

SURGICAL MANAGEMENT OF OBSTRUCTIVE SLEEP APNEA SYNDROME

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OUTLINE

- History of Sleep
- Medical problem
- Surgical results
- Technique
- Evaluation of the airway.

HYPNOS SLEEP MYTHOLOGY

- Greek god or spirit of Sleep, opium horn
- Nyx (night) was his mother
- Somnus was the Roman equivalent
- Thanatos (peaceful Death) was his brother



THE POSTHUMOUS PAPERS OF THE PICKWICK CLUB (ALSO KNOWN AS THE PICKWICK PAPERS) IS THE FIRST NOVEL BY CHARLES DICKENS 1837



OBSTRUCTIVE SLEEP APNEA OSA

- "Picwickian syndrome" Charles Dickens, *Posthumous papers of the pickwick club*, 1837
- Burwell, 1956 1st published case
- Day time fatigue, EDS
- Sleep deprivation
- 10 sec cessation of airflow
- RDI or AHI, events/hr



SLEEP DISORDERS

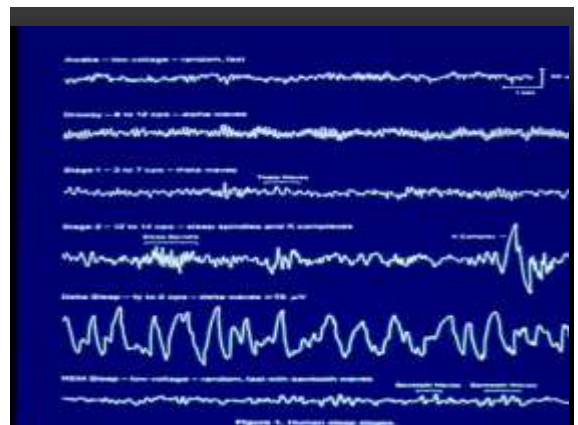
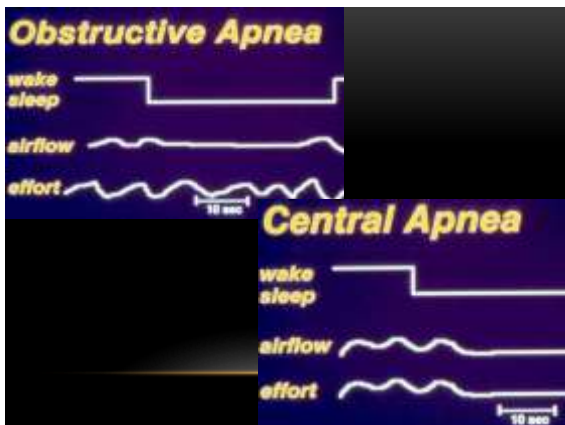
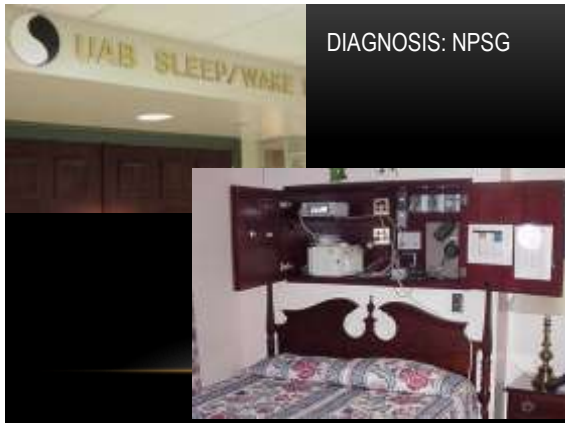
- 1979: First official classification of sleep disorders
- Estimated 40% of adults experience some form of sleep disorder
 - Sleep apnea
 - Narcolepsy
 - Insomnia
- Estimated cost: \$16 billion

SLEEP DISORDERED BREATHING

- Snoring
- Upper Airway Resistance Syndrome (UARS)
 - Sleep disturbance without desaturation
- Sleep Apnea
 - Central
 - Obstructive
 - Mixed

OSA : INCIDENCE

- 1-3 % of adult population: conservative
- Higher in industrialized countries
- Middle age males: 1-16%
- Elderly males: 18-67%
- Middle age females: 1-5%
- Elderly females: 20-54%



OBSTRUCTIVE SLEEP APNEA PATHOPHYSIOLOGY

- Maximal relaxation during REM sleep
- Most cases: multiple sites of obstruction



OBSTRUCTIVE SLEEP APNEA CARDIOPULMONARY CHANGES

- Pulmonary
 - Pulmonary Hypertension
 - Polycythemia
- Cardiac
 - CHF
 - Systemic Hypertension
 - Arrhythmias
 - Decreased cardiac output

CARDIO VASCULAR DISEASE IN OSA

- HTN correlates to OSA even when other factors are controlled
 - Ventricular arrhythmia
 - Brady-tachy syndrome most common
 - PVCs increase in OSA
 - Decrease in CO = bradycardia, BP, neg pressure
 - MI= BP surge, plaque fracture, vasospasm more common in AM assoc with REM
- Sleep Heart Health Study, Young, JAMA

MI AND OSA

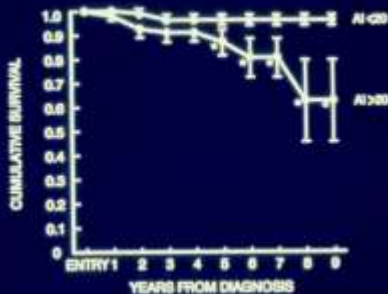
- 23 times risk of MI in high OSA

ref Lancet



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EFFECT OF AI ON MORTALITY UNTREATED, ALL AGES



Source: Ho J, Kryger M, Zoroff P, et al. Mortality and Apnea Index in Obstructive Sleep Apnea. Chest 1988; 94: 5-14.

OBSTRUCTIVE SLEEP APNEA MORBIDITY / MORTALITY

- 75 % of patients that suffer from OSA have motor vehicle accidents attributable to EDS



SLEEP INDUCED DISASTERS

- In 1998, 200,000 MVAs were caused by sleepiness in the US, National comm on sleep 92
- “fall asleep MVA” are now one of leading causes of fatal crash, 25% Horne 94, Lamberg JAMA 96, Lyznicki JAMA 98
- 30 –90% of work place accidents- Chernobyl, 3 mile island, Exxon valdes, Bhopal, and Challenger disaster National comm on sleep 92, Dinges 95

MAXILLO-MANDIBULAR ADVANCEMENT FOR THE TREATMENT OF OSA: A SYSTEMEATIC REVIEW AND META-ANALYSIS, HOLTY GUILLEMINAULT, SLEEP MEDICINE REVIEWS, 14, 2010, 287

- 53 reports, 627 adults
- Success rate 86% mean follow up at 44mo
- Predictors: younger, lower BMI, lower pre AHI and larger maxillary advancement (not mand)
- Complication rate: 1%

OBSTRUCTIVE SLEEP APNEA
MMA: UAB EXPERIENCE
WAITE ET AL. JOMS 1989

- 23 patients
- Technique
 - 7 had UP3 also
 - 15 had HOM (high genioplasty)
 - 8 had partial glossectomy
 - No hyoid suspension
 - Septoplasty
 - Most did not have orthodontics

OBSTRUCTIVE SLEEP APNEA
MMA: UAB EXPERIENCE
RESULTS

- Strictest definition of cure: RDI <10 and no desaturations
- 65 % cured
- 100 % success in patients that had UP3 and MMA

OBSTRUCTIVE SLEEP APNEA
MMA: UAB RESULTS
N=71

Results	RDI	# SaO2 <90	# of Pts	Percent
Excellent	<10	0	20	28.2
Good	<10	<20	26	36.6
Satisfactory	<20	>20	15	21.1
Poor	>20	>20	10	14.1

LONG TERM RESULTS. ORAL AND MAXILLOFACIAL SURGERY CLINICS OF NORTH AMERICA, MAY 1995

- 15 patients, age 30-76, 9male, 6 female
- 39mo follow-up
- Maxillary advance 8.3mm
- Mandibular advance 10.3mm
- Airway increase 7.8mm
- BMI 31.9 – 32.5
- AHI 44.3 - 9.5
- Arousal index 31 .5 – 5.5
- Longest event 50 – 26 sec.

BOYD, WAITE LONGTERM QOLIFE.

Ref
Lye KW, Waite PD, Meara D, Wang D. Quality of life evaluation of maxillomandibular advancement surgery for treatment of obstructive sleep apnea. *J Oral Maxillofac Surg.* 2008 May;66(5):968-72.

LONG TERM RESULTS 6YRS



LONG TERM RESULTS 7YRS.



TECHNIQUE: HOW I DO IT.

TECHNIQUE: 25 YRS AGO.





PEARL: PREBENT PLATES INSURE ADEQUATE ADVANCEMENT

- Lye KW, Waite PD, Wang D, Sittitavornwong S. Predictability of prebent advancement plates for use in maxillomandibular advancement surgery. *J Oral Maxillofac Surg.* 2008 Aug;66(8):1625-9.
- Lye KW, Deatherage JR, Waite PD. The use of demineralized bone matrix for grafting during Le Fort I and chin osteotomies: techniques and complications. *J Oral Maxillofac Surg.* 2008 Aug;66(8):1580-5

Table 1: Bone Graft Group

Maxillary Advancement and relapse as measured at UPL, ANS, APT and PNS

Patient	UPL		ANS		APT		PNS	
	Adv.	Rel.	Adv.	Rel.	Adv.	Rel.	Adv.	Rel.
Y	9.7	0.6	10.6	0.7	9.9	0.8	9.1	0.7

Table 2: Non-Bone Graft Group

Maxillary Advancement and relapse as measured at UPL, ANS, APT and PNS

Patient	UPL		ANS		APT		PNS	
	Adv.	Rel.	Adv.	Rel.	Adv.	Rel.	Adv.	Rel.
X	10.0	1.8	11	1.9	9.5	1.7	9.8	1.9

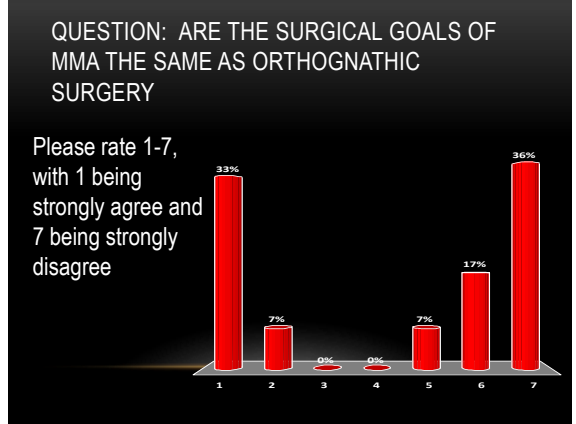
STABILITY

- Waite PD, Tejera TJ, Anucul B. The stability of maxillary advancement using Le Fort I osteotomy with and without genial bone grafting. *Int J Oral Maxillofac Surg.* 1996 Aug;25(4):264-267
- Nimkarn Y, Miles PG, Waite PD. Maxillomandibular advancement surgery in obstructive sleep apnea syndrome patients: long-term surgical stability. *J Oral Maxillofac Surg.* 1995 Dec;53(12):1414-8; discussion 1418-9
- Louis PJ, Waite PD, Austin RB. Long-term skeletal stability after rigid fixation of Le Fort I osteotomies with advancements. *Int J Oral Maxillofac Surg.* 1993 Apr;22(2):82-6.

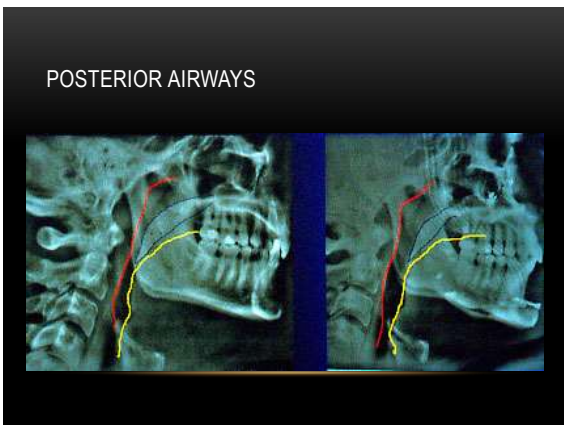
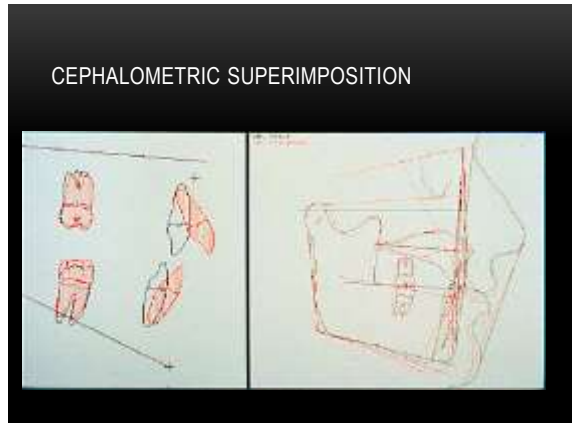


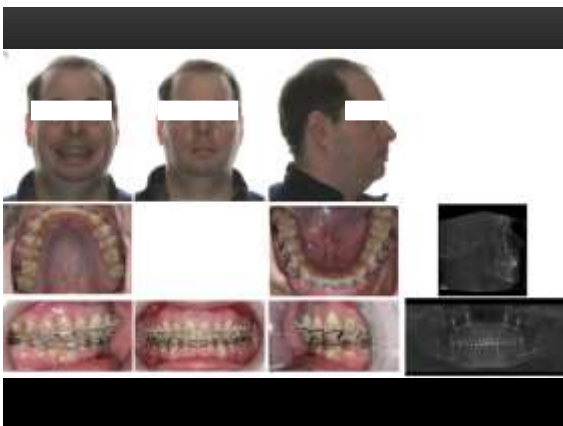
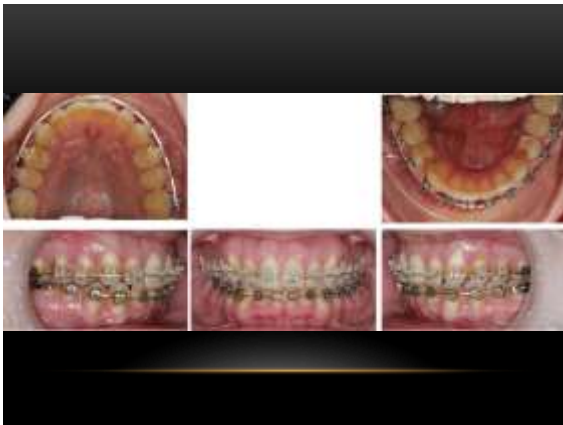
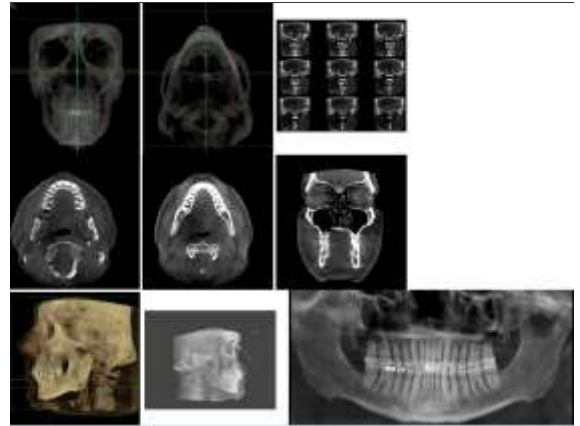
PITFALL: CEPHALOMETRIC CHANGES IN PAS DO NOT EQUAL SUCCESS

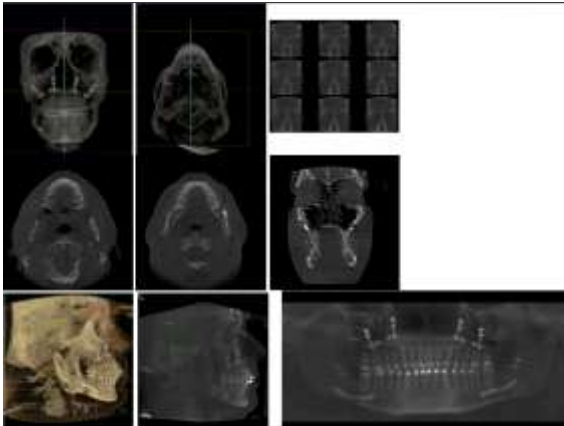




- PRESURGICAL ORTHODONTIC PLAN
- Place fixed appliances to align and de-crowd
 - Torque and advance upper incisors
 - Progress to full dimension arch wires and surgery
 - Advancement based on OSA
 - Sarver DM, The role of orthodontics in the surgical treatment of osa. OMS clinic of NA May 1995







Post-Surgical
02-12-2014



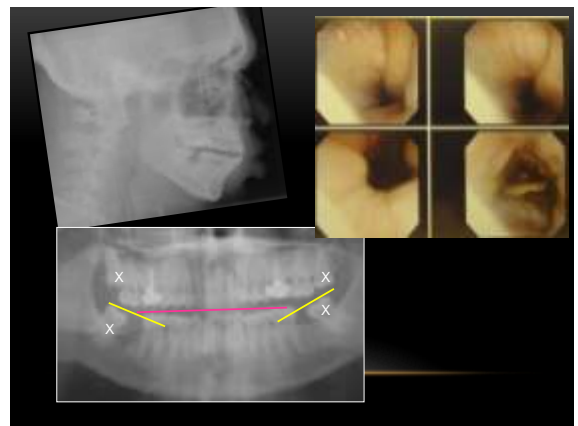
Initial
10-26-2012

Pre-Surgical
10-08-2013

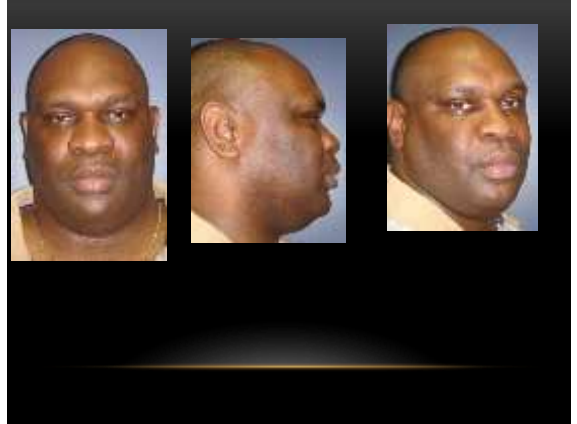
Post-Surgical
01-17-2014

TG

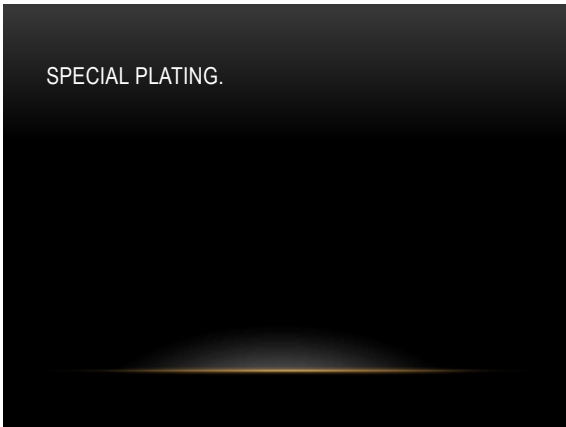
- 40 yobm cc OSA
- 144/78, 77, 276wt, neck 18", RDI 78
- Mallampati class 4, mueller maneuver 4
- 9-24-08; MMA, UP3, osa plates, bicortical screws and monocortical plate
- 3-2-09: post RDI 4.7



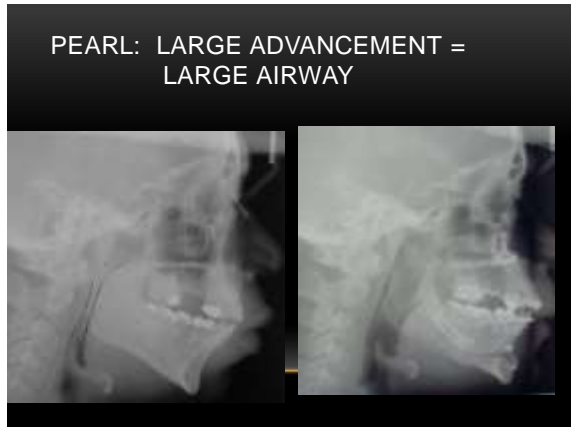
PEARL: ADVANCE THE MANDIBLE FIRST WITH ADVANCEMENT SPLINT.



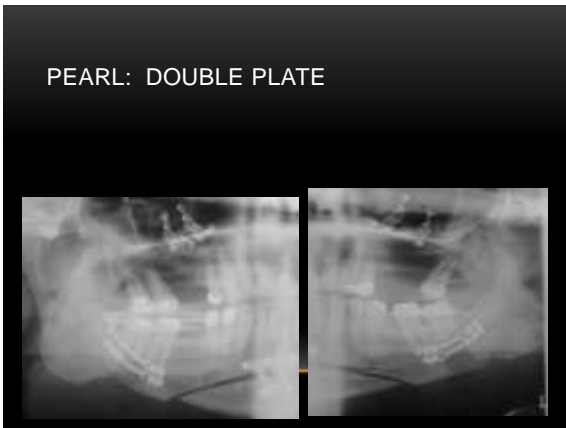
SPECIAL PLATING.

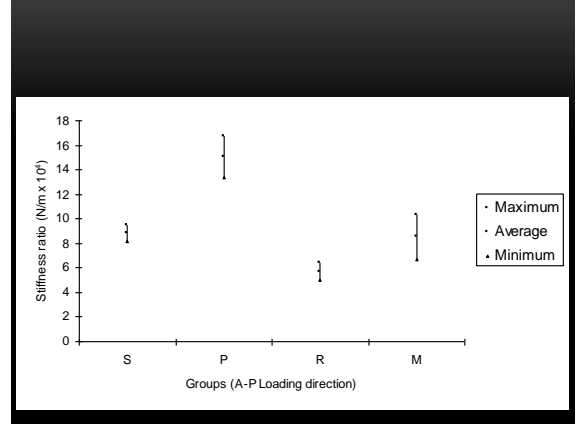
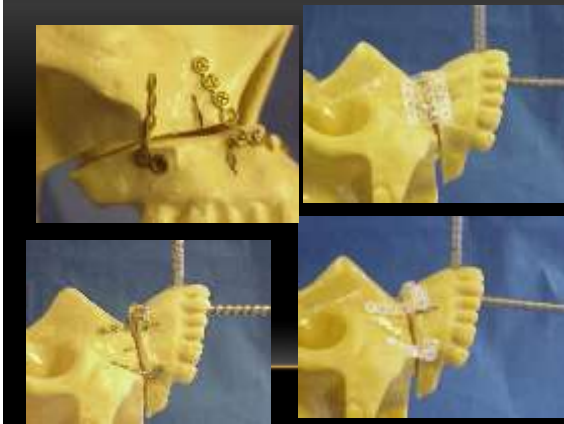


PEARL: LARGE ADVANCEMENT = LARGE AIRWAY



PEARL: DOUBLE PLATE





RESORBABLES

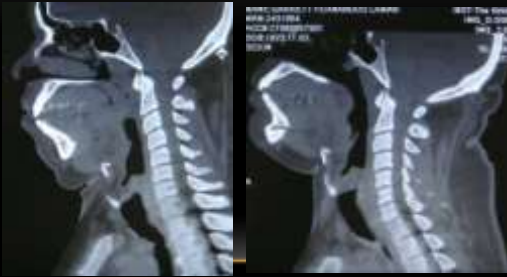
- Sittitavornwong S, Waite PD, Dann JJ, Kohn MW. The stability of maxillary osteotomies fixated with biodegradable mesh in orthognathic surgery. *J Oral Maxillofac Surg.* 2006 Nov;64(11):1631-4.
- Anucul B, Waite PD, Lemons JE. In vitro strength analysis of sagittal split osteotomy fixation: noncompression monocortical plates versus bicortical position screws. *J Oral Maxillofac Surg.* 1992 Dec;50(12):1295-9.

COMPUTATIONAL FLUID DYNAMIC ANALYSIS OF THE POSTERIOR AIRWAY SPACE AFTER MMA FOR OSAS

Funded under NIH R21 Grant



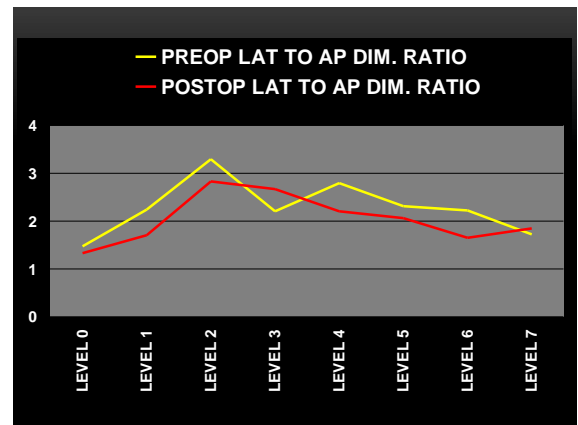
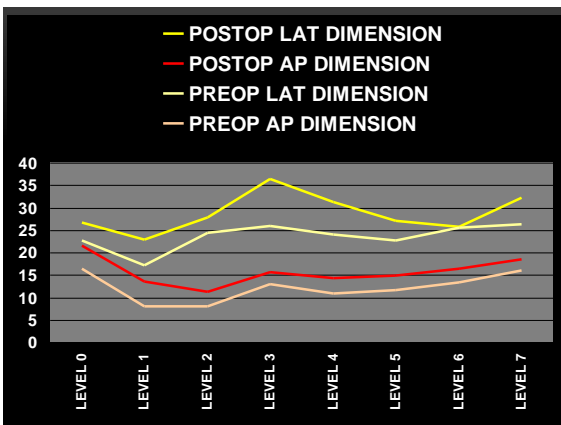
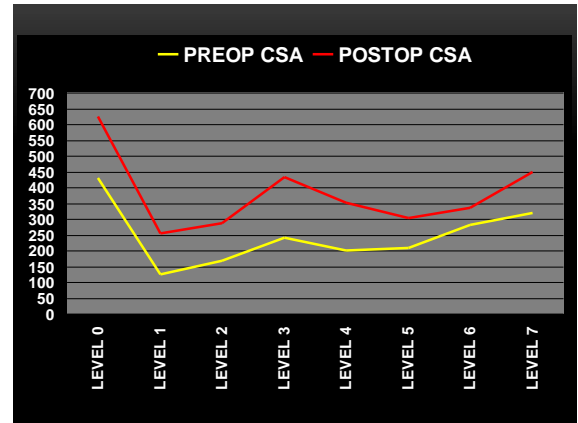
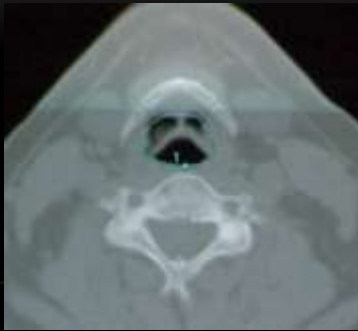
HEAD POSITION IN CT



3 MEASUREMENTS AT EACH LEVEL

- AP dimension on the mid sagittal plane
- Maximum LAT in an orientation perpendicular to the mid sagittal plane
- Cross sectional area of the airway CSA

CROSS SECTION AREA: CSA



EVALUATION

- Increase in both AP and LAT
- LAT to AP ratio; generally less postop. Except at level 3 (high retroglossal area). At this area **MMA stretched the airway in a more lateral than in AP fashion.**



- **Waite PD, Vilos GA.** *Oral Maxillofac Surg Clin North Am.* 2002 Aug;14(3):385-99.
- **Waite PD.** *Surgical management of obstructive sleep apnea: changing the upper airway.* *Alpha Omegan.* 2009 Jun;102(2):74-8.
- **Fairburn SC, Waite PD, Vilos G, Harding SM, Bernreuter W, Cure J, Cherala S.** *Three-dimensional changes in upper airways of patients with obstructive sleep apnea following maxillomandibular advancement.* *J Oral Maxillofac Surg.* 2007 Jan;65(1):6-12.

RESULTS

- MMA increases both the AP and the LAT dimensions of the upper airway. The CSA was increased in all levels.
- The quantitative effect of MMA on the LAT/AP dimension ratio at each level was analyzed.
- *Patients with the best post RDI, had airways stretched more laterally at higher levels.*

RESULTS; LEVEL OF AIRWAY

- Good responders had more lateral change at higher levels
- Poor responders had less lateral change
- **MMA increased CSA at all levels by both AP and LAT.**

$$VA = \frac{\Delta P (Po - Pi)}{R}$$

VA = Airway Flow
Po = Atmo. Press
Pi = Inspir. Press
R = Resistance

$$R = \frac{(L)(K)}{r^4}$$

APPLICATIONS OF COMPUTER FLUID DYNAMICS

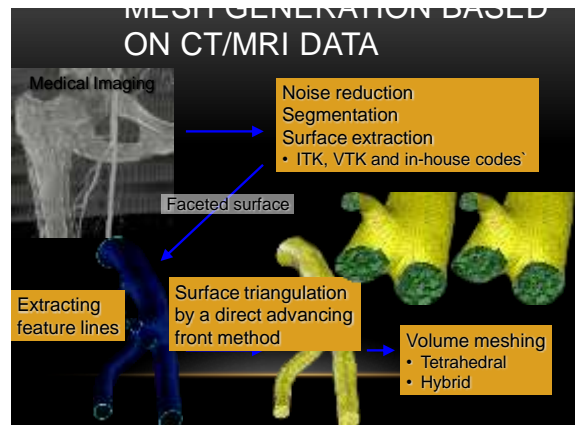
- Transportation
 - Aircrafts, automobiles, ships
- Biological
 - Blood flow, air flow through lungs
- Environmental
 - Weather prediction, spread and control of atmospheric pollution, lava flows, ocean currents



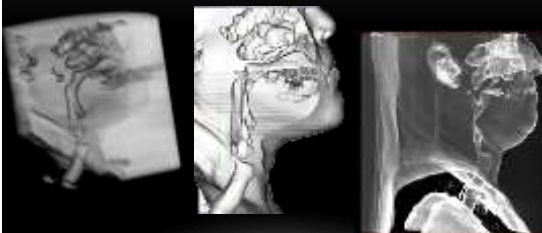
PATIENTS AND METHODS

- 8 cases
- Using pre- and post-operative helical computed tomogram data for MMA
- Created models from 3-D CT: pre- and post-op
- Simulations using computational fluid dynamics (CFD)

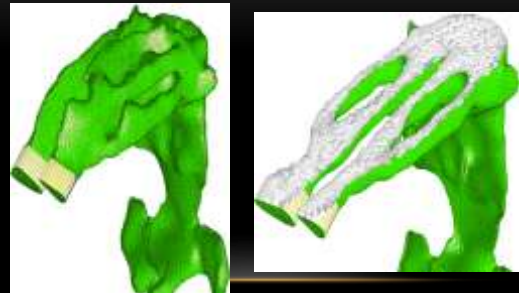
Case	Op.	RDI	Distance for jaw movement [mm]					
			Average A-Base	Difference between pre- and post-op	Average B-Base	Difference between pre- and post-op	Average Pg-Base	Difference between pre- and post-op
1	Pre	22.6	114.57	3.95	113.39	6.44	119.23	7.23
	post	9.7	118.52		119.83		126.46	
5	Pre	38	123.59	9.41	122.58	9.9	135.88	10.34
	post	8.2	133		132.48		146.22	
6	Pre	17.1	120.93	6.36	125.54	6.82	131.93	5.61
	post	5.4	127.29		132.36		137.54	
12	Pre	14	127.61	6.17	121.45	4.92	126.57	4.52
	post	0.7	127.78		126.37		130.89	
13	Pre	50	124.25	4.95	123.38	12.5	131.15	10.59
	post	13	129.2		135.88		141.74	
18	Pre	40.3	140.91	7.62	139.18	11.24	149.32	14.53
	post	6	148.53		150.42		163.85	
19	Pre	48	121.96	7.51	120.55	8.48	127.64	12.97
	post	7	129.47		129.03		140.61	
23	Pre	30.9	132.93	10.32	141.52	8.86	149.02	9.15
	post	0.5	143.25		150.38		158.17	



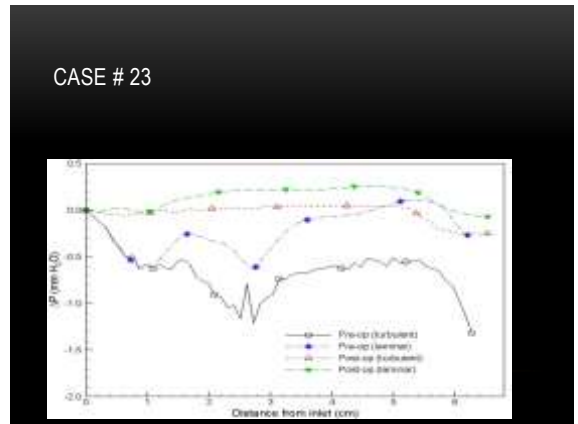
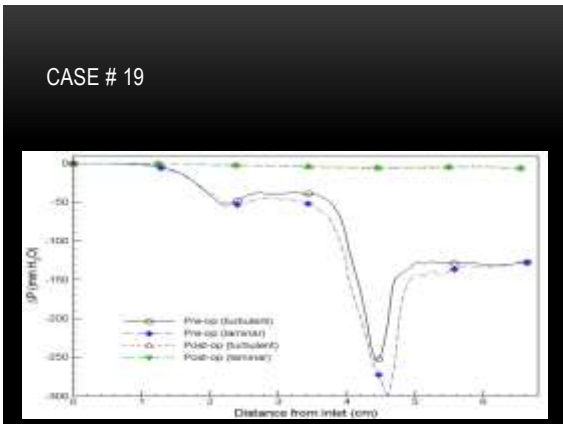
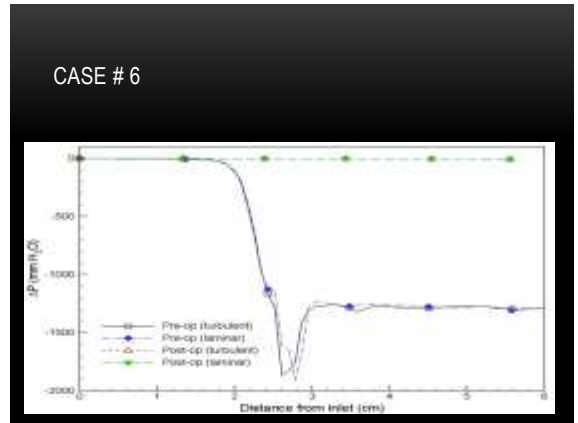
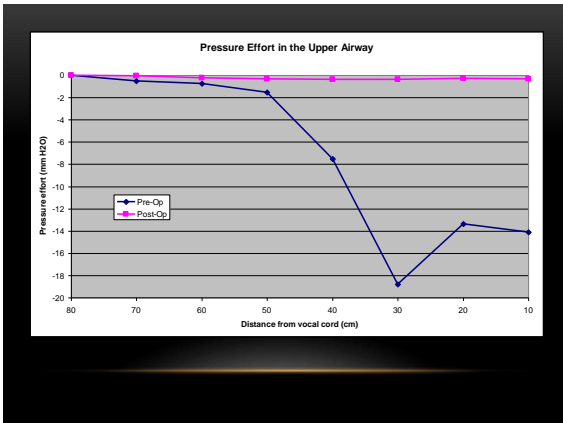
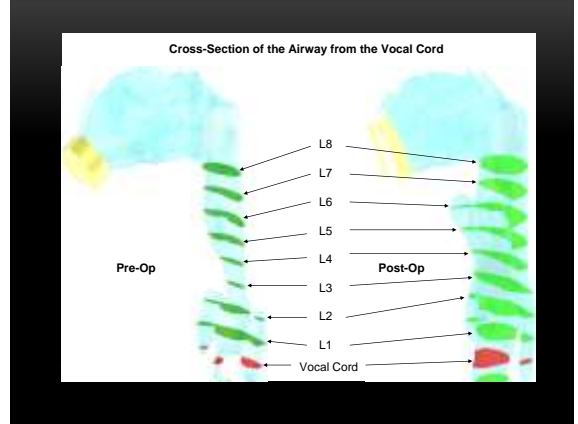
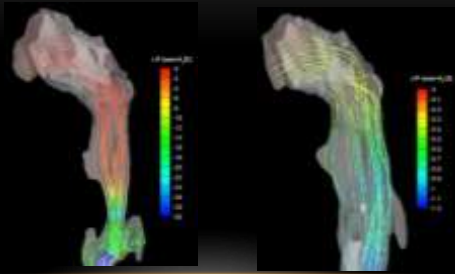
MESH GENERATION BASED ON CT/MRI DATA: COMPUTER FLUID DYNAMICS



DOMAIN DISCRETIZATION



VISUALIZATION: CFD



MULTIPLE SITES OF OBSTRUCTION

- It is now well recognized that most patients with retropalatal narrowing, have other areas of pharyngeal collapse during sleep.



CONCLUSION

- MMA increases airway in all dimensions
- Maxillary and Mandibular synergy, multiple muscles of support on the airway
- Lateral change is most important for airway.
- I suspect that if CPAP increase the airway so will MMA