VOLUMETRIC THREE-DIMENSIONAL UPPER AIRWAY ANALYSIS IN PATIENTS WITH DENTO-FACIAL DEFORMITY FOLLOWING ORTHOGNATHIC SURGERY

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PURPOSE & BACKGROUND

• 3-D volumetric analysis is reproducible and accurate

• 3-D upper airway volume in non OSA patients have been described
  • Schendel S, Jacobson R. Normal Upper Airway Growth & Development. Presented at AAOMS Chicago 2010

• MMA has a high success rate in treating patients with OSA

• Evidence is lacking on airway volume changes after orthognathic surgery
## Our Analytical Approach

**Identify morphological & volumetric changes of the airway**

<table>
<thead>
<tr>
<th>Volumetric (cm³)</th>
<th>Surface Area (mm²)</th>
<th>Length (mm)</th>
<th>Height (mm)</th>
</tr>
</thead>
</table>
| • Upper Airway Space (UAS)  
  • Posterior of post-nasal spine to superior point of hyoid bone | • Choke Points  
  • Area of smallest surface area  
  • Identified independently in Retropalatal Space and Retroglossal Space  
  • PNS  
  • Occlusal Plane  
  • Hyoid | • 2-Dimensional length parameters of the choke points  
  • Transverse Dimension  
  • Anterior-Posterior Dimension  
  • PNS – Tip of Soft Palate  
  • Mandibular Plane - Hyoid | • 2-Dimensional Height of the airway  
  • UAS height  
  • Retropalatal height  
  • Retroglossal height |
Clinical Experience

Patient Demographics

- 25 patients undergoing orthognathic surgery
  - 9 Male
  - 16 Female
- Age at time of Maxillomandibular Advancement
  - 17-58 years old
  - Average 30.8 years old
Clinical Experience

- CBCT Scan
- 3D Cephalometric Analysis
- Model Surgery/Fabrication of Splints
- Virtual Treatment Objectives
- Dental Models
- Orthodontic Treatment
- 3dMDVultus Airway Analysis

Pre-Operative Work-Up
Surgical Technique

• LeFort I Maxillary Osteotomy Advancement (+/- segmental)
  With Bone grafting
• Bilateral Sagittal Split Osteotomy of the Mandible Advancement
  • +/- Genioplasty

• Average Maxillary Movement: 6.5 mm
• Average Mandibular Movement: 12.3 mm
• Average Genio Movement: 6.4 mm
Post-Operative Care

Patients admitted to hospital for 2-4 nights

Discharged

Weekly surgical and orthodontic follow-up

Post-operative CBCT scan obtained 3-6 months
Pre- & Post- Operative Volumetric Analysis

- Average UAS Pre 13.69 cm³
- Average UAS Post 19.44 cm³
- Average % Change UAS • 35.04%
- Average % Change RP • 44.65%
- Average % Change RG • 248.7%
Pre- & Post- Operative Choke Point Surface Area Analysis

- Average Choke Point RP Pre
  - 184.11 mm²
- Average Choke Point RP Post
  - 286.91 mm²
- Average % Change RP
  - 55.84%
- Average Choke Point RG Pre
  - 157.46 mm²
- Average Choke Point RG Post
  - 213.29 mm²
- Average % Change RG
  - 35.45%
- Location of Choke Pt Pre-Operatively
  - 15 RG Pre-Op, 10 RP Pre-Op
- Location of Choke Pt Post-Operatively
  - 19 RG Post-Op, 6 RP Post-Op
Pre- & Post- Operative Surface Area Slice Analysis

- **Average PNS Pre** 567.83 mm²
- **Average PNS Post** 619.21 mm²
- **Average % Change PNS** 9.05%
- **Average OP Pre** 252.57 mm²
- **Average OP Post** 382.29 mm²
- **Average % Change OP** 7.39%
- **Average Hyoid Pre** 227.63 mm²
- **Average Hyoid Post** 272.14 mm²
- **Average % Change Hyoid** 19.55%
Pre- & Post- Operative Transverse Analysis

- **Average mm change in the transverse dimension**
  - Retropalatal Choke Pt: 5.91 mm
  - Retroglossal Choke Pt: 2.98 mm
  - PNS: 2.70 mm
  - OP: 4.38 mm
  - Hyoid: .88 mm
Pre- & Post- Operative A-P Analysis

- Average mm change in the A-P dimension
  - Retropalatal choke pt: 1.80 mm
  - Retroglossal choke pt: 2.67 mm
  - PNS: 2.44 mm
  - OP: 2.41 mm
  - Hyoid: 2.12 mm
Pre- & Post- Operative Height Analysis

- Average Change in UAS height
  - -0.48 mm
- Average Change in RP height
  - +1.44 mm
- Average Change in RG height
  - -1.92 mm
PRE & POST-OPERATIVE SOFT PALATE & HYOID LENGTH ANALYSIS

- Average Change in Soft Palate Length
  - -0.87 mm
- % change in Soft Palate Length
  - -2.29%
- Average Change in Mandibular Plane – Hyoid Length
  - -1.97 mm
- % change in Mandibular Plane – Hyoid Length
  - -10.32%
POUSEILLE’S LAW

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

Poussille’s Law
Resistance = $8\mu \text{L}/\pi r$
Results

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

• Surface Area
  – The surface area at the choke point in the retroglossal space increases by a greater percent change than the retropalatal space
  – The location of the choke point is generally post-operatively in the retroglossal space, however, the retroglossal space increases the most as does the hyoid surface area slice
    • Indication of normalizing the airway and eliminating any bottlenecking/funneling
    – The airway enlarges in a rectangular fashion

• Width
  – 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-and post-operatively longer in the retropalatal space than the retroglossal space
  – The height of the retropalatal space increase on average and the height of the retroglossal space decreases
  – The height of the mandibular plane to the hyoid bone decreases
# Case I

<table>
<thead>
<tr>
<th>Feature</th>
<th>Pre</th>
<th>Post</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retropalatal</td>
<td>117.63 mm²</td>
<td>286.91 mm²</td>
<td>143.91</td>
</tr>
<tr>
<td>Retroglossal</td>
<td>135.36 mm²</td>
<td>154.89 mm²</td>
<td>14.43</td>
</tr>
<tr>
<td>PNS Surface Area</td>
<td>577.33 mm²</td>
<td>629.48 mm²</td>
<td>9.03</td>
</tr>
<tr>
<td>Occlusal Plane Surface Area</td>
<td>155.35 mm²</td>
<td>400.4 mm²</td>
<td>157.74</td>
</tr>
<tr>
<td>Hyoid Surface Area</td>
<td>172.71 mm²</td>
<td>226.52 mm²</td>
<td>31.16</td>
</tr>
<tr>
<td>Soft Palate Length</td>
<td>35.07 mm</td>
<td>34.67 mm</td>
<td>-0.4 mm</td>
</tr>
<tr>
<td>Mandibular Plane – Hyoid Length</td>
<td>10.83 mm</td>
<td>10.19 mm</td>
<td>-0.64 mm</td>
</tr>
<tr>
<td>Height</td>
<td>60 mm</td>
<td>54 mm</td>
<td>-6 mm</td>
</tr>
</tbody>
</table>
CASE I

Pre-Surgical

Post-Surgical
Case I
Case I
Conclusions

• 3-Dimensional airway analysis indicates that orthognathic surgery for dento-facial deformities positively increases the patients airway by increasing tension and changing the position of the palatal and pharyngeal muscles. As a result:
  – Airway volume increases
  – Shape of airway changes
    • Bottleneck to cylinder
    • Height of airway decreases
  – Resistance decreases
    • Radius of the airway increases
    • Height of the airway decreases
References


