# 3RD WILLIAM H. BELL LECTURESHIP

## ACCELERATED ORTHOGNATHIC SURGERY AND INCREASED ORTHODONTIC EFFICIENCY:

## A PARADIGM SHIFT

# VOLUMETRIC THREE-DIMENSIONAL UPPER AIRWAY ANALYSIS IN PATIENTS WITH OBSTRUCTIVE SLEEP APNEA FOLLOWING MAXILLOMANDIBULAR ADVANCEMENT

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# Background

- Maxillomandibular advancement is an effective treatment option for patients with sleep apnea
  - Holty JE, Guilleminnault C. Maxillomandibular Advancement for the Treatment of OSA: A Systematic Review and Meta-Analysis, *Sleep Medical Review.* 2010 Oct.; 14(5): 287-97
  - Schendel S., Powell N., Jacobson R. Maxillary, Mandibular, and Chin Advancement: Treatment Planning Based on Airway Anatomy in Obstructive Sleep Apnea. *Journal of Oral and Maxillofacial Surgery.* 2011 March; 69(3):663-76
- 3-Dimensional volumetric analysis is reproducible and accurate
  - Schendel S. Automated 3-D Airway Analysis by Cone Beam CT. *Journal of Oral and Maxillofacial Surgery.* 2010 March; 68(3):696-701
- 3-Dimensional airway analysis has been reported
  - Kaban LB et al. Three-Dimensional Computed Tomographic Airway Analysis of Patients with Obstructive Sleep Apnea Treated by Maxillomandibular Advancement. *Journal of Oral and Maxillofacial Surgery.* 2011 March; 69(3):677-86

# OUR ANALYTICAL APPROACH

## Identify morphological & volumetric changes of the airway

### Volumetric ($cm^3$)

- **Upper Airway Space (UAS)**
  - Posterior of post-nasal spine to superior point of hyoid bone
- **Retropalatal Space**
  - Posterior of post-nasal spine to edge of the soft palate
- **Retroglossal Space**
  - Edge of soft palate to superior point of hyoid bone

### Surface Area ($mm^2$)

- **Choke Points**
  - Area of smallest surface area
  - Identified independently in Retropalatal Space and Retroglossal Space

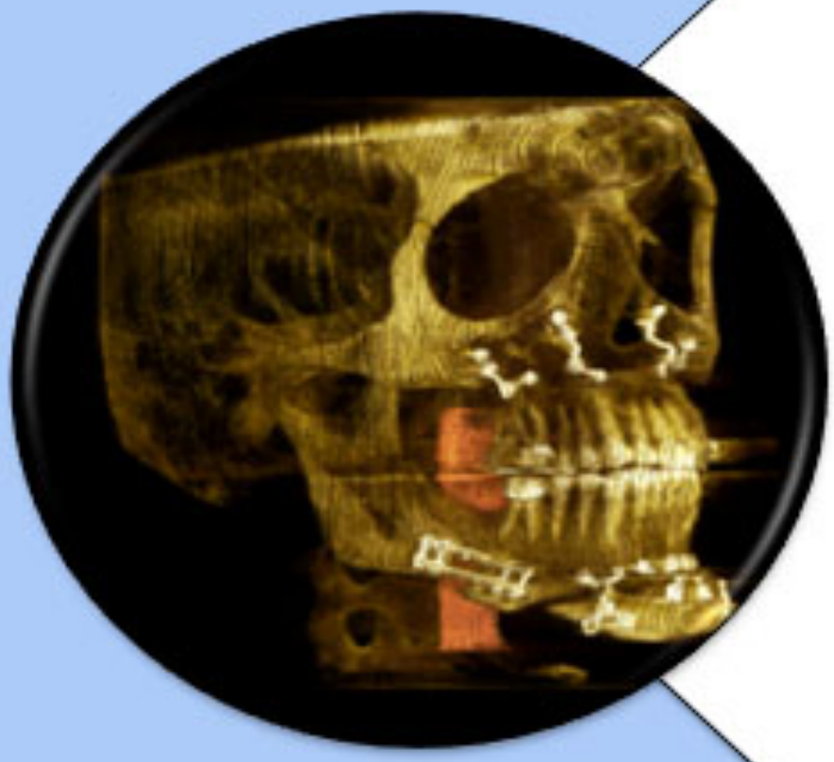
### Length (mm)

- **2-Dimensional length parameters of the choke points**
  - Transverse Dimension
  - Anterior-Posterior Dimension

### Height (mm)

- **2-Dimensional Height of the airway**
  - UAS height
  - Retropalatal height
  - Retroglossal height

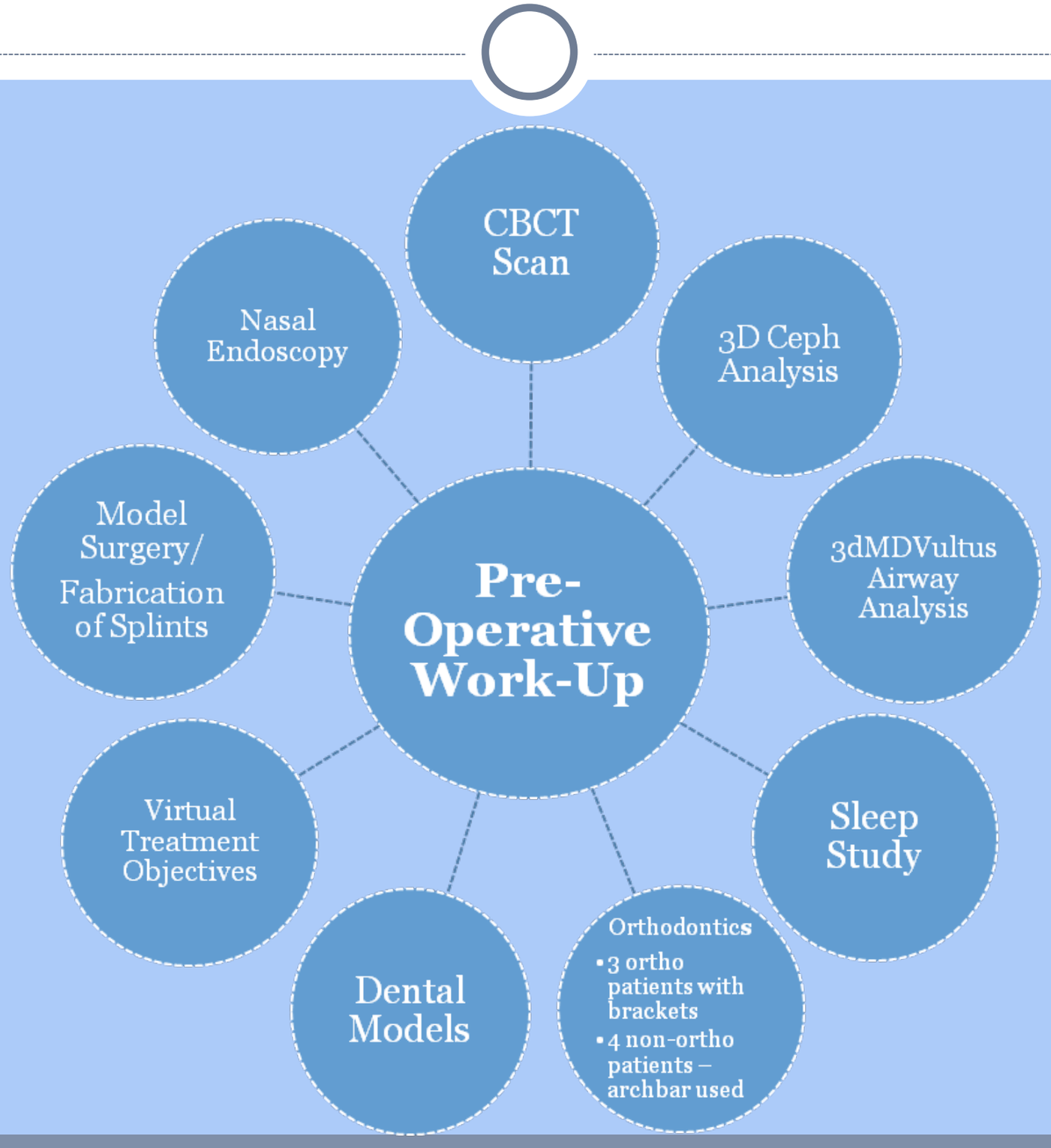
# CLINICAL EXPERIENCE



**Patient Demographics**

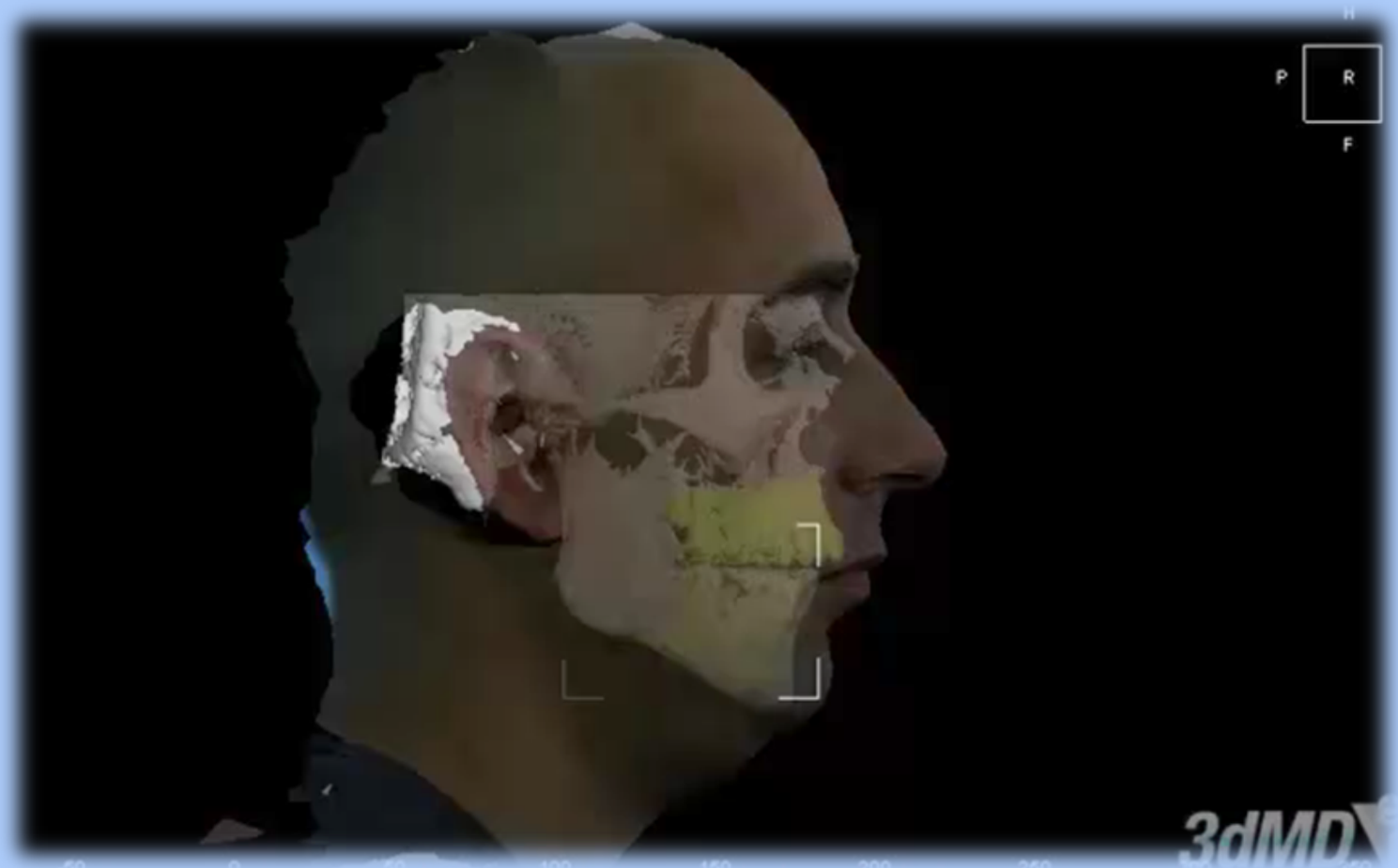
- **7 Patients with Obstructive Sleep Apnea**
  - 6 Male
  - 1 Female
- **Age at time of Maxillomandibular Advancement**
  - 35-56 years old
  - Average 46.4 years old
- **Pre-Operative AHI**
  - Ranged from 18-54.6
  - Average 38.27

# CLINICAL EXPERIENCE



# SURGICAL TECHNIQUE

- LeFort I Maxillary Osteotomy Advancement
  - Bone grafting
  - +/- Septoplasty and/or turbinectomy
- Bilateral Sagittal Split Osteotomy of the Mandible Advancement
  - +/- Genioglossal Advancement



# POST-OPERATIVE CARE

Patients admitted to ICU for 1-2 nights

Transferred to surgical floor for +1-2 nights prn

Discharged

Surgical follow-up

Post-operative CBCT scan and airway analysis obtained 3-6 months post-operatively

Sleep study obtained 3-6 months post-operatively

# Complication

- Major
  - *None*
- Minor
  - *Fevers of unknown origin*
  - *Removal of hardware*

# PRE- AND POST- OP DATA: AHI

Average pre-operative AHI 38

Average post-operative AHI 6

| PT | SEX | AGE | BMI | PRE-AHI | POST-AHI |
|---|---|---|---|---|---|
| 1 | M | 51 | 27 | 42 | 3.8 |
| 2 | M | 36 | 30.5 | 31 | 0 |
| 3 | M | 51 | 29 | 48 | 0 |
| 4 | M | 35 | 28 | 54.6 | 1.5 |
| 5 | M | 47 | 23 | 18 | 4 |
| 6 | F | 49 | 19.8 | 53.5 | 28.4 |
| 7 | M | 56 | 29.2 | 21 | 5 |

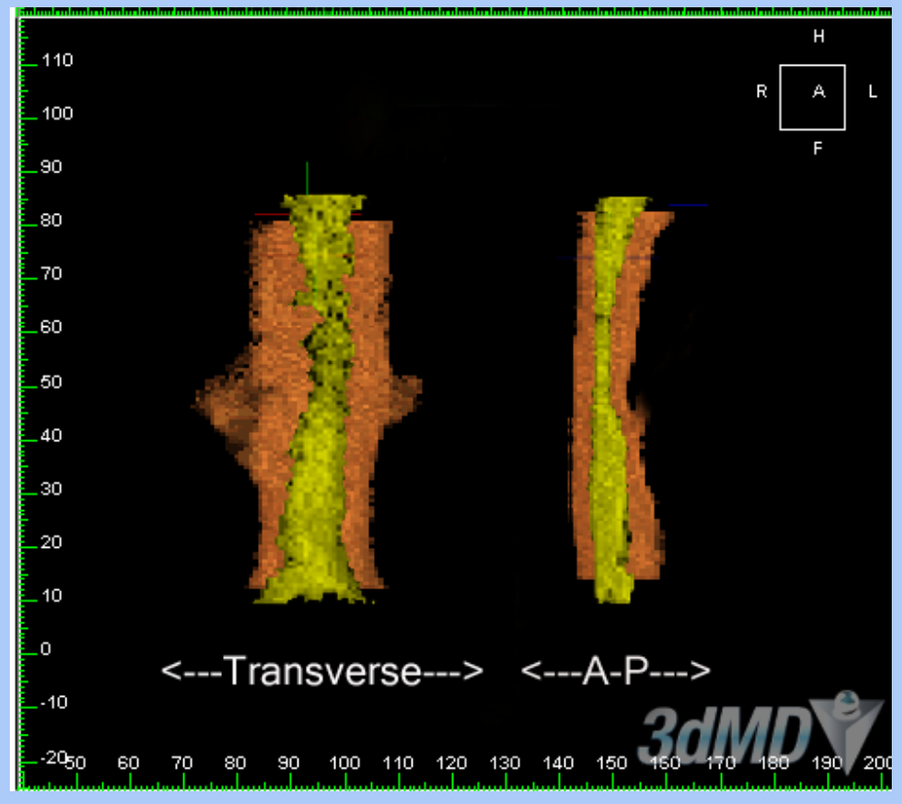
# PRE- AND POST- OP DATA:  MOVEMENT (MM)

- Average Mandibular Movement:  9.57 mm
- Average Maxillary Movement:  9.86 mm
- Average Genioglossal Movement:  6 mm

| PT | SKELETAL PATTERN | MAND MOVEMENT (MM) | MAX MOVEMENT (MM) | GENIO MOVEMENT (MM) |
|---|---|---|---|---|
| 1 | II | 9 | 9 | 8 |
| 2 | I | 9 | 9 | 0 |
| 3 | II | 9 | 9 | 0 |
| 4 | II | 8 | 12 | 6 |
| 5 | II | 11 | 8 | 0 |
| 6 | II | 10 | 11 | 4 |
| 7 | I | 11 | 11 | 0 |

# PRE- & POST- OPERATIVE VOLUMETRIC ANALYSIS

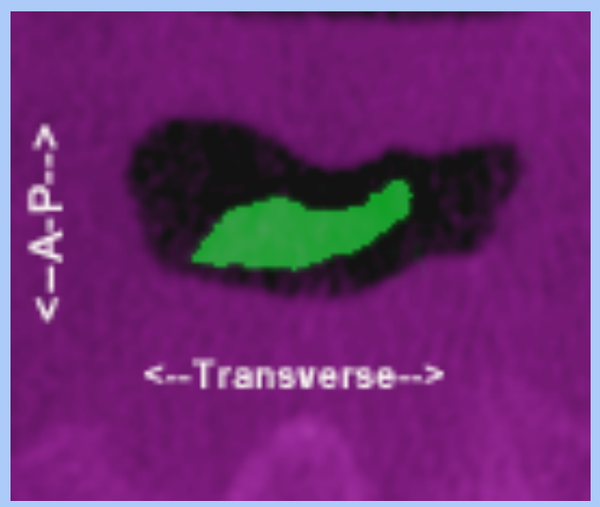
- Average % Change UAS
  - 236.99%
- Average % Change RP
  - 361.97%
- Average % Change RG
  - 164.56%




| PT | PRE-UAS VOL $cm^3$ | POST- UAS VOL $cm^3$ | % CHNGE UAS | PRE-RP VOL $cm^3$ | POST- RP VOL $cm^3$ | % CHNGE RP | PRE-RG VOL $cm^3$ | POST-RG VOL $cm^3$ | % CHNGE RG |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.35 | 21.46 | 540.60% | 1.33 | 8.46 | 536.09% | 1.89 | 13.00 | 587.83% |
| 2 | 7.56 | 10.22 | 35.19% | 3.97 | 4.49 | 13.10% | 3.59 | 5.73 | 59.61% |
| 3 | 11.6 | 16.44 | 41.72% | 3.91 | 5.77 | 47.57% | 7.16 | 10.67 | 49.02% |
| 4 | 3.46 | 30.9 | 793.06% | 1.20 | 20.56 | 1613.33% | 2.26 | 9.34 | 313.27% |
| 5 | 10.27 | 14.17 | 37.97% | 4.92 | 8.89 | 80.69% | 5.41 | 5.53 | 2.22% |
| 6 | 12.39 | 29.48 | 137.93% | 7.44 | 16.04 | 115.59% | 4.82 | 8.02 | 66.39% |
| 7 | 11.88 | 20.49 | 72.47% | 4.70 | 10.69 | 127.45% | 7.00 | 12.15 | 73.57% |

# PRE- & POST- OPERATIVE SURFACE AREA ANALYSIS

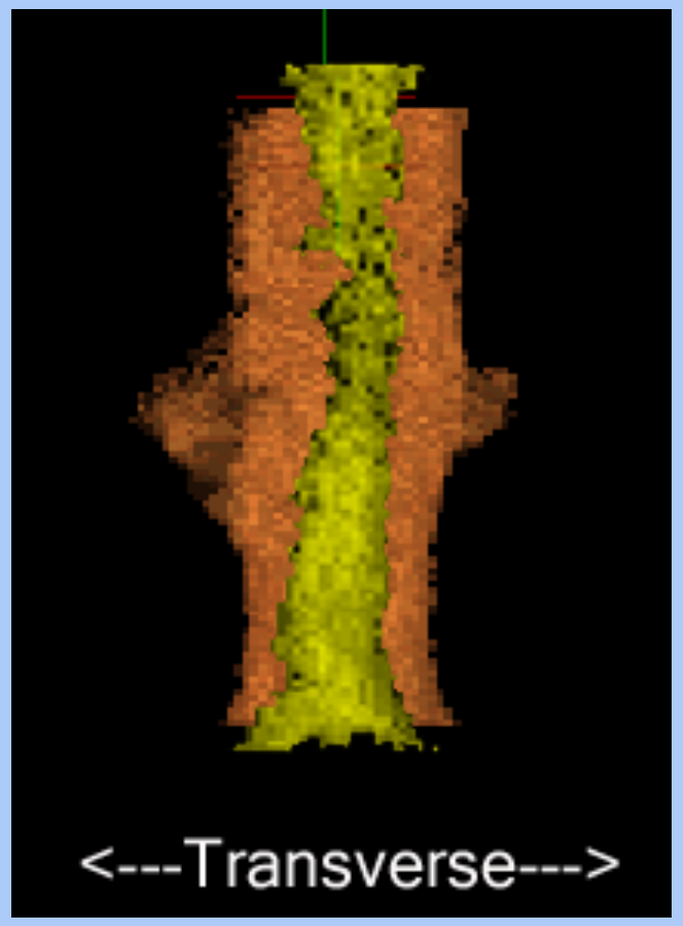
- Average % Change RPS Choke Point
  - 664.22%
- Average % Change RGS Choke Point
  - 100.98%
- Location of Choke Point Pre-Op
  - Retropalatal Space
- Location of Choke Point Post-Op
  - Retroglossal Space




| PT | Pre-Choke Point Retro-palatal $mm^2$ | Post-Choke Point Retro-palatal $mm^2$ | % Chnge | Pre-Choke Point Retro-glossal $mm^2$ | Post-Choke Point Retro-glossal $mm^2$ | % Chnge | Pre- Loc-ation of Chke Pt | Post-Location of Chke Pt |
|---|---|---|---|---|---|---|---|---|
| 1 | 19.71 | 191.87 | 873.47% | 49.68 | 155.34 | 212.68% | P | G |
| 2 | 74.52 | 61.83 | -17.03% | 88.65 | 116.01 | 30.86% | P | P |
| 3 | 103.80 | 158.85 | 53.03% | 109.89 | 152.01 | 38.33% | P | G |
| 4 | 8.37 | 273.5 | 3167.62% | 44.28 | 156.60 | 253.66% | P | G |
| 5 | 104.84 | 187.83 | 79.16% | 107.46 | 161.10 | 49.92% | P | G |
| 6 | 139.70 | 400.58 | 186.74% | 133.65 | 268.46 | 100.87% | G | G |
| 7 | 95.36 | 387.69 | 306.55% | 60.00 | 72.32 | 20.53% | G | G |

# PRE- & POST- OPERATIVE TRANSVERSE ANALYSIS

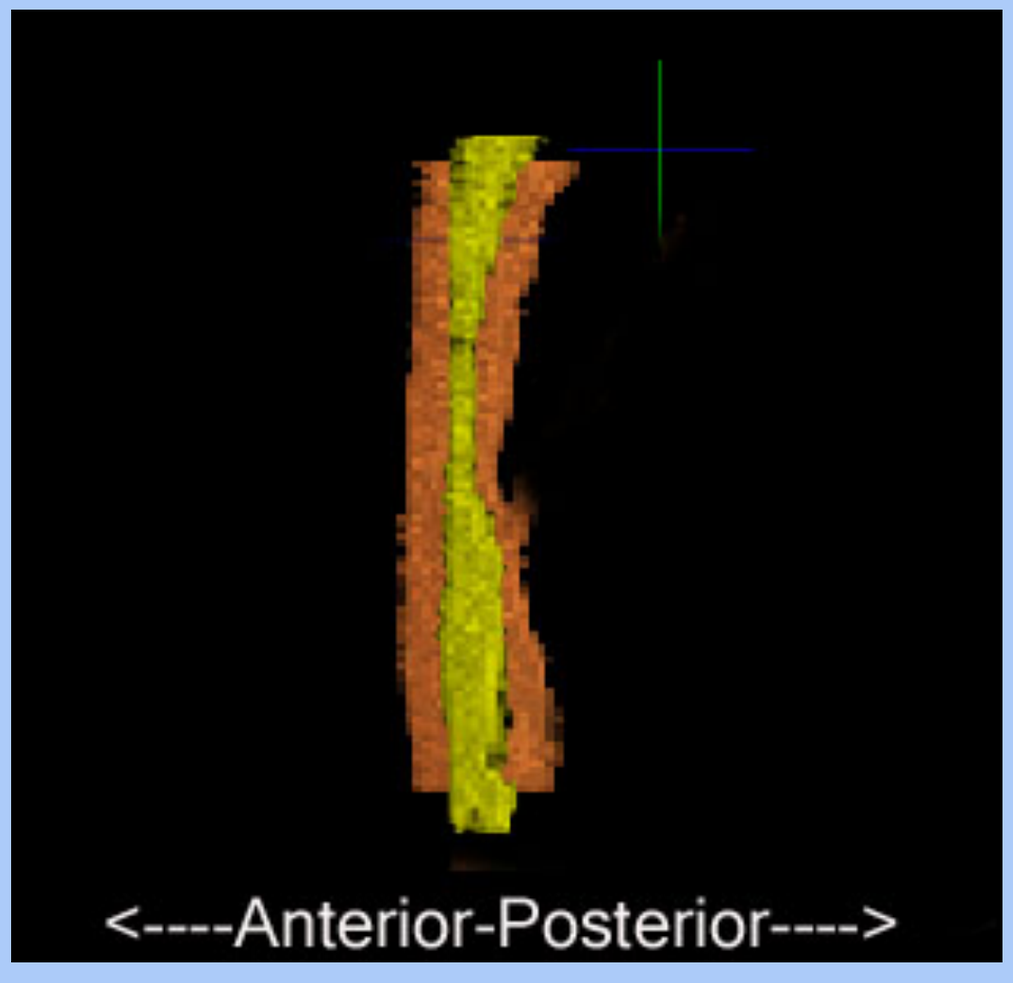
- Average change in the transverse dimension
  - Retropalatal: 11.64 mm
  - Retroglossal: 7.11 mm




| PT | Pre-Choke Pt RP Trans-verse (mm) | Post-Choke Pt RP Trans-verse (mm) | Mm differ-ence | Pre-Choke Pt RG Trans-verse (mm) | Post-Choke Pt RG Trans-verse (mm) | Mm differ-ence |
|---|---|---|---|---|---|---|
| 1 | 8.1 | 30.6 | 22.5 | 10.2 | 23.4 | 13.2 |
| 2 | 16.5 | 16.8 | 0.3 | 19.8 | 19.2 | -0.6 |
| 3 | 24.0 | 29.7 | 5.7 | 21.9 | 27.3 | 5.4 |
| 4 | 1.8 | 28.2 | 26.4 | 12 | 30 | 18 |
| 5 | 28.5 | 34.8 | 6.3 | 23.7 | 32.4 | 8.7 |
| 6 | 26.4 | 37.5 | 11.1 | 26.1 | 28.8 | 2.7 |
| 7 | 22.0 | 31.2 | 9.2 | 12.4 | 14.8 | 2.4 |

# PRE- & POST- OPERATIVE A-P ANALYSIS

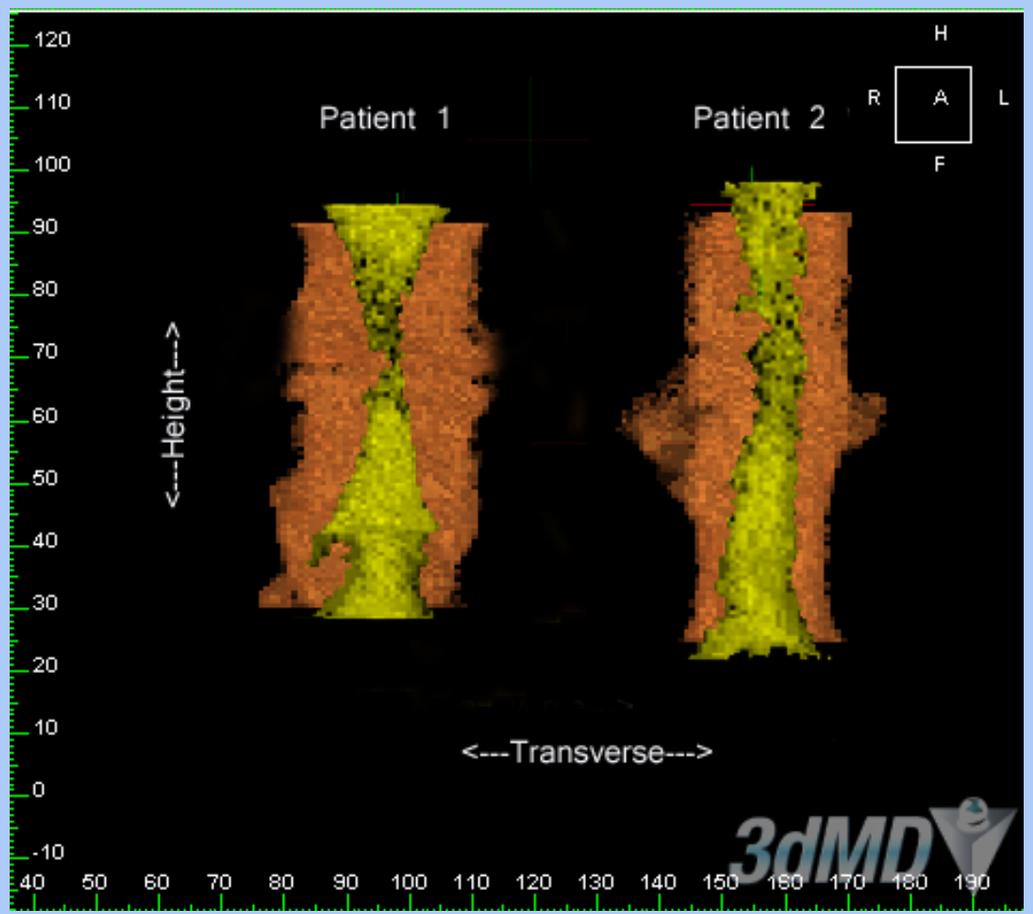
- Average change in the A-P dimension
  - Retropalatal: 6.40 mm
  - Retroglossal: 2.61 mm




| PT | Pre-Choke Pt RP A-P (mm) | Post-Choke Pt RP A-P (mm) | Mm differ-ence | Pre-Choke Pt RG A-P (mm) | Post-Choke Pt RG A-P (mm) | Mm differ-ence |
|---|---|---|---|---|---|---|
| 1 | 2 | 5.7 | 3.7 | 5.4 | 6.9 | 1.5 |
| 2 | 5.7 | 6.6 | 0.9 | 6 | 9 | 3 |
| 3 | 3 | 4.5 | 1.5 | 6.9 | 8.7 | 1.8 |
| 4 | 6 | 25.2 | 19.2 | 4.2 | 6.6 | 2.4 |
| 5 | 2.1 | 6.9 | 4.8 | 5.1 | 6 | 0.9 |
| 6 | 4.8 | 9.6 | 4.8 | 3.9 | 12.6 | 8.7 |
| 7 | 4 | 11.2 | 7.2 | 6.4 | 6.4 | 0 |

# PRE- & POST- OPERATIVE HEIGHT ANALYSIS

- Average Change in UAS Height
  - 2.0 mm
- Average Change in RPS Height
  - 2.2 mm
- Average Change in RGS Height
  - 2.1 mm




| PT | Pre-UAS (mm) | Post-UAS (mm) | Pre-RP (mm) | Post-RP (mm) | Pre-RG (mm) | Post-RG (mm) |
|---|---|---|---|---|---|---|
| 1 | 80 | 74 | 46 | 44 | 32 | 30 |
| 2 | 70 | 70 | 40 | 38 | 30 | 32 |
| 3 | 74 | 80 | 38 | 32 | 36 | 48 |
| 4 | 68 | 66 | 38 | 32 | 30 | 32 |
| 5 | 74 | 72 | 34 | 34 | 40 | 38 |
| 6 | 64 | 62 | 32 | 34 | 32 | 28 |
| 7 | 76 | 78 | 26 | 22 | 50 | 56 |

# RESULTS

- Volume
  - The UAS enlarged significantly
  - The shape of the UAS changed from a funnel to a tube like shape
  - The retropalatal space increases in volume more than the retroglossal space

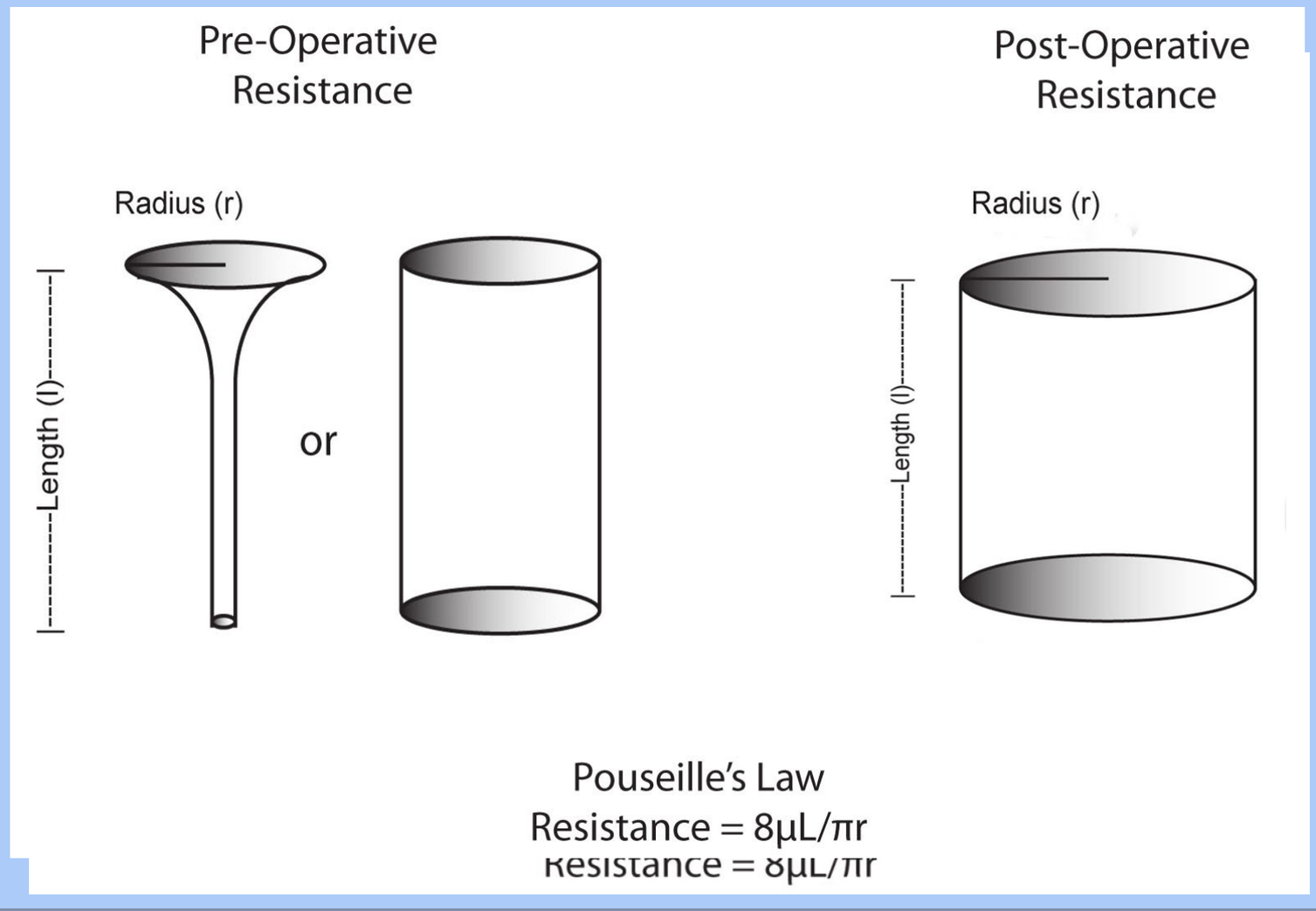
- Surface Area
  - The surface area at the choke point in the retropalatal space increases by a greater percent change than the retroglossal space
  - The location of the choke point is generally pre-operatively in the retropalatal space and changes post-operatively to the retroglossal space
    - *Indication of normalizing the airway and eliminating any bottlenecking/funneling*
  - The airway enlarges in a oval fashion

# RESULTS

- Length
  - The transverse dimension increases more than the A-P dimension in millimeter change
  - The A-P dimension increases more than the transverse dimension in percent change
  - The retropalatal space increases more in the transverse and A-P dimensions than the retroglossal space does
- Height
  - The height of the upper airway space generally decreases post-operatively
  - The height of the airway pre-operatively was shortest in the retroglossal space
  - The height of the airway post-operatively was shortest in the retropalatal space

# POUSEILLE'S LAW

- As radius increases and height decreases, the resistance of flow decreases



# Conclusion

- 3-Dimensional airway analysis indicates that maxillomandibular advancement is an effective treatment option for patients with obstructive sleep apnea by increasing tension and changing the position of the palatal and pharyngeal muscles.  As a result:

- Airway volume increases

- Shape of airway changes
  - *Change from a funnel to cylindrical shape*
- Resistance to air flow decreases
  - *Radius of the airway increases*
  - *Height of the airway decreases*

# CASE I

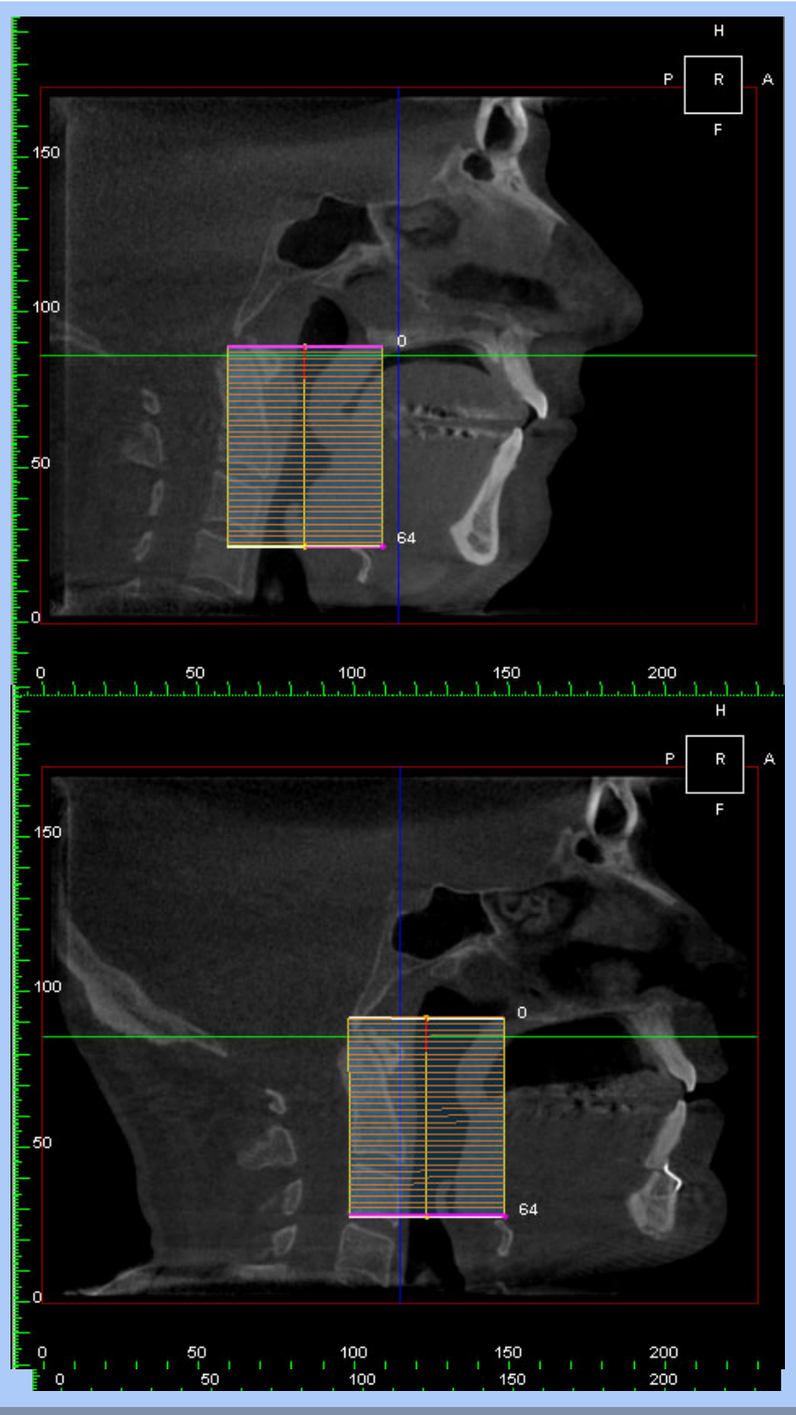
- 45 yo male with OSA
- BMI 28
- Pre-op AHI 54.6
- Skeletal/Dental Class II
- MMA/GGA, bone graft, septo & turb
  - *Maxilla 8 mm, Mandible 12 mm, Genioglossal 6 mm*
- Post-op AHI 1.5
- UAS pre-op volume 3.46 $cm^3$, post-op 30.9 $cm^3$
  - *Surface area at retropalatal chock point was 8.37 $mm^2$, changed to 273 $mm^2$*
  - *Transverse dimension at retropalatal chock point was 1.8 mm, changed to 28.2 mm*
  - *A-P dimension at retropalatal chock point was 6 mm, changed to 25 mm*
- UAS pre-op height 68 mm, post-op 66 mm

# CASE I

## Pre-Surgical


## Post-Surgical

# CASE I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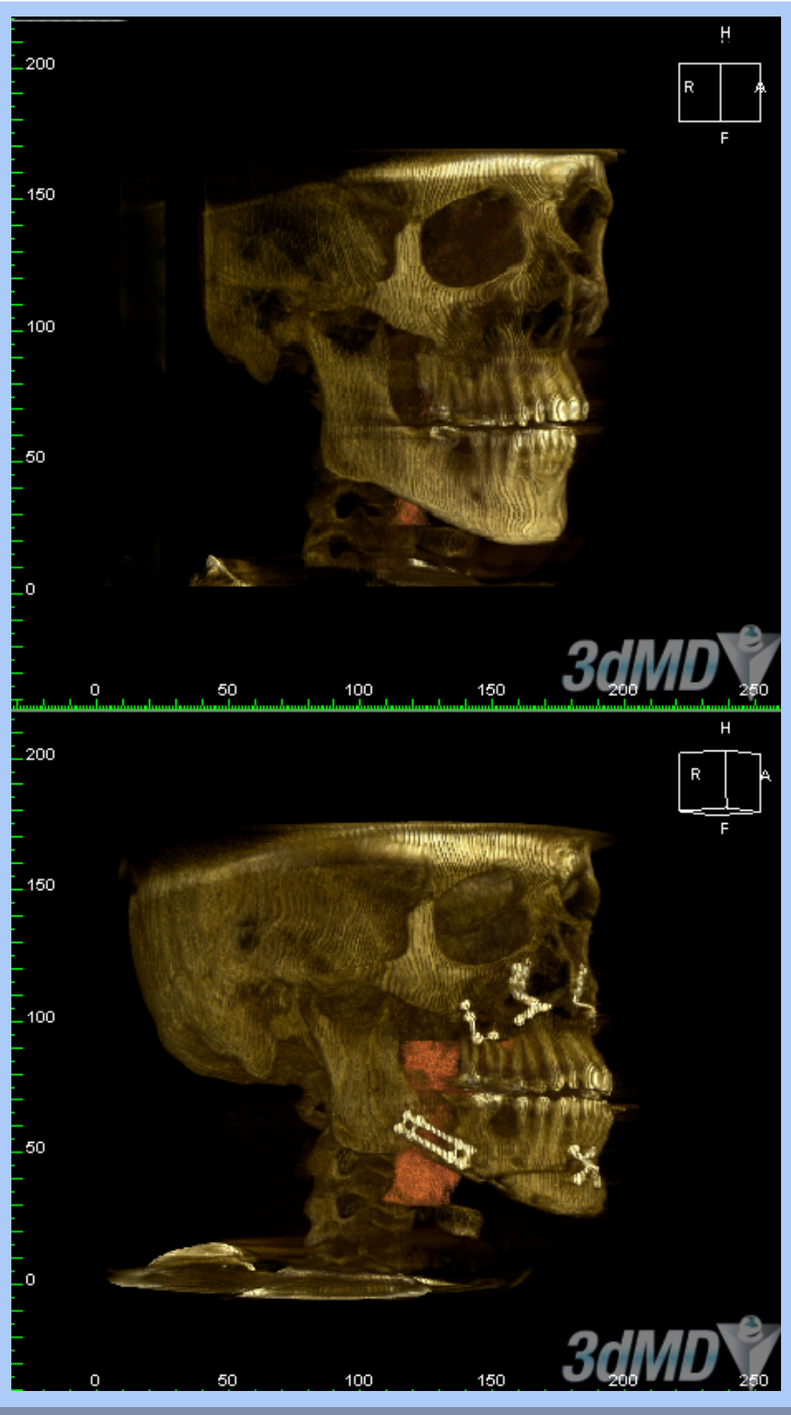
200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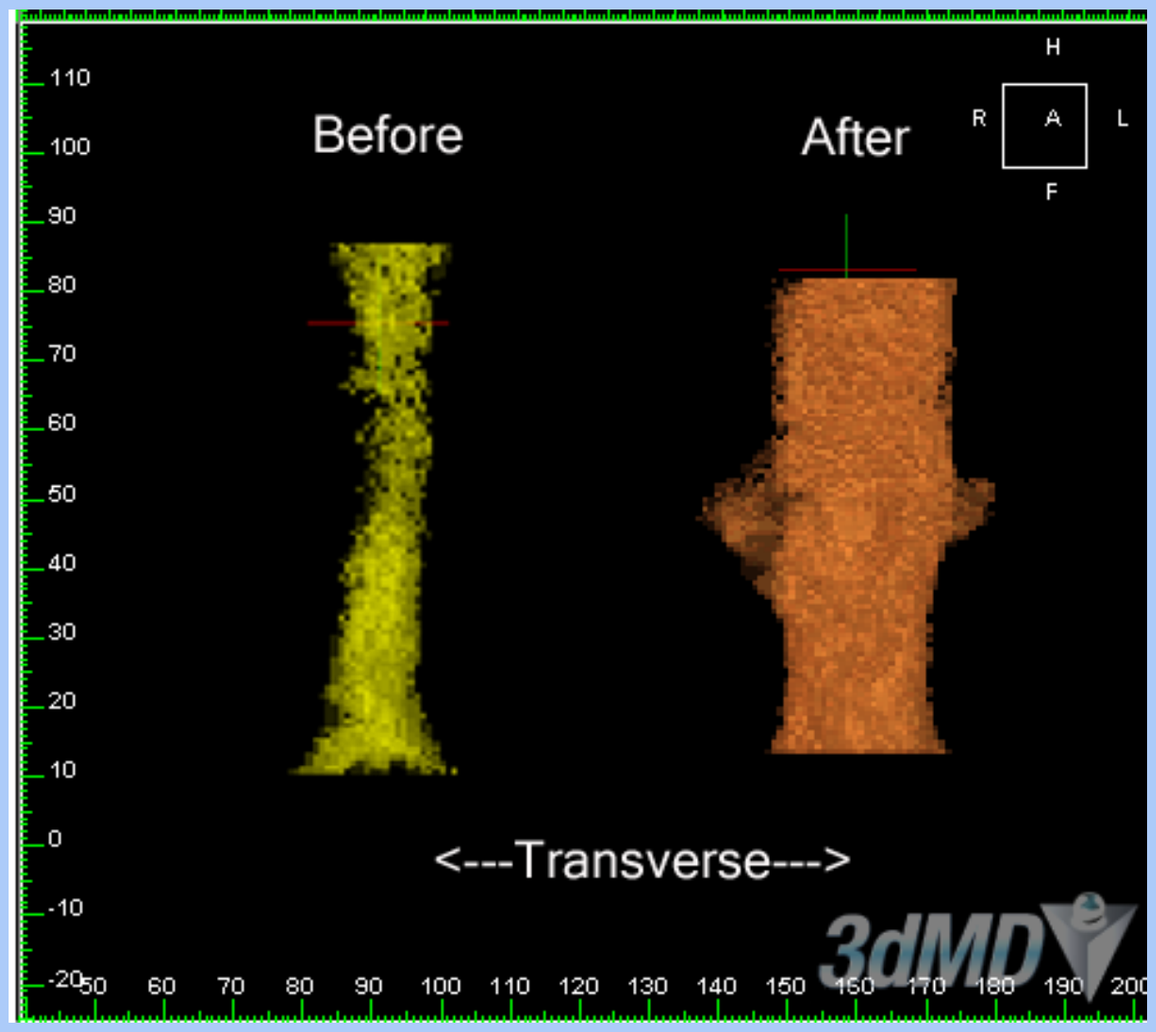
3dMD

# CASE I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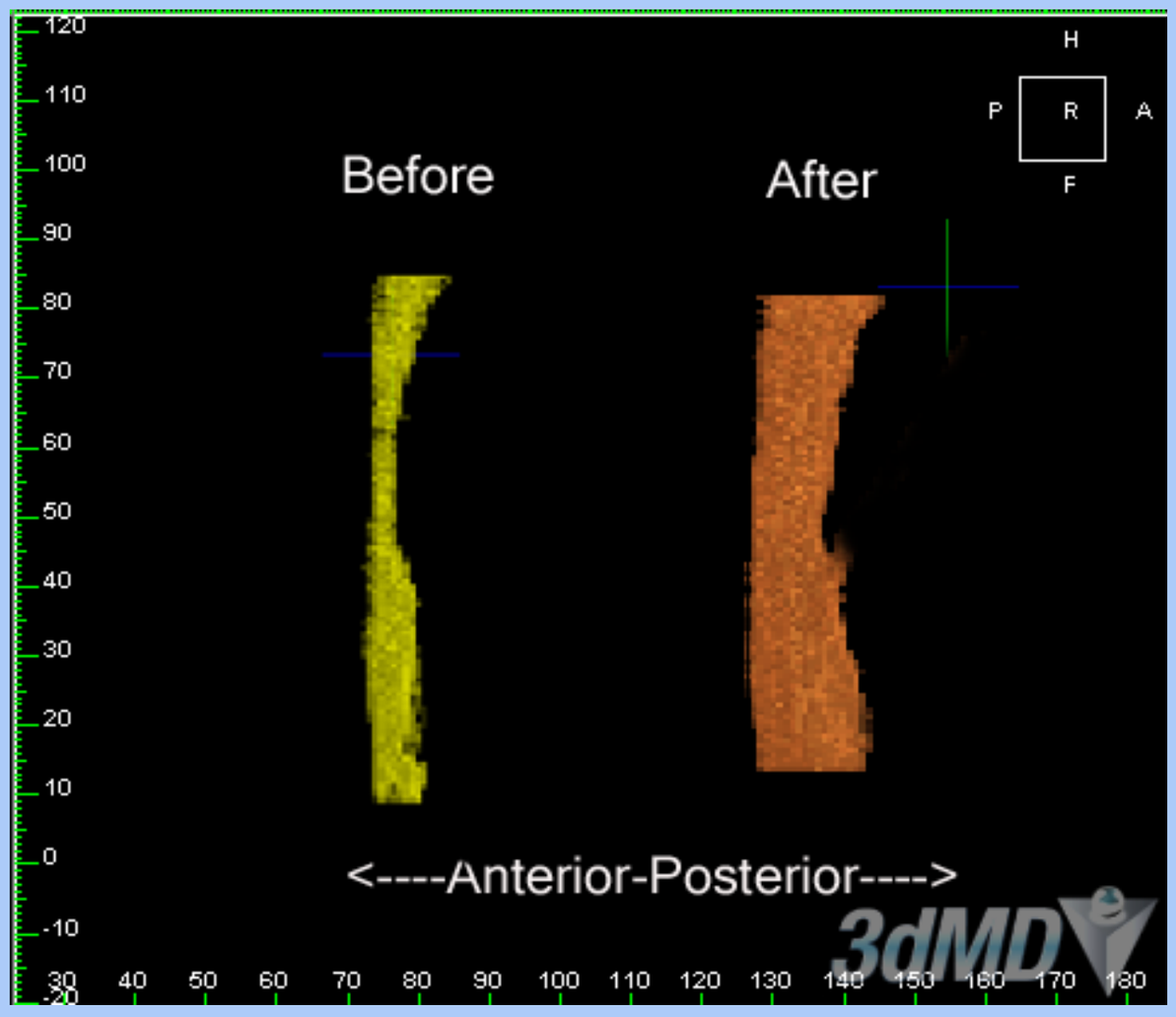
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
<---Transverse--->
3dMD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30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
<----Anterior-Posterior---->
3dMD

# REFERENCES


- Maxillomandibular advancement is an effective treatment option for patients with sleep apnea
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