

# ***2<sup>nd</sup> International Congress on Technological Advances in Head and Neck Oncology and Cranio-Maxillofacial Surgery***



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# **3D Volumetric Upper Airway Analysis following Maxillo-Mandibular Advancement in Patients with Obstructive Sleep Apnea**

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# Up to Date Knowledge

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

- Holty JE, Guilleminault 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
- 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<sup>3</sup>)

- **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<sup>2</sup>)

- **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
  - MP-H
  - Soft Palate

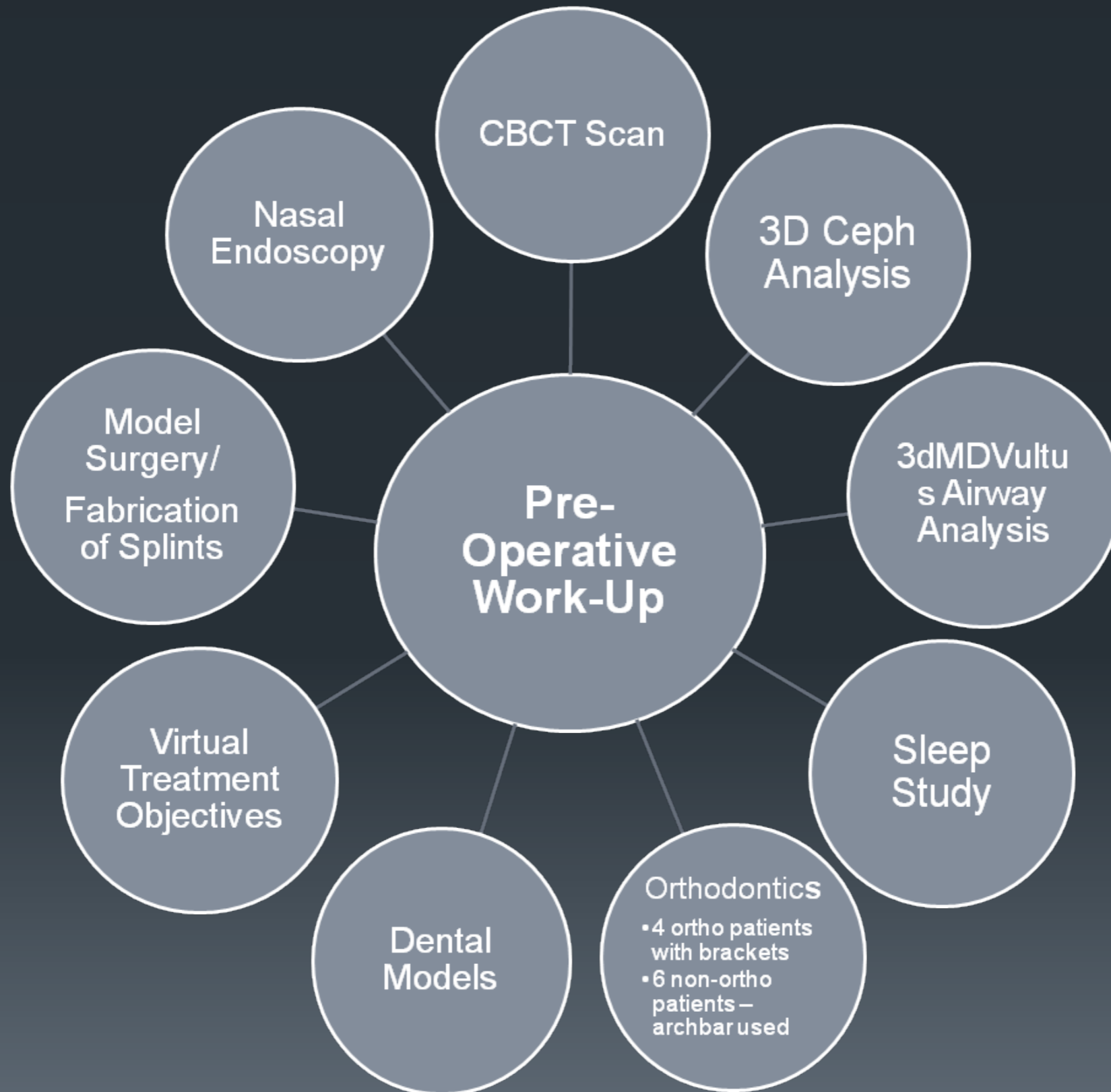
# CLINICAL EXPERIENCE



## Patient Demographics

- **10 Patients with Obstructive Sleep Apnea**
  - 8 Male
  - 2 Female
- **Age at time of MMO**
  - 35-65 years old
  - Average 46.4 years old
- **Pre-Operative AHI**
  - Ranged from 18-77
  - Average 43

# CLINICAL EXPERIENCE



# SURGICAL TECHNIQUE

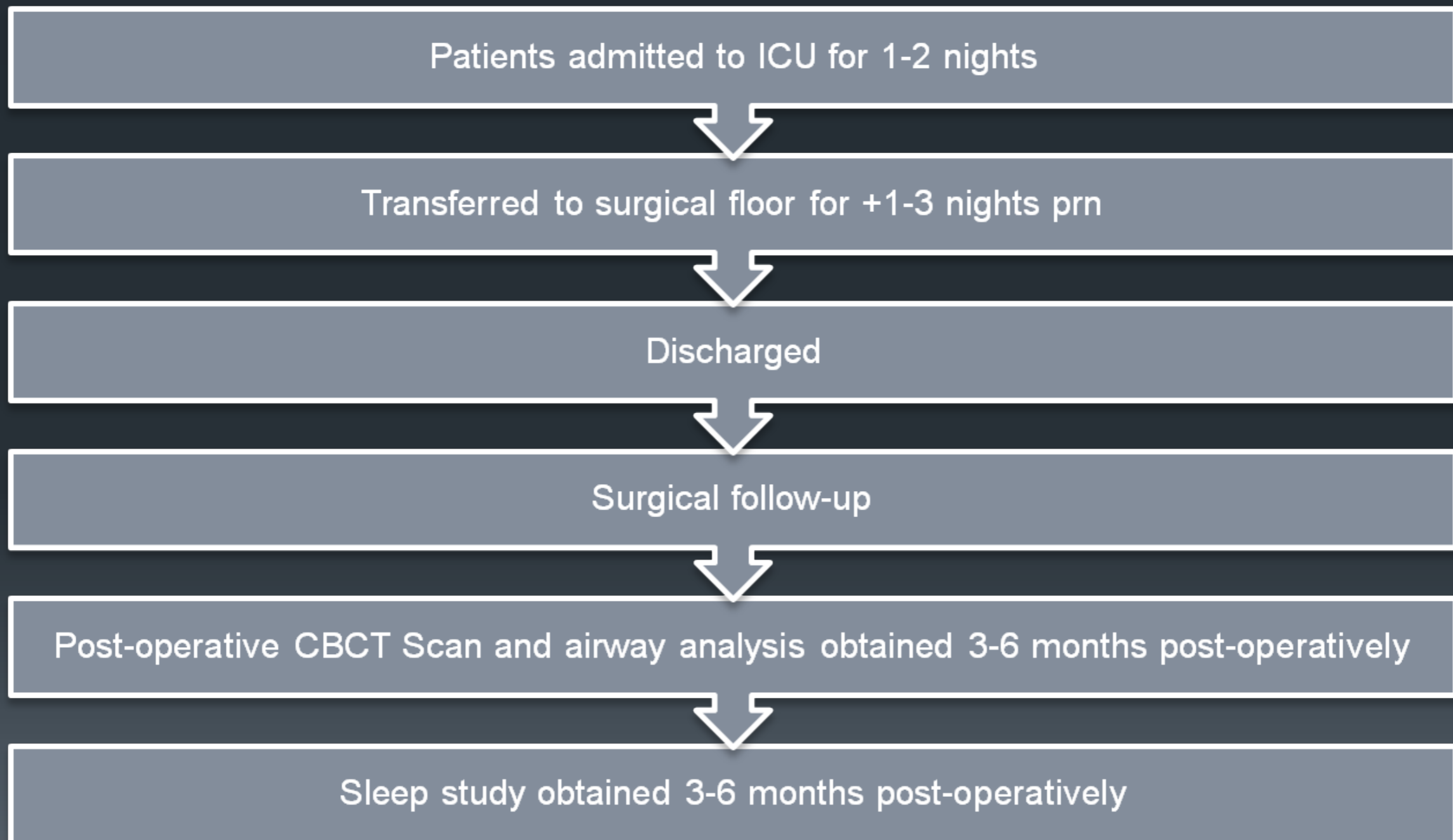
- LeFort I Maxillary Osteotomy Advancement

- Bone grafting
- +/- Septoplasty and/or turbinectomy

- Bilateral Sagittal Split Osteotomy of the Mandible Advancement

- +/- Genioglossal Advancement

# POST-OPERATIVE CARE





# Complications

- Major
  - None
- Minor
  - One Infection/ plate removal
  - One Unfavorable split/ complete osteotomy

# PRE- AND POST-OPERATIVE DATA: AHI

PRE-OP AHI 42 AVERAGE  
POST-OP AHI 2.7 AVERAGE

PT	SEX	AGE	BMI	PRE-AHI	POST-AHI
NB	M	51	27	42	3.8
CD	M	36	30.5	31	0
KG	M	51	29	48	0
RJ	M	35	28	54.6	1.5
SD	M	47	23	18	4
VE	F	49	19.8	53.5	28.4
TM	M	56	29.2	21	5
RC	M	47	35	68	3
NS	M	65	27	77	4
MS	F	62	37	16	2

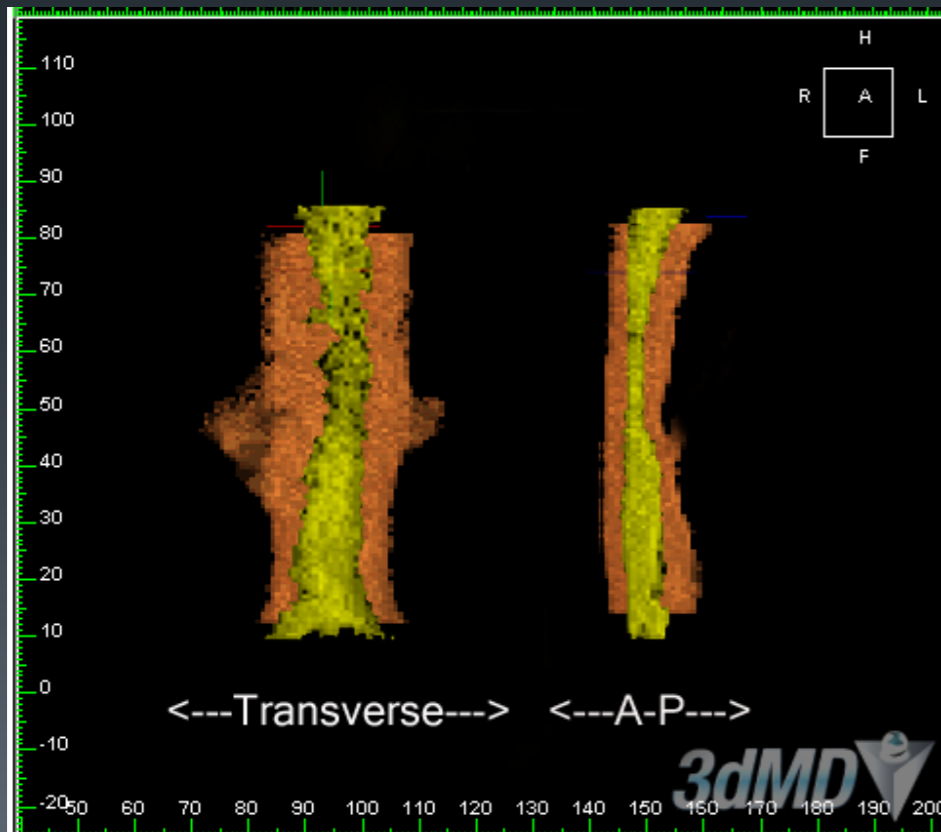
# PRE- AND POST-OP DATA: MOVEMENT

- Average Mandibular Movement: 9.5 mm
- Average Maxillary Movement: 9.37 mm
- Average Genio Movement: 6 mm

PT	SKELETAL PATTERN	MAND MOVEMENT (MM)	MAX MOVEMENT (MM)	GENIO MOVEMENT (MM)
NB	II	9	9	8
CD	I	9	9	0
KG	II	9	9	0
RJ	II	12	8	6
SD	II	11	8	0
VE	II	11	10	4
TM	I	11	11	0
RC	II	9	9	0
NS	II	10	8	0
MS	II	6	4	0

# PRE- AND POST-OP VOLUMETRIC ANALYSIS

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



PT	PRE-UAS VOL cm <sup>3</sup>	POST- UAS VOL cm <sup>3</sup>	% CHNGE UAS	PRE-RP VOL cm <sup>3</sup>	POST- RP VOL cm <sup>3</sup>	% CHNGE RP	PRE-RG VOL cm <sup>3</sup>	POST-RG VOL cm <sup>3</sup>	% CHNGE RG
NB	3.35	21.46	540.60%	1.33	8.46	536.09%	1.89	13.00	587.83%
CD	7.56	10.22	35.19%	3.97	4.49	13.10%	3.59	5.73	59.61%
KG	11.6	16.44	41.72%	3.91	5.77	47.57%	7.16	10.67	49.02%
RJ	3.46	30.9	793.06%	1.20	20.56	1613.3%	2.26	9.34	313.27%
SD	10.27	14.17	37.97%	4.92	8.89	80.69%	5.41	5.53	2.22%
VE	12.39	29.48	137.93%	7.44	16.04	115.59%	4.82	8.02	66.39%
TM	11.88	20.49	72.47%	4.70	10.69	127.45%	7.00	12.15	73.57%
RC	10.37	27.8	268%	3.4	8.98	264%	7.01	15.31	228%
NS	11.85	32.04	270%	4.49	9.86	219%	6.7	7.66	114%
MS	8.52	16.82	197%	6.07	10.36	170%	1.91	5.28	276%

# PRE- AND POST-OP SURFACE AREA ANALYSIS



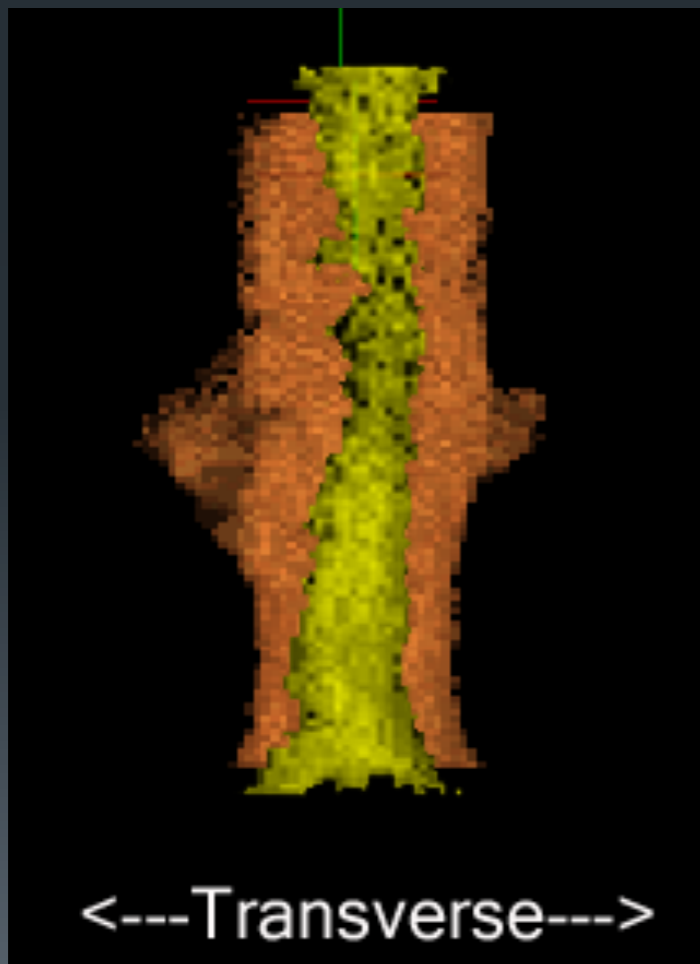
- Average % Change RP
  - **664.22%**
- Average % Change RG
  - **100.98%**
- Location of Choke Pt Pre-Operatively
  - **Retropalatal**
- Location of Choke Pt Post-Operatively
  - **Retroglossal**

PT	Pre-Choke Point Retro-palatal mm <sup>2</sup>	Post-Choke Point Retro-palatal mm <sup>2</sup>	% Chnge	Pre-Choke Point Retro-glossal mm <sup>2</sup>	Post-Choke Point Retro-glossal mm <sup>2</sup>	% Chnge	Pre- Location of Chke Pt	Post- Location of Chke Pt
NB	19.71	191.87	873.47%	49.68	155.34	212.68%	P	G
CD	74.52	61.83	-17.03%	88.65	116.01	30.86%	P	P
KG	103.80	158.85	53.03%	109.89	152.01	38.33%	P	G
RJ	8.37	273.5	3167.62%	44.28	156.60	253.66%	P	G
SD	104.84	187.83	79.16%	107.46	161.10	49.92%	P	G
VE	139.70	400.58	186.74%	133.65	268.46	100.87%	G	G
TM	95.36	387.69	306.55%	60.00	72.32	20.53%	G	G
RC	48.78	395.2	810%	121.32	368.45	304%	P	G
NS	99.63	277.9	228%	196.55	183.78	-9%	P	G
MS	68.85	197.09	286%	75.33	188.64	249%	P	G



# PRE- AND POST- OP TRANSVERSE ANALYSIS

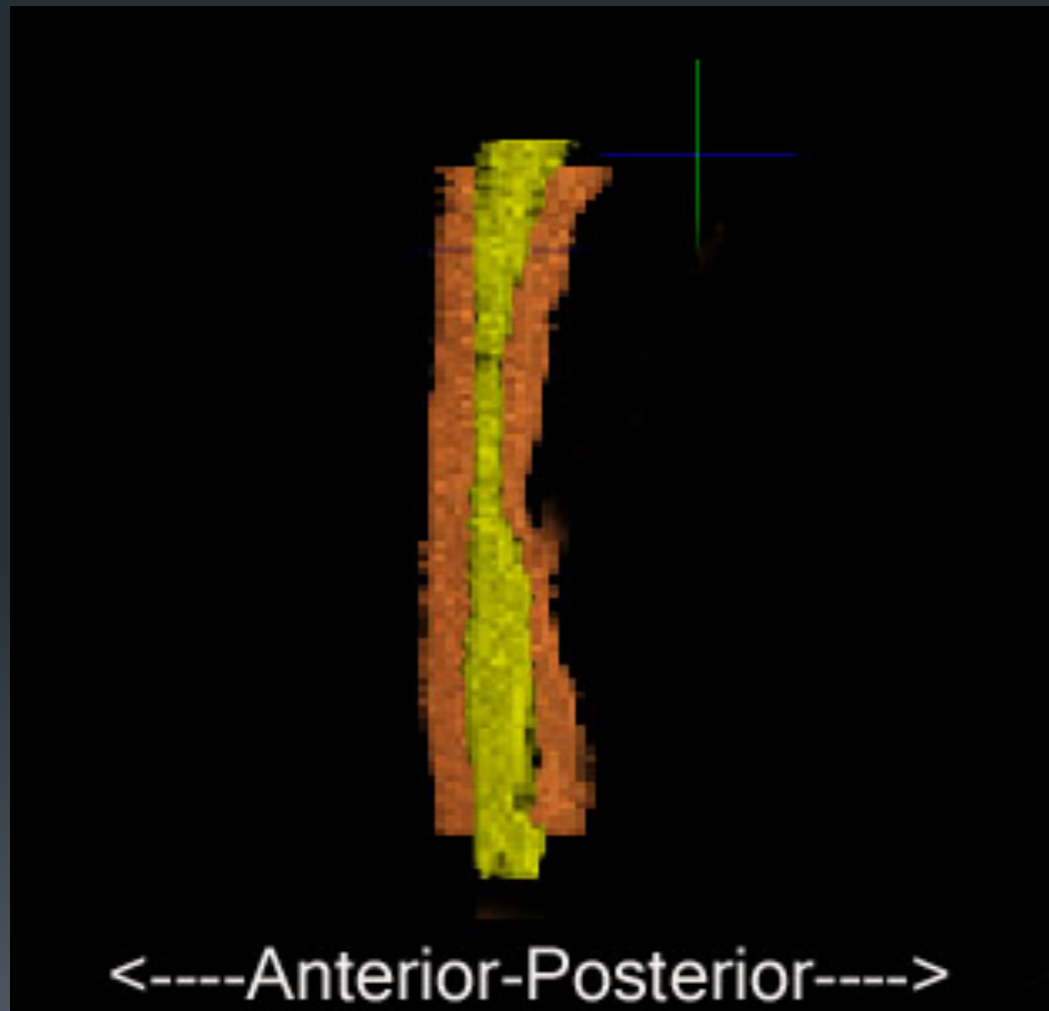
- Average change in the transverse dimension
  - Retropalatal: 11.64 mm
  - Retroglossal: 7.11 mm



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
NB	8.1	30.6	22.5	10.2	23.4	13.2
CD	16.5	16.8	0.3	19.8	19.2	-0.6
KG	24.0	29.7	5.7	21.9	27.3	5.4
RJ	1.8	28.2	26.4	12	30	18
SD	28.5	34.8	6.3	23.7	32.4	8.7
VE	26.4	37.5	11.1	26.1	28.8	2.7
TM	22.0	31.2	9.2	12.4	14.8	2.4
RC	11.4	29.4	13.5	14.7	28.2	13.5
NS	16.8	24.9	8.1	19.8	33	13.2
MS	17.1	28.8	11.7	26.1	24.6	-1.5

# PRE- AND POST-OP A-P ANALYSIS

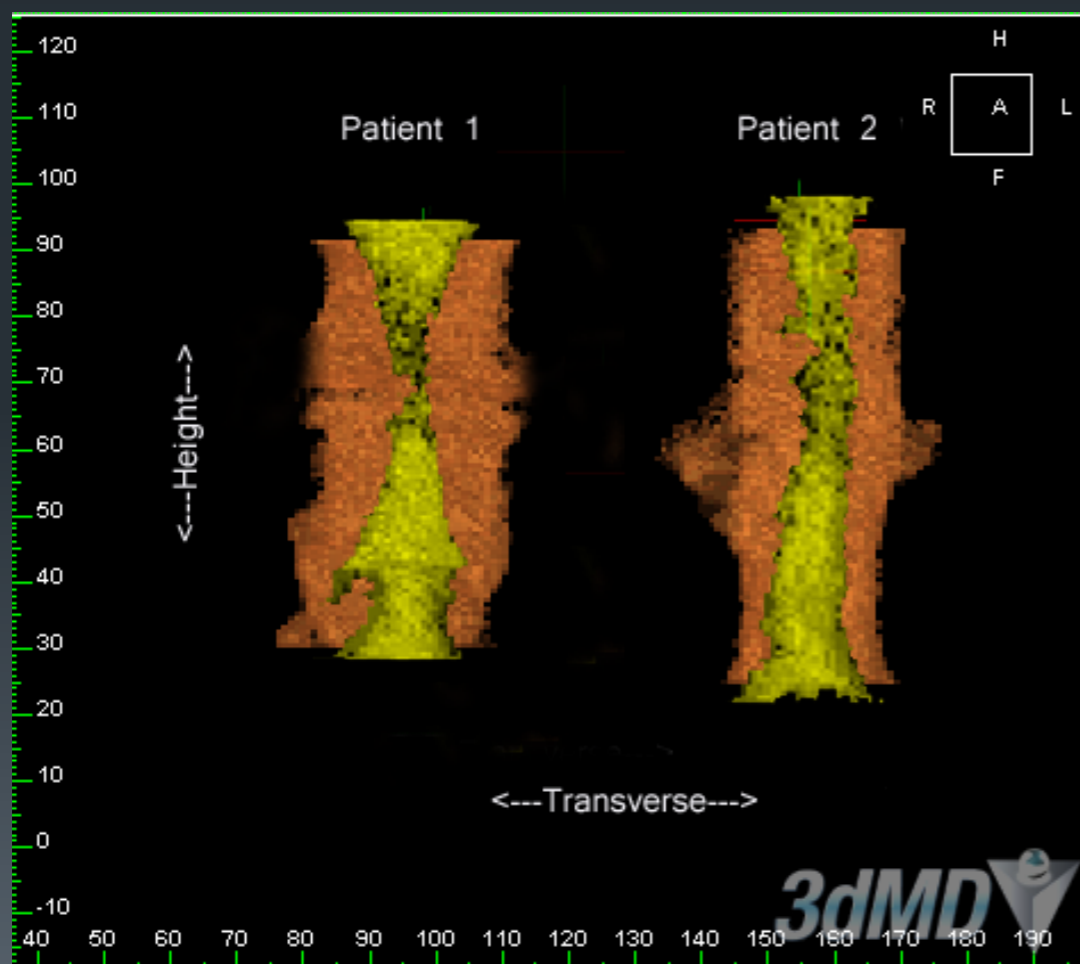
- Average change in the A-P dimension
  - Retropalatal: 6.40 mm
  - Retroglossal: 2.61 mm



PT	Pre-Choke Pt RP A-P (mm)	Post-Choke Pt RP A-P (mm)	Mm difference	Pre-Choke Pt RG A-P (mm)	Post-Choke Pt RG A-P (mm)	Mm difference
NB	2	5.7	3.7	5.4	6.9	1.5
CD	5.7	6.6	0.9	6	9	3
KG	3	4.5	1.5	6.9	8.7	1.8
RJ	6	25.2	19.2	4.2	6.6	2.4
SD	2.1	6.9	4.8	5.1	6	0.9
VE	4.8	9.6	4.8	3.9	12.6	8.7
TM	4	11.2	7.2	6.4	6.4	0
RC	4.8	15.9	11.1	9.6	17.5	7.9
NS	6.9	14.1	7.2	10.2	6.93	-3.3
MS	3	7.5	4.5	3	15.3	12.3

# PRE- AND POST- OPERATIVE HEIGHT ANALYSIS

- Average Change in UAS height
  - 2.86 mm
- Average Change in RP height
  - 3.14 mm
- Average Change in RG height
  - 4.29 mm

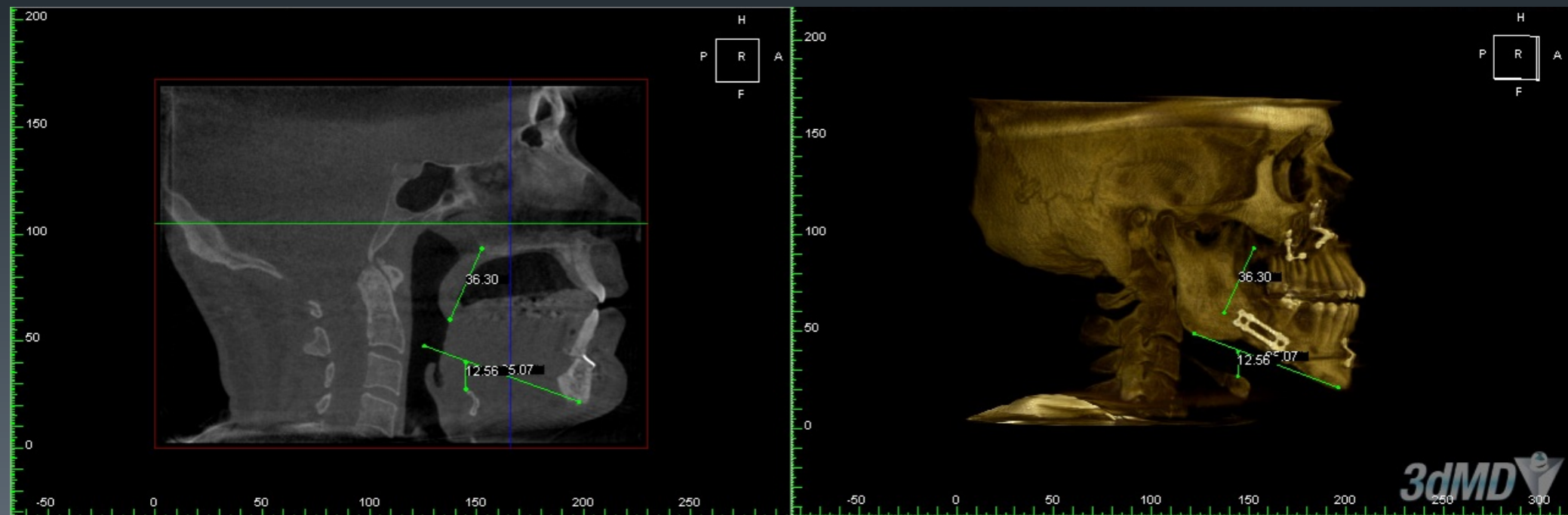


PT	Pre-UAS (mm)	Post-UAS (mm)	Pre-RP (mm)	Post-RP (mm)	Pre-RG (mm)	Post-RG (mm)
NB	80	74	46	44	32	30
CD	70	70	40	38	30	32
KG	74	80	38	32	36	48
RJ	68	66	38	32	30	32
SD	74	72	34	34	40	38
VE	64	62	32	34	32	28
TM	76	78	26	22	50	56

# PRE- AND POST- OPERATIVE LENGTH ANALYSIS

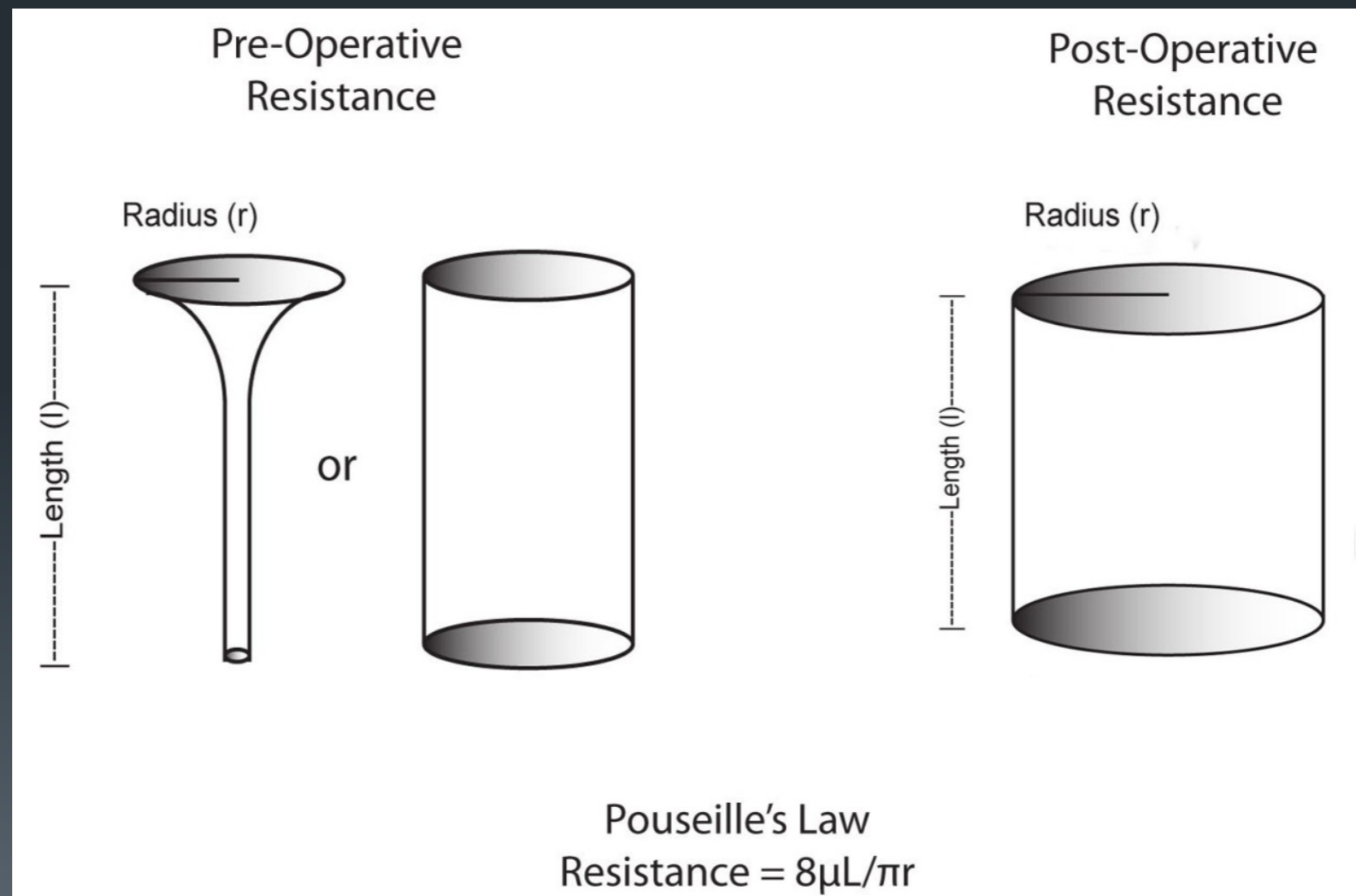
	Pre-SP mm	Post- SP Mm	Pre- H- MP mm	Post- H- MP mm
NB	47.75	47.05	27.22	19.78
CD	42.6	41.6	17.8	12.91
KG	35.63	34.11	24.81	24.61
RJ	38.67	36.3	13.13	12.56
SD	42.69	43.65	26.62	26.17
VE	36.69	37.74	17.7	15.58
TM	29.73	28.23	21.25	22.77
RC	33.1	31.35	23.5	21.6
NS	41.7	40.6	19.6	18.5
MS	36.6	36.1	16.3	15.9

- Average Change SP length:
  - -.73 mm
- Average Change H-MP length
  - -2.02 m
- Greatest Change in H-MP length: -7.44 mm



# POUSEILLE'S LAW

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



# 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 post-operatively in the retroglossal space
    - Indication of normalizing the airway and eliminating any bottlenecking/funneling
  - The airway enlarges in a rectangular fashion
- 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 airway measured from the posterior of the post nasal spine to the superior tip of the hyoid bone generally decreases post-operatively
  - The height of the airway was pre-operatively shorter in the retropalatal space than the height of the retroglossal space
  - The height of the airway was post-operatively shorter in the retroglossal space than the retropalatal space

# Case I

- 45 YO male
- BMI 28
- AHI 53
- Sat 81%
- Skeletal Class II
- UAS 3.46 cm<sup>3</sup>

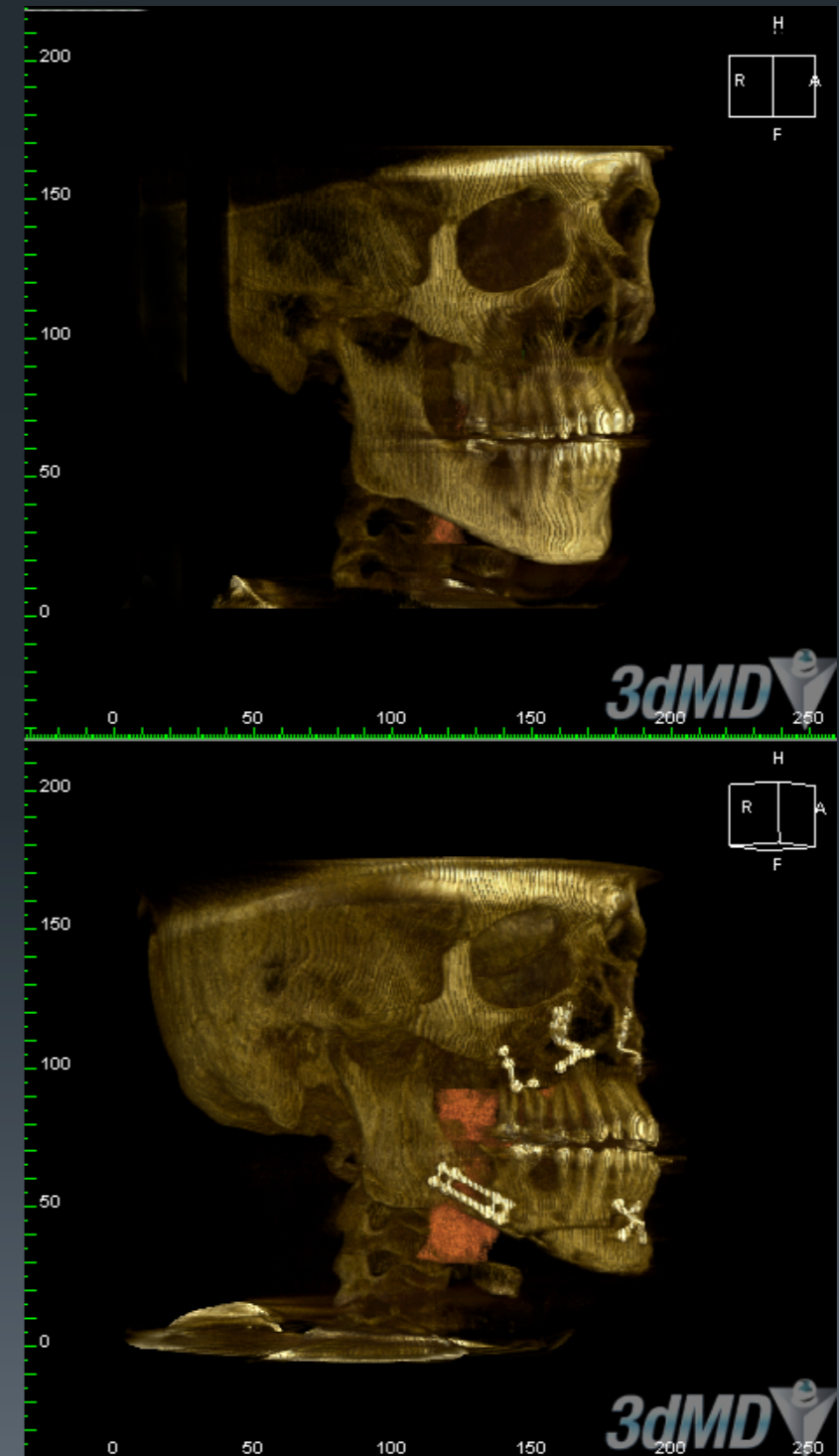
# CASE I



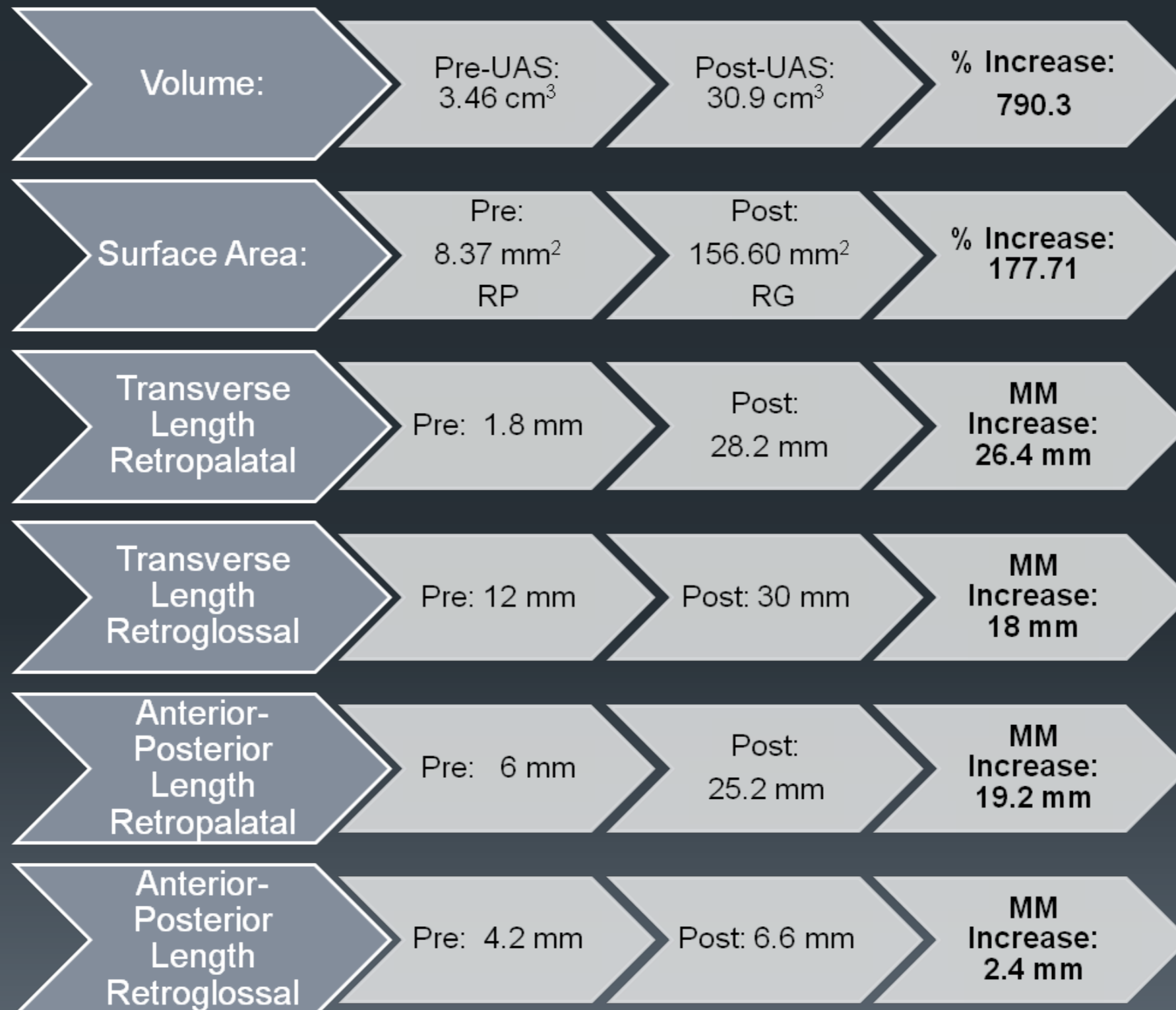
**Pre Surgical**

**Post-Surgical**

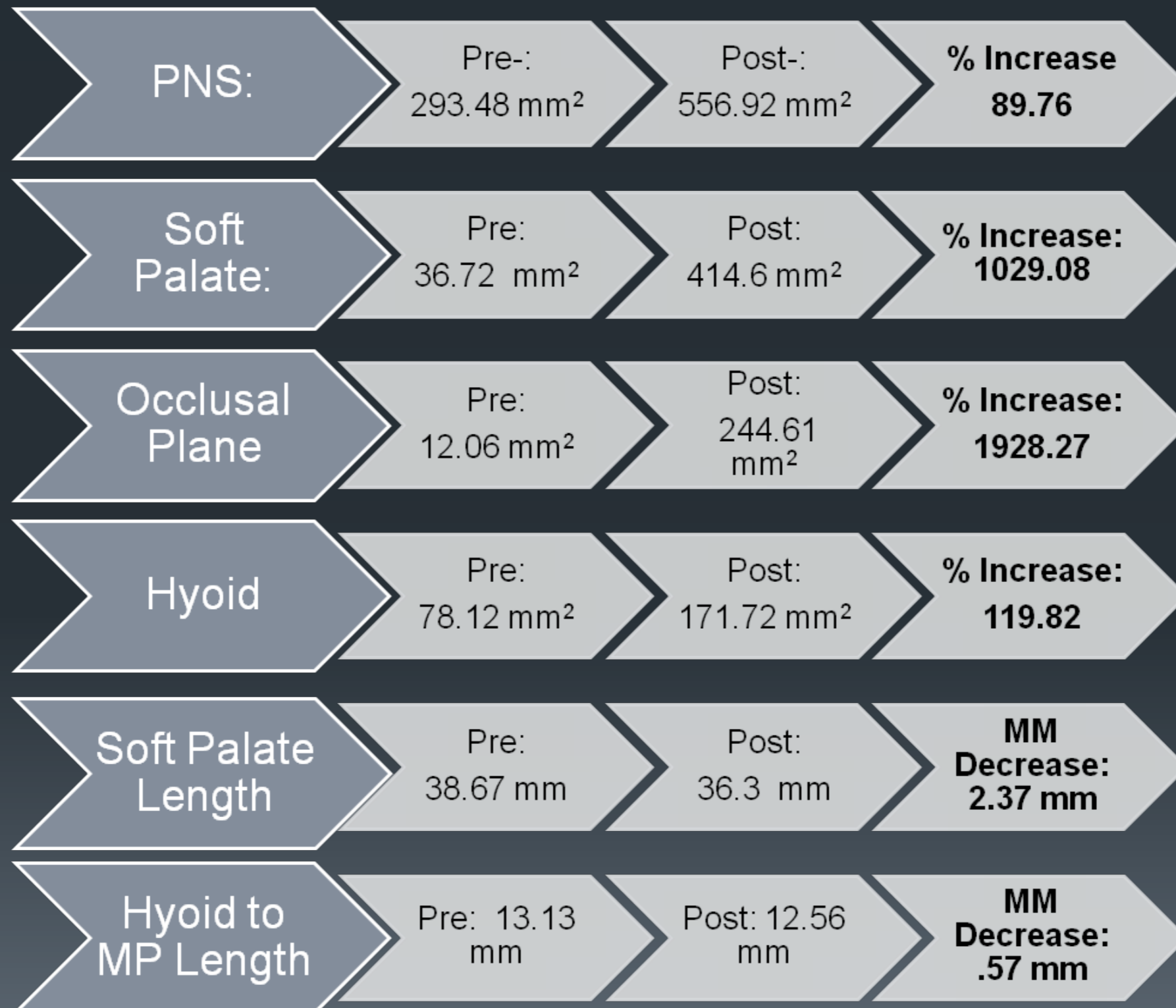
# CASE I



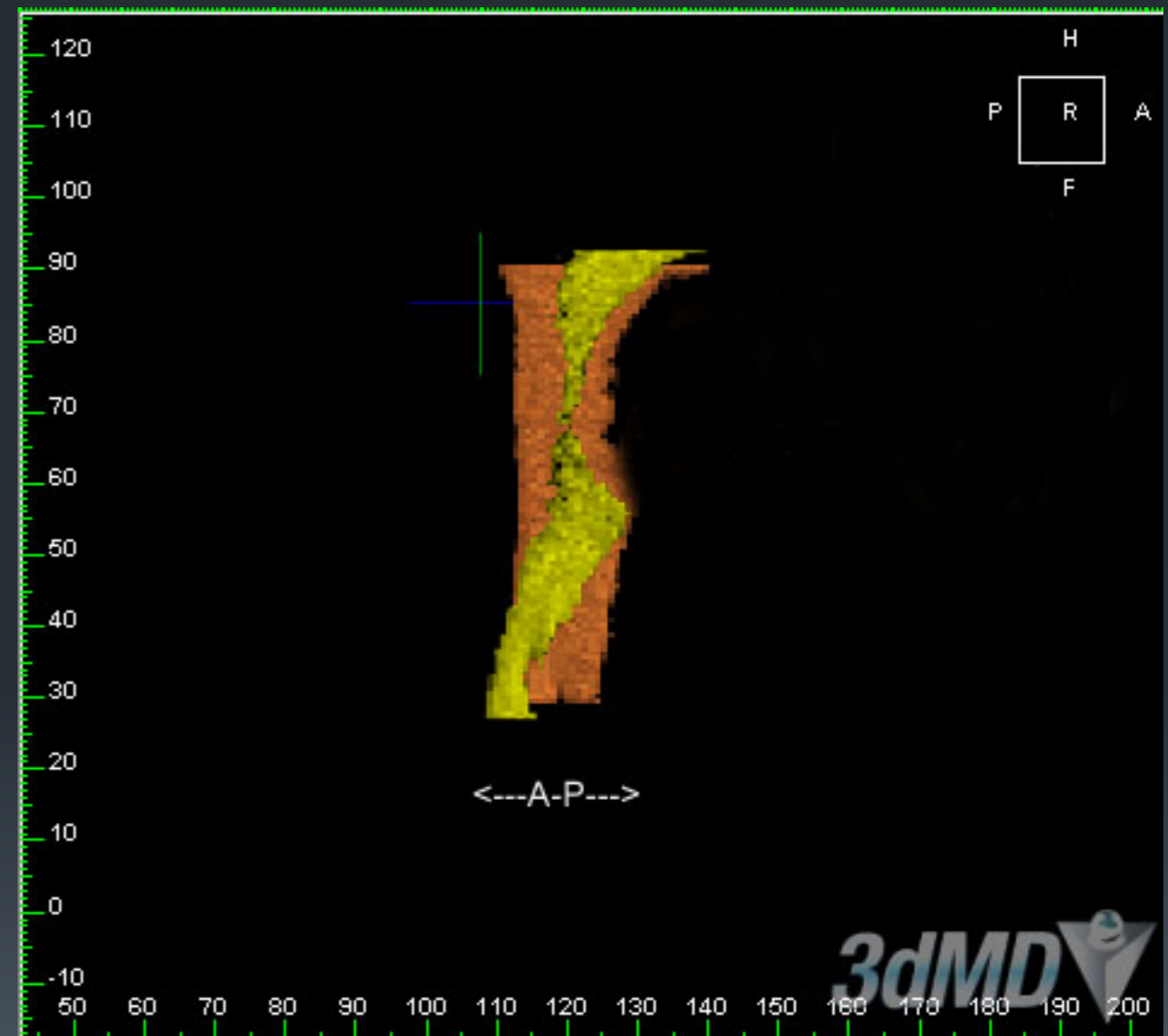
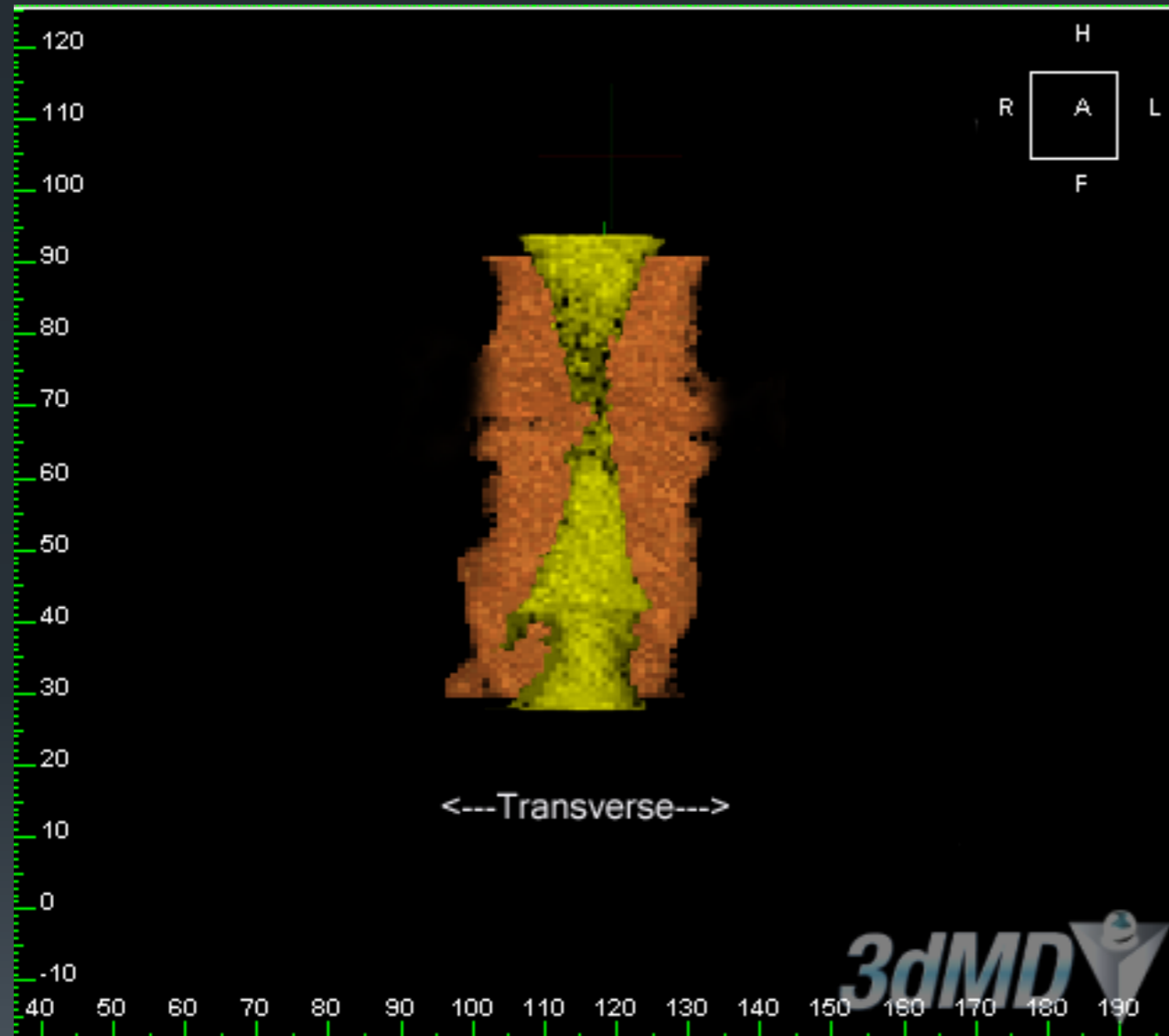
# CASE I:



# CASE I:



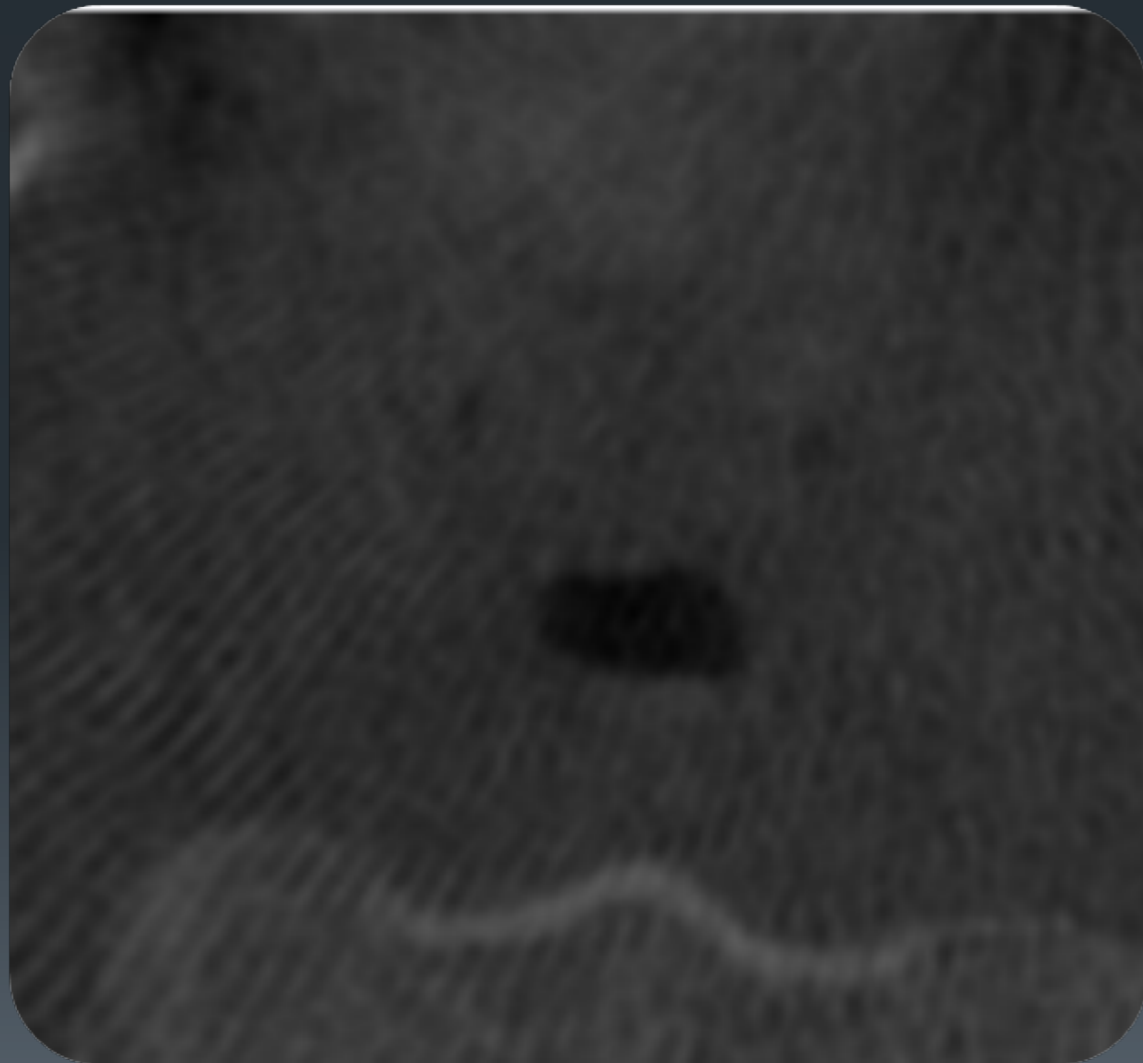
# CASE I



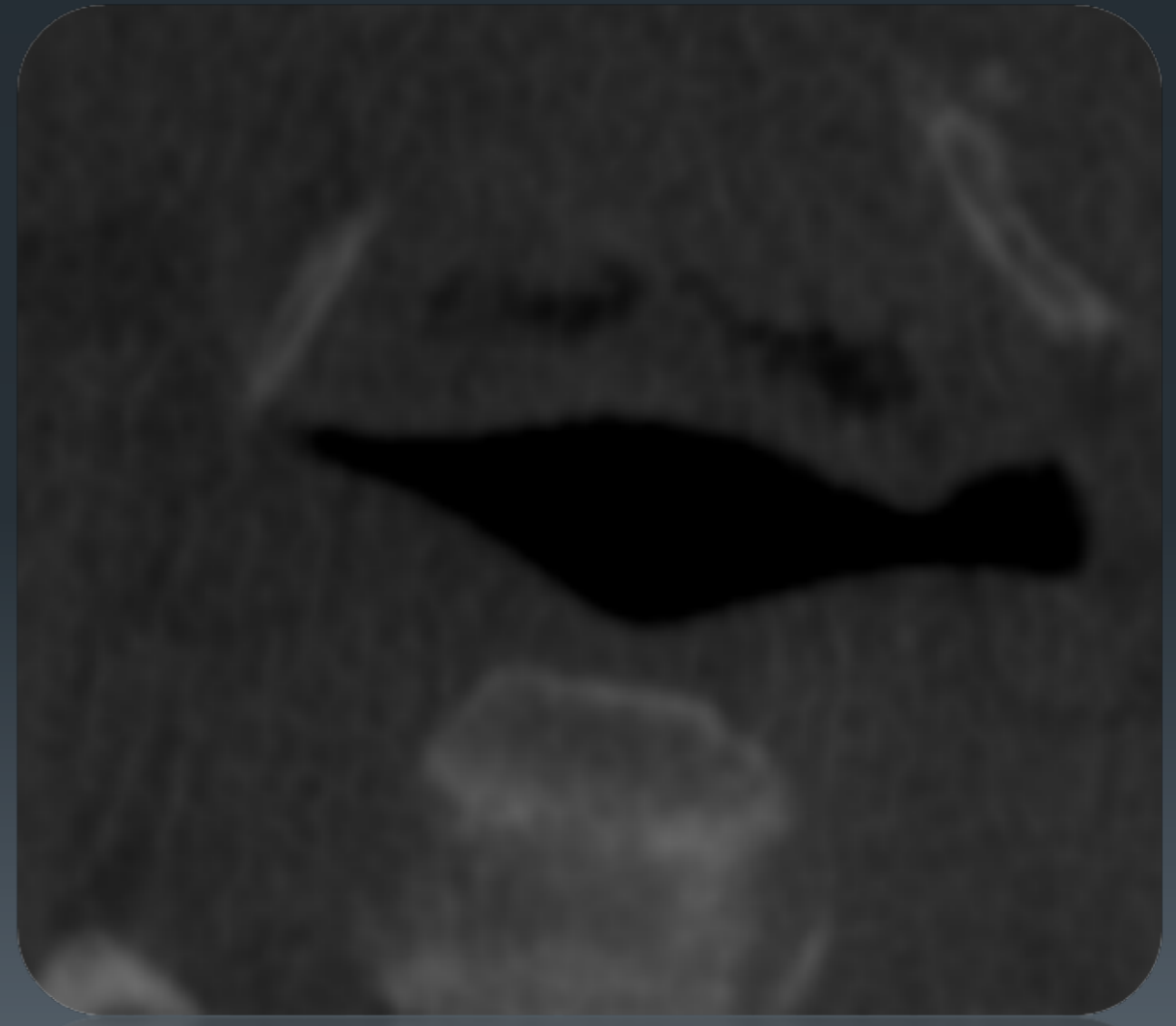
# CASE I

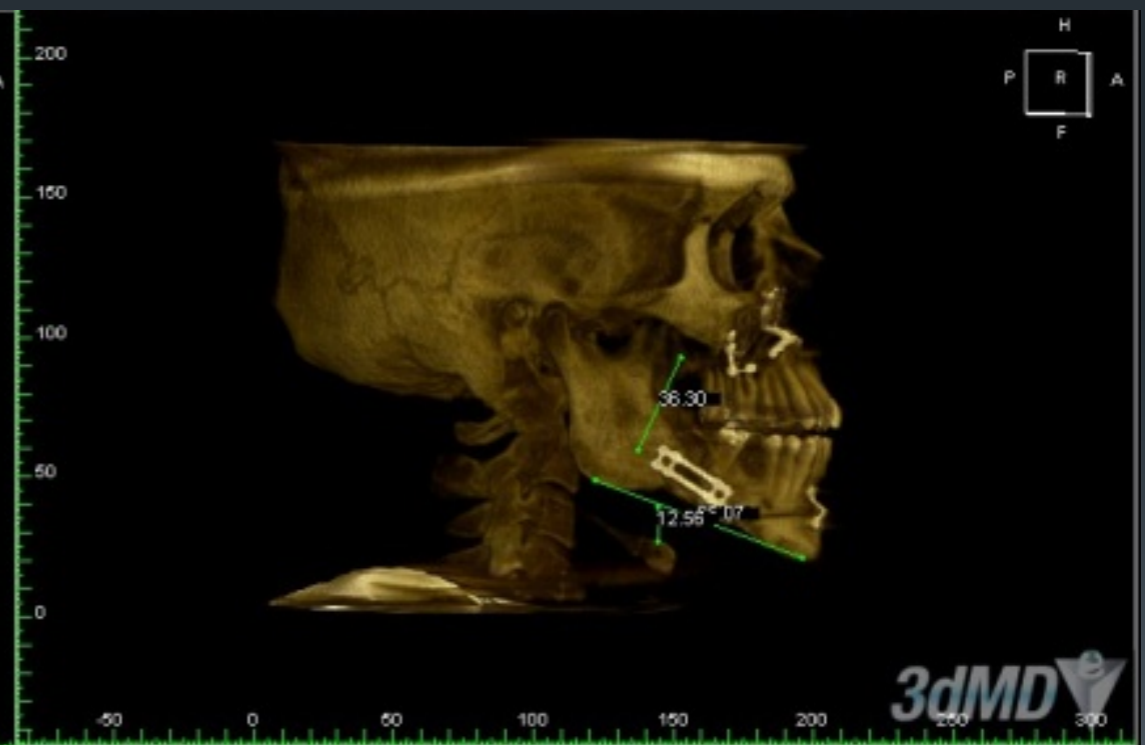
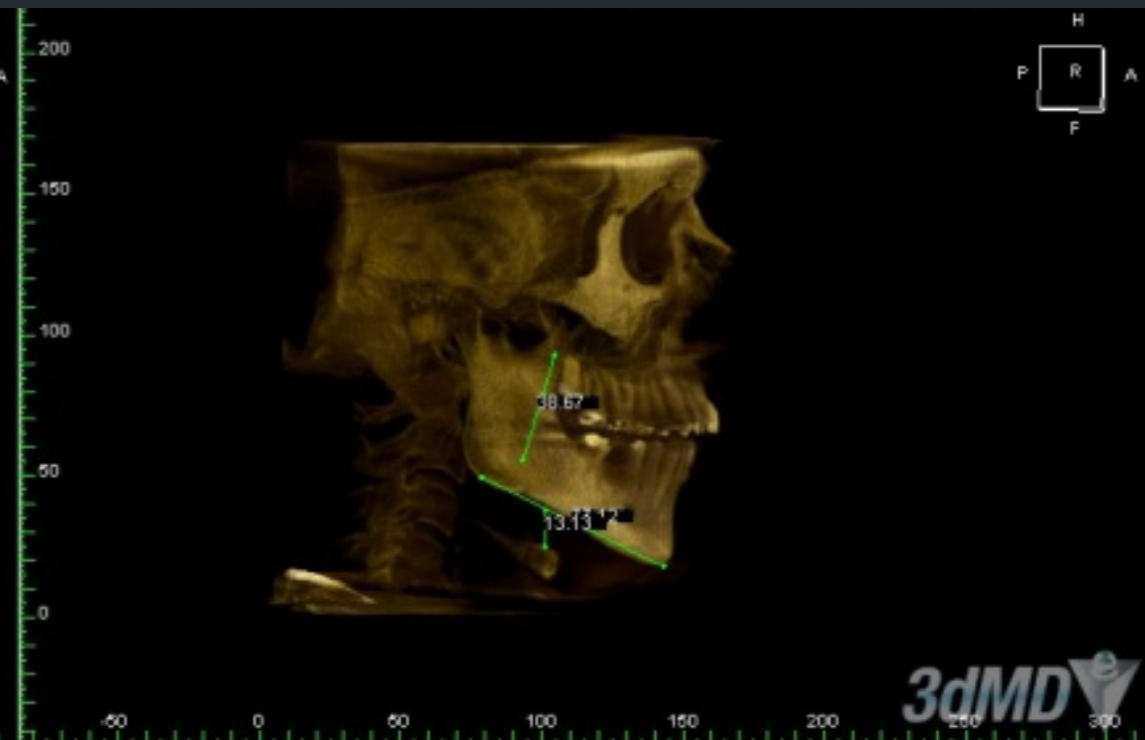
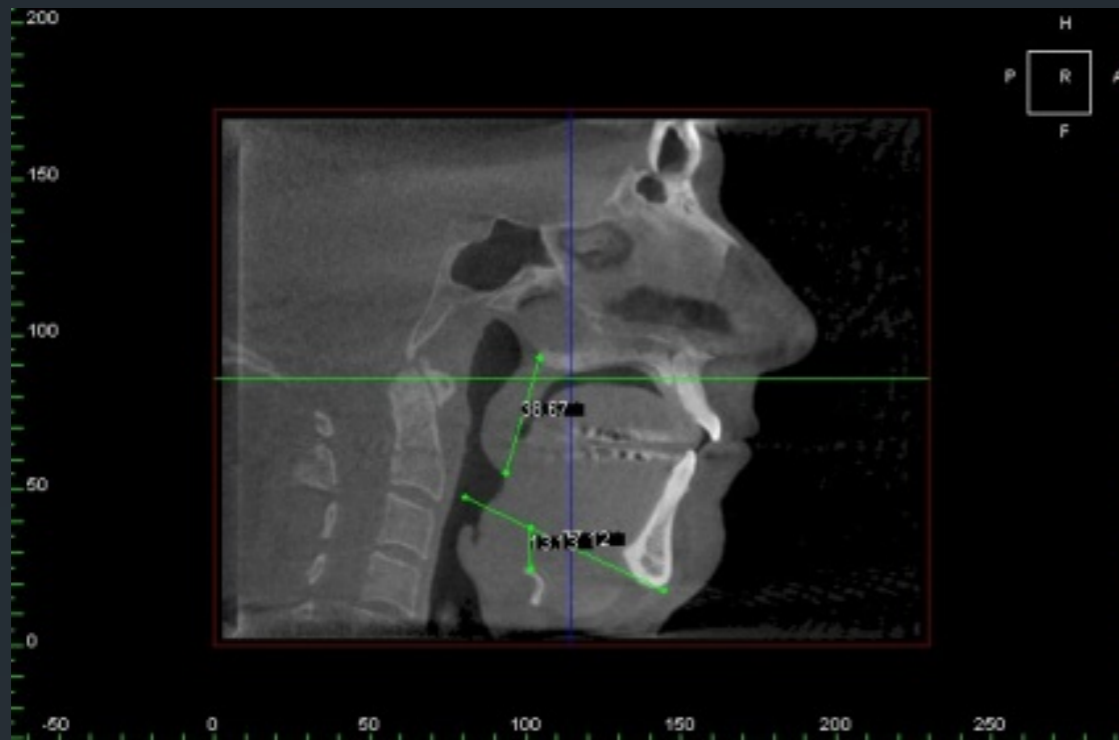


**Pre-Surgical**



**Post- Surgical**

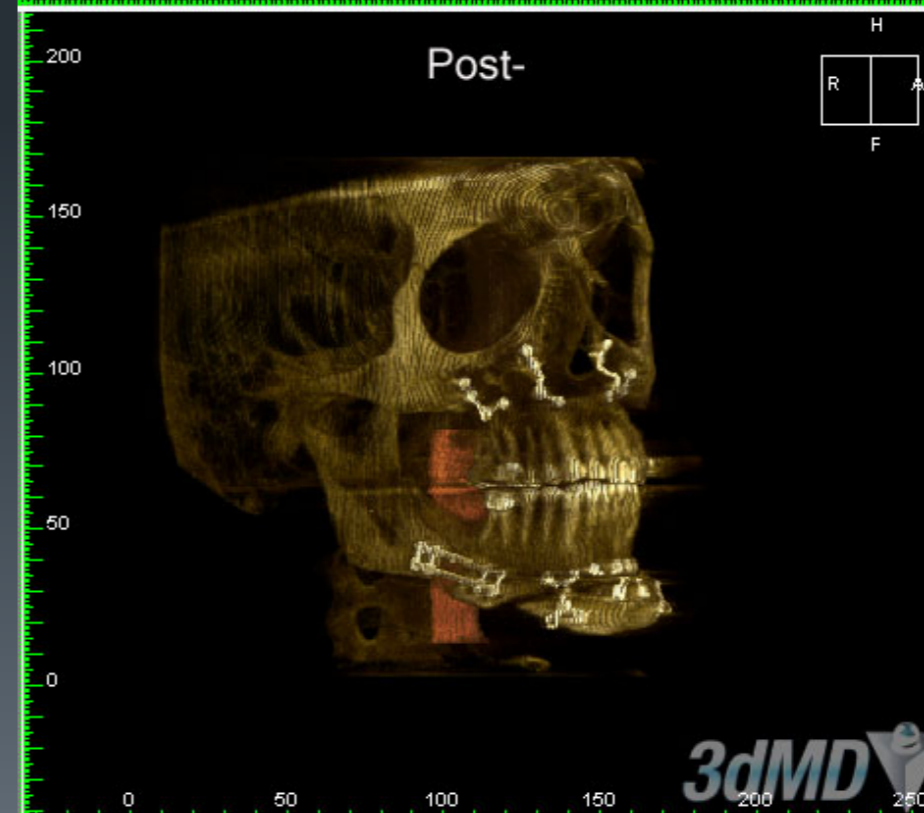
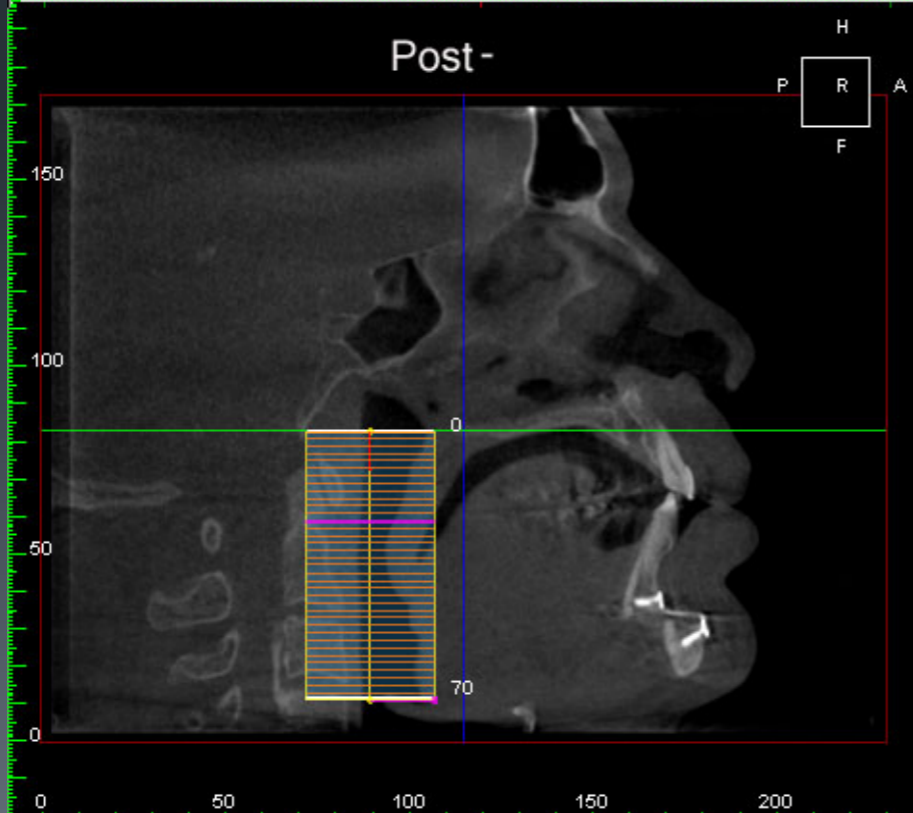
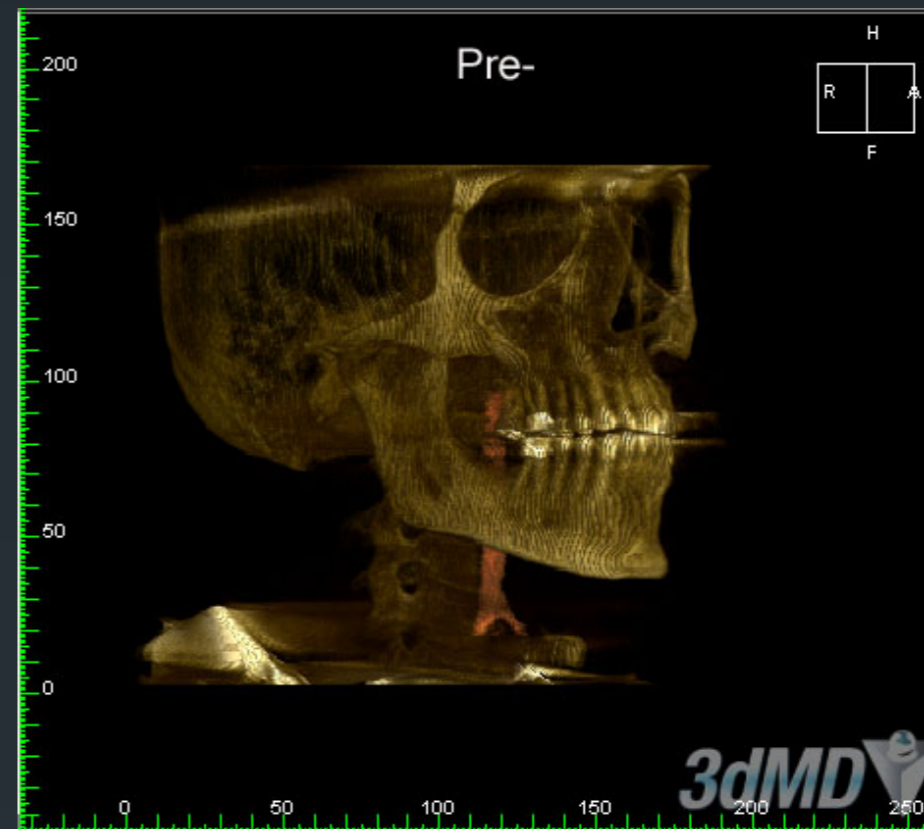
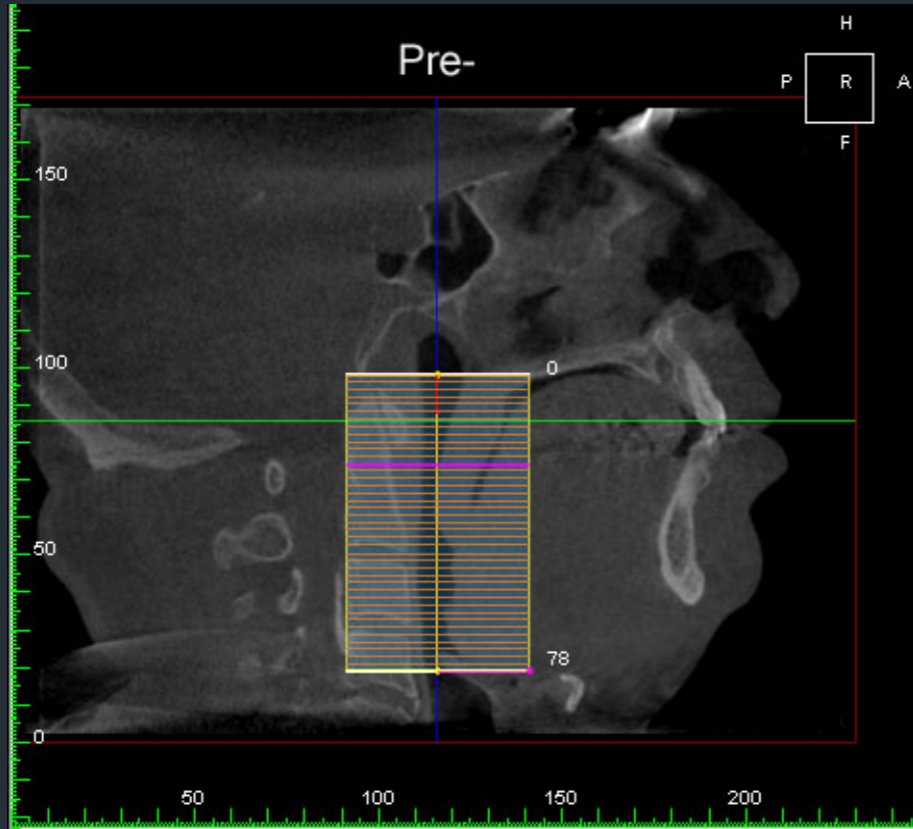




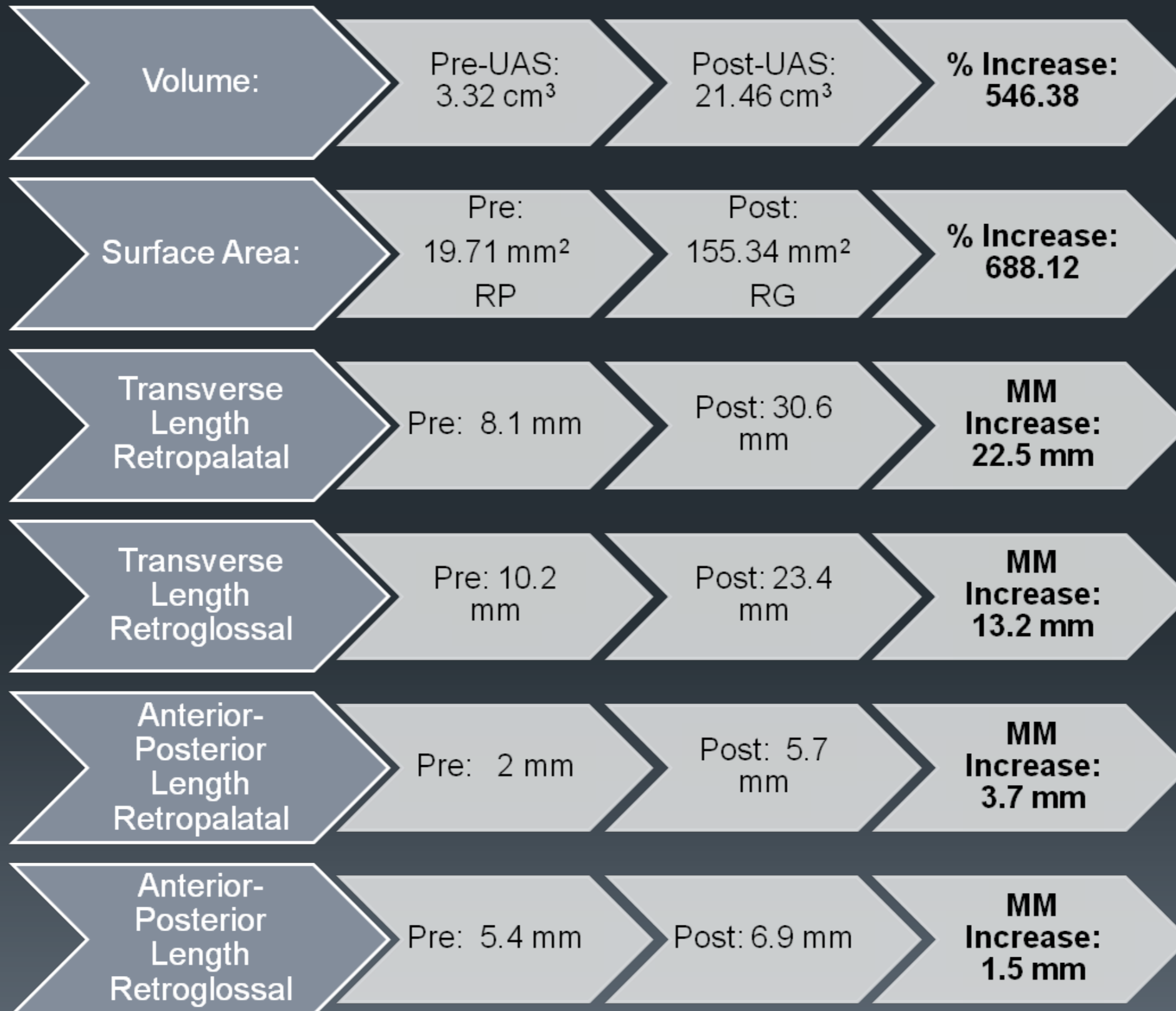
# Case II

- 49 yo male
- BMI 27
- AHI 53
- Sat 79%
- Skeletal Class II
- UAS 3.32 cm<sup>3</sup>

# CASE II



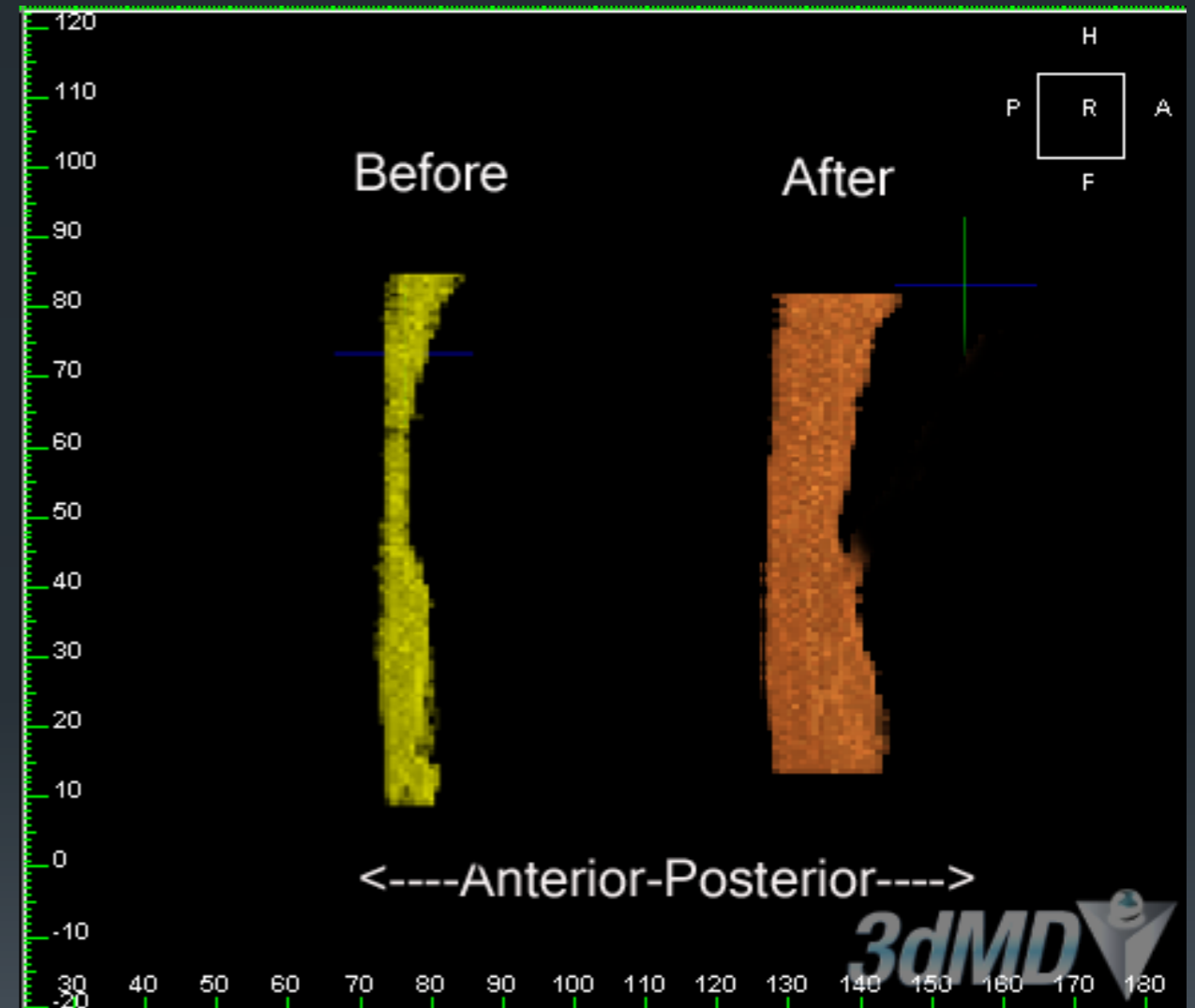
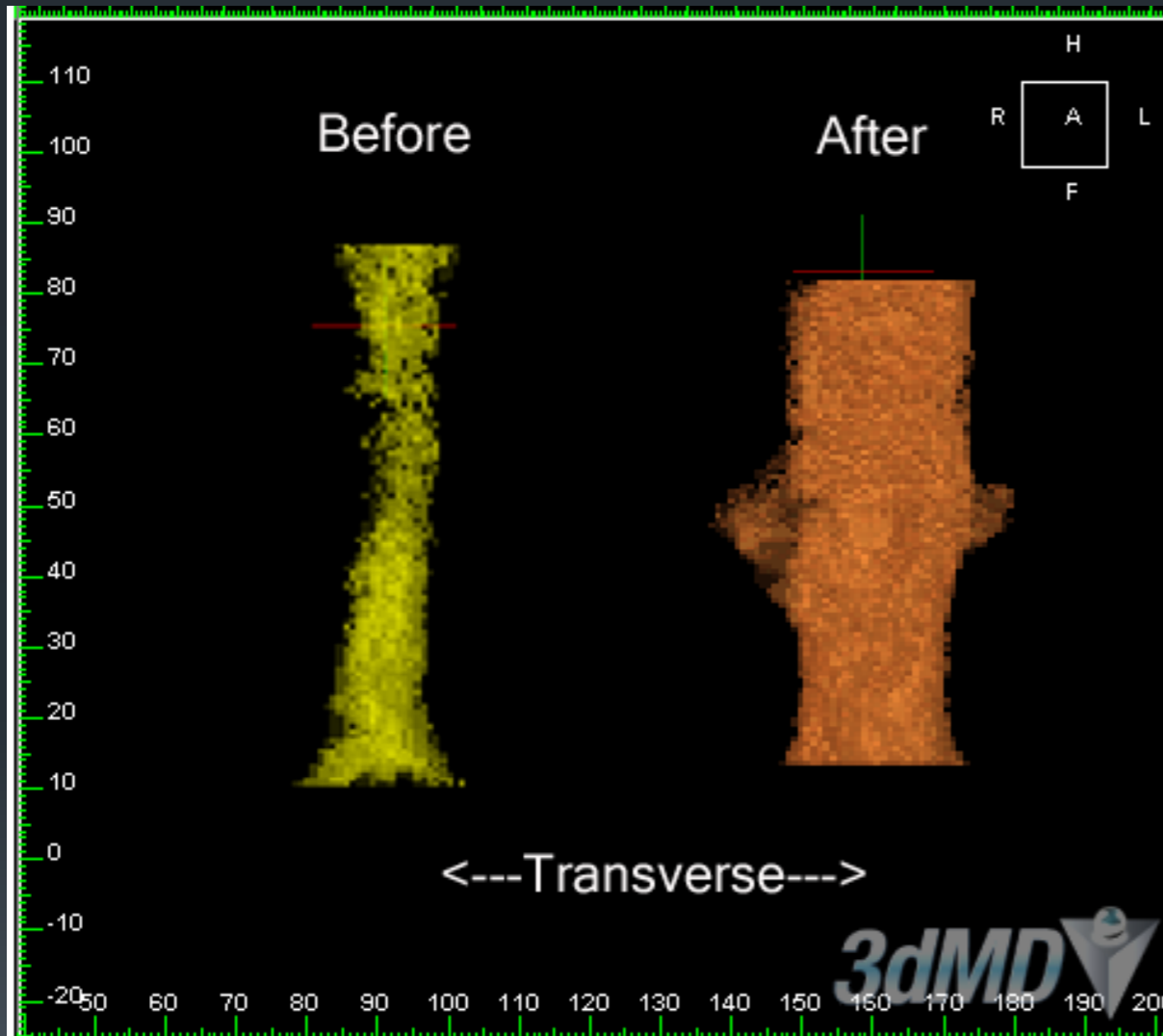
# CASE II



# CASE II:

PNS:	Pre: 142.74 mm <sup>2</sup>	Post: 231.65 mm <sup>2</sup>	% Increase 62.28
Soft Palate:	Pre: 33.48 mm <sup>2</sup>	Post: 217 mm <sup>2</sup>	% Increase: 548.15
Occlusal Plane	Pre: 216 mm <sup>2</sup>	Post: 244.27 mm <sup>2</sup>	% Increase: 3.81
Hyoid	Pre: 56.16 mm <sup>2</sup>	Post: 222.11 mm <sup>2</sup>	% Increase: 295.50
Soft Palate Length	Pre: 47.75 mm	Post: 47.05 mm	MM Decrease: .7 mm
Hyoid to MP Length	Pre: 27.22 mm	Post: 19.78 mm	MM Decrease: 7.44 mm

# CASE II



# CONCLUSIONS

- 3-Dimensional upper airway analysis indicates that maxillo-mandibular 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
    - Height of airway decreases
  - Resistance decreases
    - Radius of the airway increases
    - Height of the airway decreases