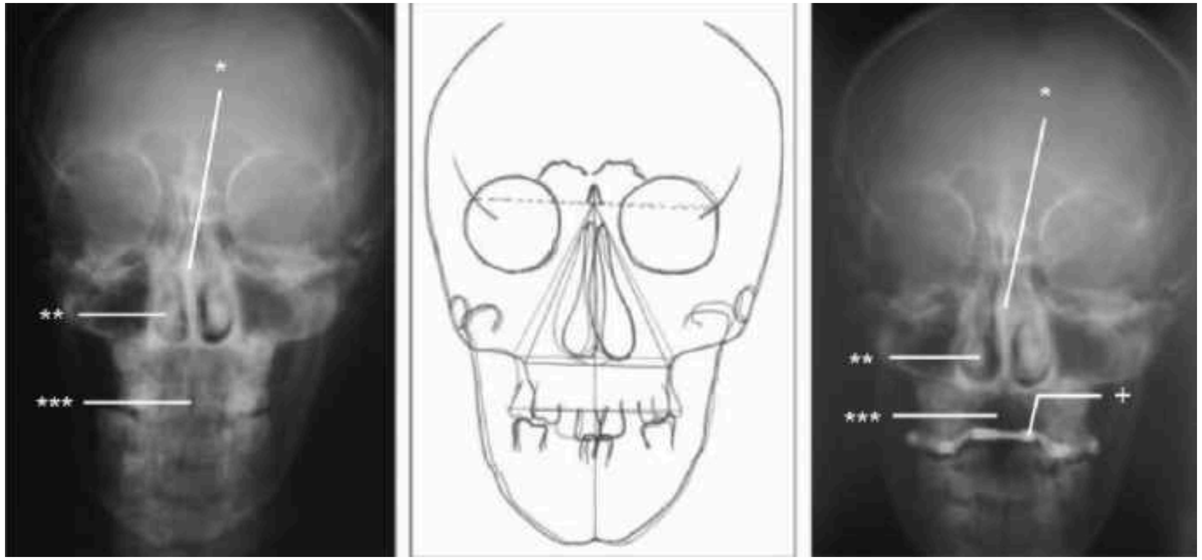
Nasal Surgery: Inferior Turbinate Reduction

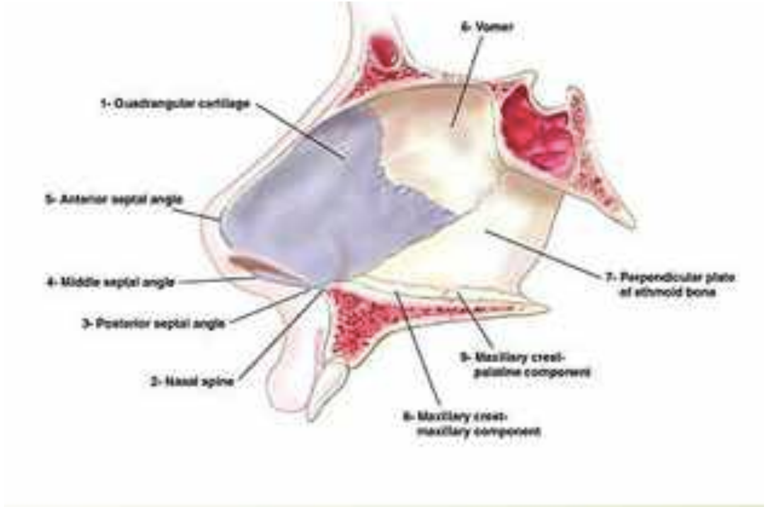




Maxillary Hypoplasia & Nasal Obstruction







Rapid Maxillary Expansion

Table 1—Polysomnographic Data for 31 Subjects

Polysomnographic Parameter	T_0	T_1	T_2
Obstructive apnea-hypopnea index	12.18 ± 2.6	9.8 ± 2.7	0.4 ± 1.1
Range	5.7-21.1	0-8.1	0-2.1
Nadir SpO_2, %	78.5 ± 8.2	89.6 ± 5.9	95.3 ± 1.7
Duration of longest obstructive apnea, sec	35.2 ± 18.6	28.3 ± 14.1	12.6 ± 7.4
Duration of desaturation (SpO_2 < 92%), % total sleep time	19.7 ± 3.5	6.6 ± 1.9	1.3 ± 1.1
Sleep efficiency, %	87.1 ± 8.8	88.6 ± 6.4	89.2 ± 7.7

T_0 refers to time before any orthodontic therapy; T_1, after 4 to 6 weeks with the device; T_2, 4 months after the end of the orthodontic treatment. All data are displayed as mean ± SD, unless otherwise indicated.

- **Pirelli et al. (Sleep 2004):**
  - 31 children without T&A hypertrophy, non-obese, and with OSA
  - **Mean pyriform opening increase 1.3 ± 0.3 mm**
  - Mean cross-sectional maxillary expansion **4.32 ± 0.7 mm.**
  - **Anterior rhinometry was normal.**

Guilleminault et al. (Sleep Breath 2011):

Table 1 Studied groups and results after each treatment

Variables	Baseline		*p* value	Treatment 1		*p* value	Treatment 2		*p* value
	Group 1	Group 2		Group 1 surgery	Group 2 orthodontics		Group 1 orthodontics	Group 2 surgery	
Sleep variables									
TST, min	431.3±4.1	423.1±2.2	0.09	429.1±5.6	425.1±5.3	0.51a	445.7±8.7	438.7±4.7	0.72a
						0.99b			0.00b
						0.28c			0.51c
REM, %	18.6±0.4	18.9±0.3	0.60	20.5±0.3	20.1±0.2	0.13a	22.0±0.2	21.9±0.3	0.32a
						0.00b			0.00b
						0.81c			0.45c
Sleep apnea variables									
AHI, events/h	12.5±0.8	11.1±0.7	0.20	4.9±0.6	5.4±0.6	0.15a	0.9±0.3	0.9±0.3	0.16a
									0.00b
						0.00b			0.49c
						0.53c			
RDI, events/h	21.3±1.0	19.5±1.0	0.22	8.0±0.7	7.9±0.5	0.27a	1.6±0.6	1.7±0.8	0.92a
						0.00b			0.00b
						0.29c			0.95c
Lowest SaO2%	92.1±0.5	92.5±0.4	0.53	95.2±0.3	95.9±0.3	0.65a	98.0±0.2	97.6±0.3	0.004a
						0.00b			0.00b
						0.15c			0.68c

Systematic Review

Rapid Maxillary Expansion for Pediatric Obstructive Sleep Apnea: A Systematic Review and Meta-Analysis

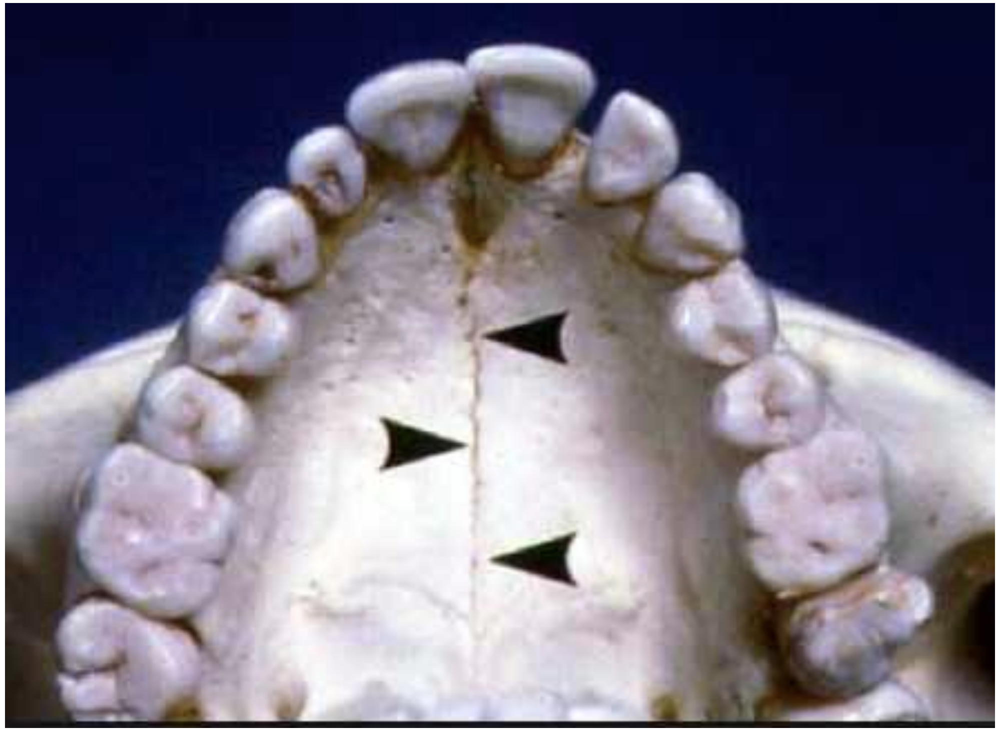
Macario Camacho, MD; Edward T. Chang, MD, MS; Sungjin A. Song, MD; Jose Abdullatif, MD; Soroush Zaghi, MD; Paola Pirelli, DDS; Victor Certal, MD, PhD; Christian Guilleminault, MD

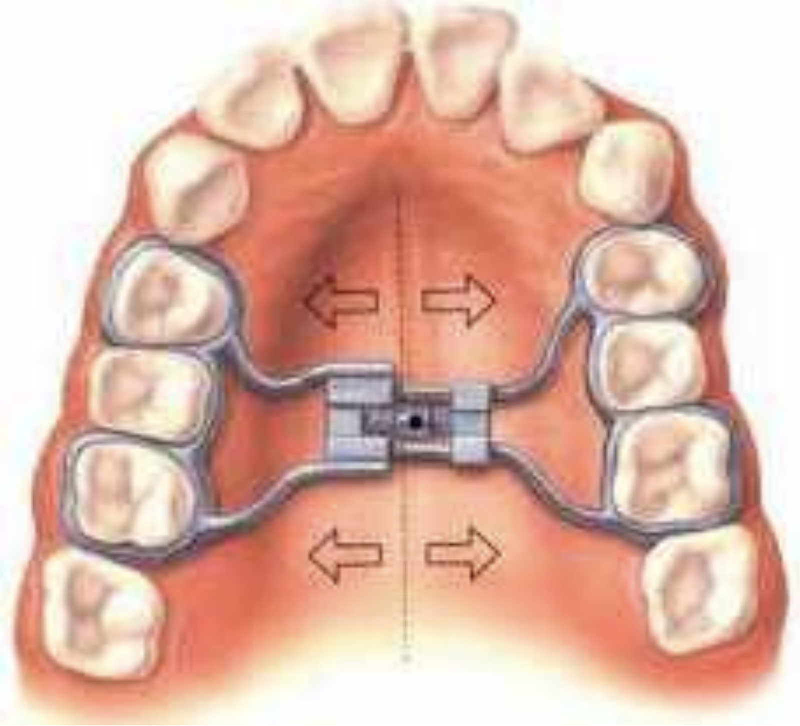
- 314 children with high arched palates where he showed significant reduction in the AHI and improvement in the lowest oxygen saturation (LSAT) pre- and post- RME.

- AHI improved more in children with previous adenotonsillectomy or with small tonsils.

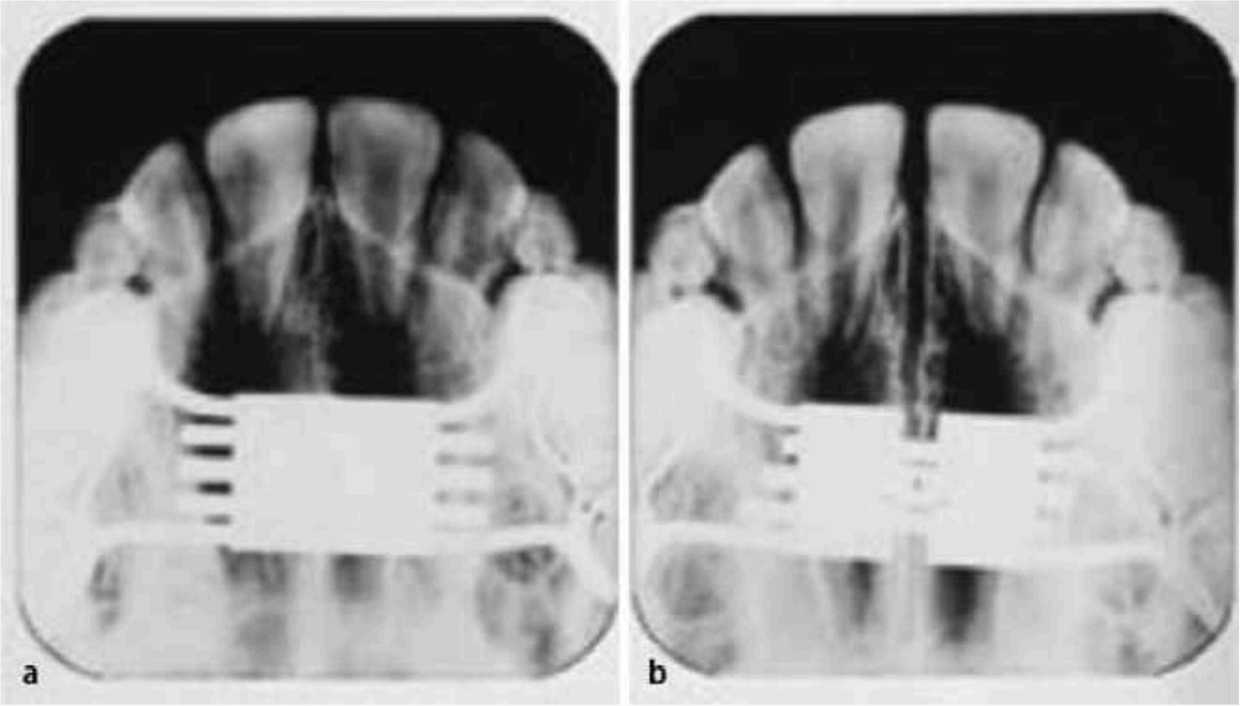
Rapid Maxillary Expansion

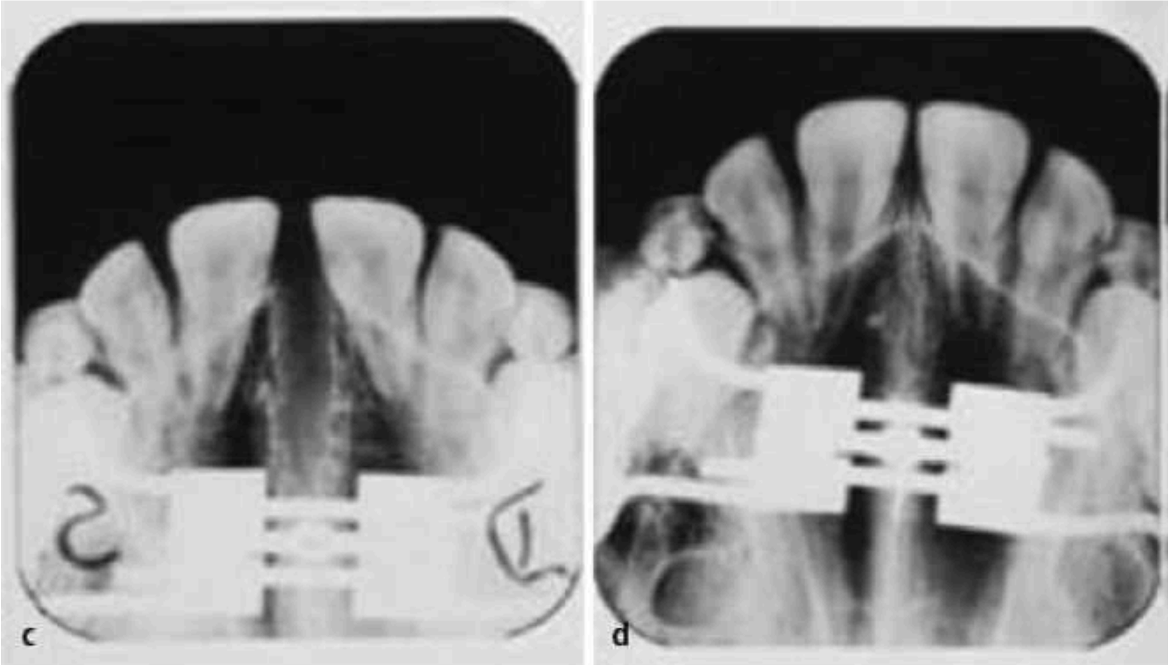
Mid-Palatal Suture: Kids vs Adults





Rapid Maxillary Expansion





Rapid Maxillary Expansion

Pirelli et al. (Sleep Medicine 2015):

-12 year follow up after pediatric maxillary expansion

-**Stability and maintenance of the expansion over time was demonstrated.**

Table 1
Polysomnographic results immediately post treatment and at long-term (12 years) follow-up.

	Results after completion of initial RME (n = 31)	Results at long term follow-up (n = 23)	p-value
PSG parameters			
AHI	0.4 ± 1.1	0.3 ± 0.9	NS
range	0–2.1	0–1.8	NS
Nadir SpO2 (%)	95.3 ± 1.7	97.2 ± 1.5	NS
% sleep time with SpO2 < 92%	1.3 ± 1.1	1.1 ± 1.0	NS
Sleep efficiency (%)	89.2 ± 7.7	90.1 ± 6.5	NS

Re-education Exercises

Guilleminault et al. (Sleep Medicine 2014):

-24 subjects (14 boys) with normal PSG following adenotonsillectomy and orthodontia

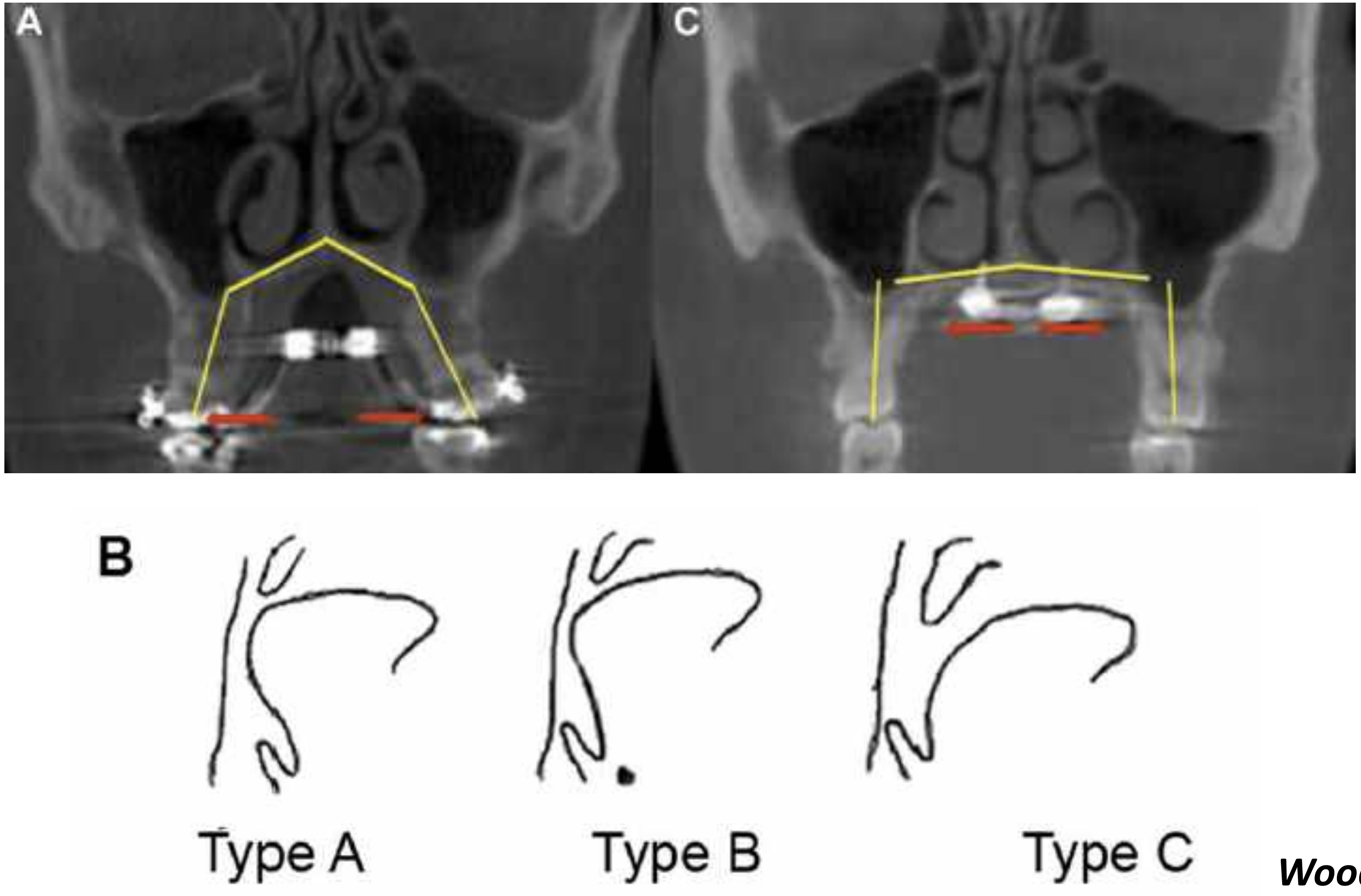
-11 subjects received myofunctional therapy; 13 did not complete treatment

-Relapse seen in patients that did not complete re-education

Table 2
Sleep-disordered breathing documented with polysomnography.

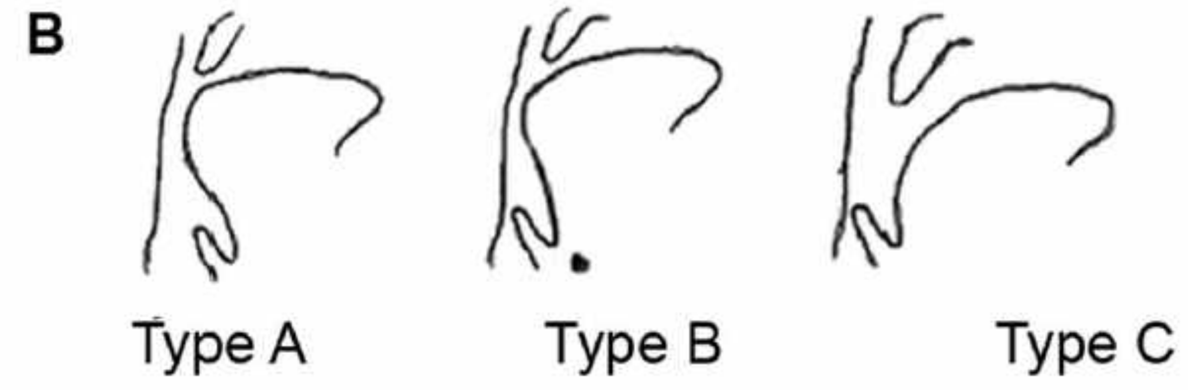
	Entry	Post-AT	Postorthodontics	Follow-up study	
				No reeducation	Reeducation
No. of children (n)	24	23	24	13	11
Age (y)	5.5 ± 1.2	5.10 ± 1.3	7.3 ± 1.5	11.8 ± 1.4	11.5 ± 1.2
AHI (event/h)	10.5 ± 2.6	4.3 ± 1.6	0.4 ± 0.3	5.3 ± 1.5	0.5 ± 0.4*
Lowest SaO_2 (%)	90 ± 1.5	92 ± 1	95 ± 1	91 ± 1.8	96 ± 1**
Flow limitation (% TST)	–	–	10 ± 10	72 ± 14	5 ± 8***

High Arched Palate and Tongue Position

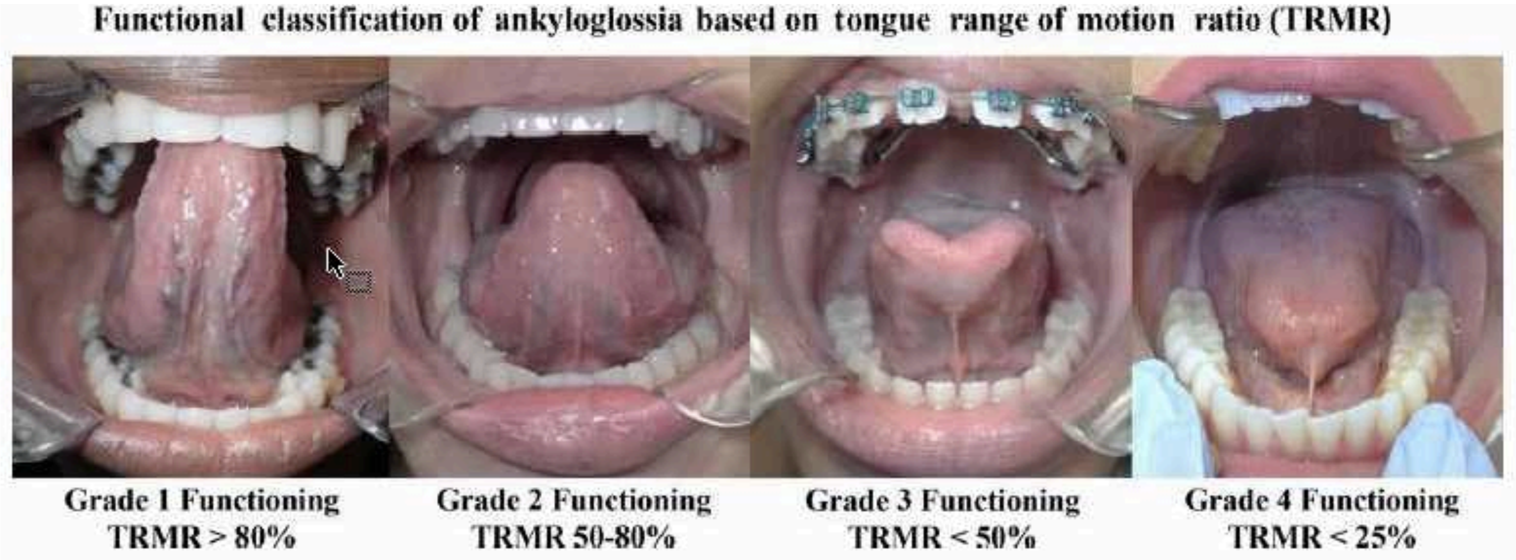


***Woodson**, Laryngoscope 2014*

Low Placement of the Tongue

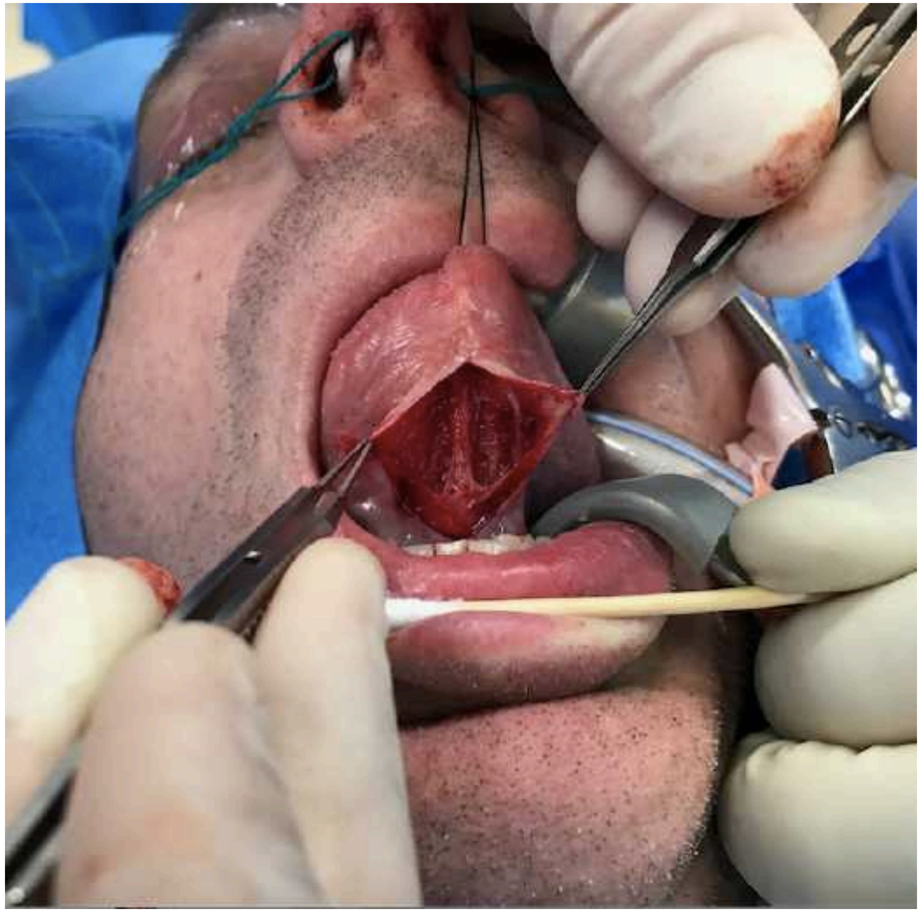


Woodson, *Laryngoscope 2014*



Yoon et al, *Orthod Craniofac Res. 2017*

Frenuloplasty with Myofunctional Therapy



Lee et al. (Sleep Breath 2015):

Table 2 Breathing parameters depending on presence of mouthing breathing, based on PSG performed 6 months after T&A (n=64)

	Mouth breathing (n=35)	Without mouth breathing (n=29)	p
Time spent mouth breathing (%)	44~100 %	0~10.3 %	
Age, mean±SD	5.16±1.31	4.77±1.38	0.58
Male/female	20:15	14:15	0.161
Overall symptoms	26 (74.3)	0 (0.0 %)	<0.0001
AHI, mean±SD	2.34±1.19	0.96±0.71	<0.0001
AHI ≥1.5	24 (68.6 %)	3 (10.3 %)	<0.0001
Flow limitation, mean±SD	13.85±11.64	0.57±1.55	<0.0001
SaO_2 nadir, mean±SD	95.71±1.48	97.00±1.04	<0.0001

- 9/18 from "mouth breathing" group, underwent 6 months of MFT.
- Non- MFT subjects were significantly worse than the MFT-treated cohort.
- **MFT led to normalization of clinical and PSG findings.**

Short Lingual Frenulum

	At entry		After 1st treatment	
	n	(%)	n	(%)
Demographics (n=27)				
Boys	18 (63%)			
Mean Age (years) (SD)	11.4 ± 5.2		12.3 ± 4.6	
Disease characteristics				
Overall symptoms	27	(100)	9	(90)
Fatigue	27	(100)	10	(37)
EDS	9	(35)	1	(4)
Poor sleep	18	(67)	9	(33)
Snoring	20	(74)	2	(7.5)
Speech problems+	13	(48)	2	(7.5)
Swallowing problems+	7	(26)	0	(0.0)
Chewing problems+	6	(22)	1	(3.7)
Tonsil scale				
0/1	8(30)		18(66.6)	
2	9(33)		9(33)	
3	5(18.5)		0 (0.0)	
4	5(18.5)		0 (0.0)	
Mouth breathing	27(100)		25 (92.5)	
AHI, mean ±SD	12 ± 4.6		3 ± 2	
SaO2nadir, mean ±SD	89 ± 2.5		94 ± 1.6	
Flow limitation, mean ±SD)	73 ± 11		31 ± 9	
Mouth breathing (%TST)	78 ± 14		61 ± 16	

Huang et al. Int J Pediatr Res 2015:

- Conclusion 1st follow-up:
    - Improvement after T&A or orthodontics, w/ and w/o frenulectomy.
    - **92.5%** still with mouth-breathing during sleep.
- **11 patient then treated with myofunctional therapy for 4 to 6 months**
    - Time spent mouth breathing during sleep of **4± 4.1%.**

Conclusions

- As a species humans are at risk of developing OSA as a results of laryngeal descend and shortening of the face.
- Establishing proper nasal breathing early in life optimizes craniofacial growth.
- Re-establishment of nasal breathing should be the ultimate goal in the management of pediatric OSA.
- Different approaches can be use to modify these anatomic changes in order to reduce airway collapse during sleep.

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