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SEGMENTAL MAXILLOMANDIBULAR ROTATIONAL ADVANCEMENT TO CORRECT OBSTRUCTIVE SLEEP APNEA IN A PATIENT SKELETAL CLASS II MALOCCLUSION - A CASE REPORT

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The first priority to solve the sleep-disordered breathing could be soft-tissue surgery or non-surgical therapy such as continuous positive airway pressure (CPAP). However, in patients with incomplete remission or relapse, the sleep quality and day time symptoms may persist. The case report presented a young man with main problems of obstructive sleep apnea (OSA) and Skeletal Class II maxillary protrusion. We proposed a segmental maxillomandibular rotational advancement (SMMRA) with surgery-first procedure at the end of his puberty. The surgical orthodontic treatment achieved good outcome of function and esthetics at the same time. The polysomnographic data and airway dimension were dramatically improved without jeopardize the facial profile of the patient. (Taiwanese Journal of Orthodontics. 29(1): 52-64, 2017)

Keywords: obstructive sleep apnea (OSA); Segmental Maxillomandibular Rotational Advancement (SMMRA); orthognathic surgery

INTRODUCTION

Sleep-disordered breathing (SDB) is the occurrence of repetitive episodes of complete or partial obstruction of the upper airway during sleep. SDB is often associated with snoring and daytime symptoms such as hyperactivity in young kids and sleepiness in adults.1 It includes sleep disturbances that range widely in severity from primary snoring to obstructive sleep apnea (OSA).2

In a study of 700 children, Powell et al reported the prevalence of 15.5% for primary snoring and 1.2% for sleep apnea.3 The risk factors for pediatric...
OSA include adenotonsillar hypertrophy, obesity, craniofacial abnormalities (e.g. Pierre-Robin sequence), and neuromuscular disorders such as muscular dystrophy. Adenotonsillar hypertrophy is the most commonly and easily detected cause of pediatric OSA. Adenotonsillectomy has been the first choice of surgical treatment for pediatric patients with high grade adenoids and tonsils. Nevertheless, up to 20~40 percent of patients have incomplete remission and persistence of abnormal polysomnographic findings after surgery. The severity of OSA has been reported as an important factor which negatively affected the effectiveness of adenotonsillectomy. Other factors considered are dentofacial growth, ethnicity, positive family history of SDB and obesity. For OSA patients with craniofacial risk factors, such as retrognathia, maxillomandibular advancement (MMA) can be the primary surgical option. However, in Asian patients with profile of bimaxillary protrusions and acute nasolabial angle, the facial change can cause great concern by conventional MMA which moves both upper and lower jaws forward greater than 10 mm. Therefore, the segmental maxillomandibular rotational advancement (SMMRA) was developed specifically for Far East Asian patients with OSA. The surgical design is composed by anterior segmental osteotomy of maxilla and/or mandible, counterclockwise rotation of occlusal plane, and MMA. All the bonny segments are moved forward to achieve maximal airway enlargement. An optimal profile is created through the rotation of occlusal plane and dentoskeletal segments.

**CASE REPORT**

**Diagnosis and etiology**

An 18-year-old male patient of sleep apnea and retrusive chin was referred from sleep center for craniofacial evaluation and preparation of surgical orthodontic treatment. He had past medical history of severe sleep apnea and denied any allergy to food or medicine. He had adenotonsillectomy at the age of 14 and started continuous positive airway pressure (CPAP) therapy due to incomplete remission of OSA. At the age of 18, the sleep study reported his severe obstructive apnea with Apnea Hypopnea Index (AHI) of 33.6 events/hour (lowest Oxygen saturation 87%), body height of 166.5 cm, and body weight of 66.5 kg (BMI= 23.9 kg/m²). The recorded snore counts 1970 times at that night. His OSA remained severe despite of adenotonsillectomy and CPAP treatment during the puberty.

- **Extraoral examination**
  
  He had convex facial profile with unremarkable facial asymmetry and maxillary protrusion. Maxillary incisor exposure was 0.0 mm at rest. His upper lip was protrusive and nasolabial angle was acute. From smiling view, no gummy smile was found and incisal show was 3.0 mm (Figure 1).

- **Intraoral examination**
  
  Overjet was +4.0 mm and overbite was +5.5 mm. His mandibular dental midline deviated to right side by 0.5 mm. Upper and lower dental arches were taper shape. The space deficiency in the upper arch was 2.5 mm, and in the lower arch was 3.5 mm. The buccal segment of dentition revealed Class II canine and molar relationship (Figure 2).

- **Radiographic findings**
  
  The panoramic X-ray showed that upper and lower third molars were all completely erupted. The morphology of TMJ showed no remarkable abnormal findings. From PA cephalogram, chin deviated to his right side for 1.5 mm. From lateral cephalogram, the upper and lower lips were protrusive with respect to the esthetic E-line. The patient exhibited a skeletal Class II with maxillary protruding appearance (Figure 3).
Figure 1. Extraoral photographs before treatment.

Figure 2. Intraoral examination before treatment.

Figure 3. Radiographic images and lateral cephalometric tracing before treatment.
Treatment objectives

Our treatment objectives were to (1) improve OSA, (2) improve his facial profile, (3) establish normal overjet and overbite, (4) achieve bilateral Class I canine and molar relationship.

Treatment plan

According to the diagnosis and his chief complaint, we proposed his treatment plan of surgical orthodontics combined with SMMRA for correction of OSA and skeletal Class II with maxillary protruding appearance.

Treatment progress

• Pre-surgical orthodontic treatment

At the preoperative orthodontic stage, full mouth brackets were bonded and upper and lower 1st premolars were extracted. The surgical splint was tried in for surgery-first orthognathic surgery.

• Orthognathic surgery

We used SimPlant OMS software (Mateiralise Dental; Leuven, Belgium) to simulate 3-dimensional (3D) composite model for treatment plan of orthognathic surgery. During the segmentation process, all vital structures including teeth, roots, and inferior alveolar nerve were traced out for surgeon’s reference to avoid possible injuries (Figure 4-7). All of the bony segments were moved forward with differential axial and rotational movements in each. Double splints were fabricated through 3D printout with intermediate splint guiding mandible first.

The surgical procedure started with bilateral sagittal split osteotomy and anterior subapical osteotomy (Köle procedure) on mandible. Intermediate splint was used to advance the mandible (12.7 mm at pogonion) and Köle segments (4.8 mm at B point). Rigid fixation using plates and screws were provided to secure the mandibular segments.

In the maxilla, LeFort I and anterior subapical osteotomies (Wasstmund procedure) were conducted to achieve differential advancement of the anterior (0.0 mm at U1) and posterior segments (7.2 mm at U6r, 5.8 mm at U6l) of maxilla. Final splint was applied to guide the maxillary position. Rigid fixation using plates and screws were performed.

Figure 4. Treatment plan simulation of orthognathic surgery. Left side: before surgery; right side: surgical simulation.
Figure 5. Presentation of maxillary segmental osteotomies in relation to dental root position.  
A & B, before surgery; C & D, simulation of the bony movement.

Figure 6. Presentation of mandibular segmental osteotomies in relation to dental root position.  
A & B, before surgery; C & D, simulation of the bony movement.
Using the alveolar space from extraction of four premolars, Wassmünd and Köle procedure modified the proclination of upper and lower front teeth, which improves the protrusion of upper and lower lips. Further, the curve of Spee was changed with the new occlusal setup and the overbite/overjet can be normalized using anterior segmental osteotomies. The counterclockwise rotation of the occlusal plane provides the chance to achieve optimal advancement in the mandible without worsening of upper lip protrusion.

- Postsurgical orthodontic treatment

In this stage of postoperative orthodontic treatment, we started to close the residual extraction space, detail the occlusion and interdigitiation (Figure 8). Four weeks...
after the operation, we inserted 0.018-in nickel-titanium wires for leveling and alignment and used 0.016 x 0.022-in stainless steel wires for finishing and detailing. All brackets were debonded at 17 months, followed by the placement of maxillary and mandibular Hawley retainers.

**Treatment results**

At the end of treatment, the patient’s chief complaints of sleep apnea and facial profile were rectified. The occlusion was finished with Class I canine and molar relationships (Figure 9-11). The overall superimposition of before and after cephalometric tracings showed improvement in the soft and hard tissues (Figure 12 and Table 1). After treatment, the polysomnographic data and airway measurements of the patient were improved (Figure 13 and Table 2). At 1 year after debonding, the occlusion, esthetic and functional results clinically remained stable.

**DISCUSSION**

In this case, we employed 3D images which taken by CBCT scan (13 cm X 2, 40 sec, 0.4 mm in slice; i-CAT; Imaging Sciences International Inc., Hatfield, PA, USA), the dental casts were scanned with a high-resolution laser scanner (3 Shape, 3D Scan Company, Atlanta, GA) into 3D objects and used SimPlant OMS software to make surgical treatment plan, trace mandibular nerve and superimpose the pre- and post-operative images. Even though CBCT was widely use in the diagnosis and dental treatment like diagnosis of impacted teeth, implantation, orthognathic surgery…etc. Some limitation of the technique exists and needs to be overcome. for example, the clearness of CBCT images could be affected by metal materials such as dental prosthesis and orthodontic brackets. The metal objects decrease the spatial resolution by the scatter. It results in insufficient accuracy in the dentition part for clinical use. For this reason, we registered accurate, laser-scanned dental model images onto CBCT images to replace the blurred teeth. Furthermore, manual 3D superimposition method to register dental model images to CBCT images is able to achieve good accuracy of registration according to Liao et al. In this study, the root mean square difference (RMSD) was both 0.31 mm in 1st and 2nd time operation by the same operator, and there was no significant difference between these two operations. The voxel-size of CBCT is 0.4 x 0.4 x 0.4 mm, and therefore the accuracy of manual 3D superimposition technique is acceptable by the RMSD less than 0.4 mm. The treatment plan simulation by 3D images can also provide the clearer concept of movement of maxilla and mandible to the surgeons, and nerve tracing can prevent to damage the surrounding tissue and decrease postoperative sensory disturbance.

![Figure 9. Facial photos in completion of orthodontic treatment.](image)
Figure 10. Intraoral photos in completion of orthodontic treatment.

Figure 11. Radiographic images in completion of orthodontic treatment.
Table 1. Cephalometric analysis in before and after treatment.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Initial</th>
<th>Finish</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skeletal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNA (°)</td>
<td>83.5</td>
<td>82.5</td>
<td>79.4 ~ 82.5</td>
</tr>
<tr>
<td>SNB (°)</td>
<td>77.0</td>
<td>80.0</td>
<td>74.6 ~ 77.8</td>
</tr>
<tr>
<td>ANB (°)</td>
<td>+6.5</td>
<td>+2.5</td>
<td>4.1 ~ 5.7</td>
</tr>
<tr>
<td>SN-MP (°)</td>
<td>35.0</td>
<td>39.0</td>
<td>34.2 ~ 38.6</td>
</tr>
<tr>
<td>SN-OP (°)</td>
<td>23.0</td>
<td>18.5</td>
<td>14 ~ 18</td>
</tr>
<tr>
<td><strong>Dental</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1-SN (°)</td>
<td>108.0</td>
<td>103.5</td>
<td>103.5 ~ 109.1</td>
</tr>
<tr>
<td>U1-NA (mm)</td>
<td>+7.0</td>
<td>+3.0</td>
<td>3.8 ~ 7.2</td>
</tr>
<tr>
<td>L1-MP (°)</td>
<td>107.0</td>
<td>90.0</td>
<td>91.1 ~ 98.3</td>
</tr>
<tr>
<td>L1-NB (mm)</td>
<td>+10.5</td>
<td>+5.5</td>
<td>6.1 ~ 9.5</td>
</tr>
<tr>
<td><strong>Soft tissue</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U lip- E line (mm)</td>
<td>+7.0</td>
<td>+3.5</td>
<td>0.8 ~ 3.2</td>
</tr>
<tr>
<td>L lip- E line (mm)</td>
<td>+9.0</td>
<td>+3.0</td>
<td>1.2 ~ 4.4</td>
</tr>
</tbody>
</table>

Figure 12. Superimposition of 3D image and lateral cephalometric tracing, before and after treatment.
Table 2. Polysomnographic findings and measurements of airway dimension.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Pre-op</th>
<th>Post-op</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Polysomnographic findings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AI (h)</td>
<td>2.0</td>
<td>0.0</td>
</tr>
<tr>
<td>AHI (h)</td>
<td>33.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Snore (counts)</td>
<td>1970</td>
<td>119</td>
</tr>
<tr>
<td>Lowest SaO₂ (%)</td>
<td>87.0</td>
<td>93.0</td>
</tr>
<tr>
<td><strong>Airway measurements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum cross area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retropalatal (mm²)</td>
<td>71.6</td>
<td>300.7</td>
</tr>
<tr>
<td>Retroglossal (mm²)</td>
<td>232.9</td>
<td>365.6</td>
</tr>
<tr>
<td>Airway volume (mm³)</td>
<td>12925.8</td>
<td>19082.5</td>
</tr>
</tbody>
</table>
From the literatures, SDB in nonsyndromic children has been found having a positive correlation with craniofacial characteristics such as high palatal vault, narrow maxilla, mandibular retrognathism, and increased facial height.\textsuperscript{12-15} This particular patient presented was a Class II skeletal relationship with maxillary protrusion. His maxillary and mandibular arch forms were taper in shape. Orthodontic treatment along could provide adequate to correct his dental problem and improve facial aesthetics. However, the medical condition of OSA prevented any treatment option that moves the dentoskeletal frame backward, which can narrow the oral cavity and decrease the pharyngeal airway and worsen his OSA. Accordingly, the only feasible treatment of choice was surgical orthodontics using the surgical plan of SMMRA, which may solve the OSA problem and improve his facial aesthetics simultaneously. SMMRA enlarges the pharyngeal airway by LeFort I advancement, especially on the posterior segment, where the velopharyngeal aponeurosis attached. The advancement of posterior maxilla tightens the velum of soft palate and enlarges the velopharyngeal airway. The mandibular advancement with counterclockwise rotation of the occlusal plane expanded the space of mouth floor. Meanwhile, the forward movement of genioglossus tubercle provides anterior traction force to drag the tongue forward and enlarge the airway space at tongue base. The OSA was cured at this particular young patient after the treatment. During the same time, the lip protrusion was improved by the rotation movement of anterior segments along with the jaw advancement and the decrease of proclination of upper and lower front teeth, which is not achievable in conventional MMA without segmental osteotomy.

In brief, the advantages of SMMRA are: (1) enlarge the posterior airway space to improve disordered breathing during sleep; (2) provides some positive effects on facial esthetic by altering front teeth proclination through the rotational movements of anterior segments of maxilla and mandible. Consequently, the SMMRA can treat OSA patients effectively while improving the facial profile.\textsuperscript{7}

The indication of surgery-first approach are (1) well-aligned to mildly crowded anterior teeth, (2) flat to mildly curve of Spee, and (3) normal to mildly proclined/retroclined incisor inclination.\textsuperscript{16} Maxillary and mandibular dentition were mild crowded, mildly curve of Spee and normal proclined maxillary incisor inclination in this case, so he agreed with above conditions. Another consideration is the advantages of the surgery-first approach, included that first, it can solve the patient’s chief complaint, dental function, and improve facial esthetics earlier; secondary, it can reduce 1 to 1.5 years of the total treatment period depending on the complexity of orthodontic treatment; and third, the phenomenon of post-operative acceleration of orthodontic tooth movement could be achieved easier and faster in a period of 4 to 5 months after surgery.\textsuperscript{16,17} Nevertheless, orthodontists should select patients carefully, as considering the postoperative bony relapse and the limitation of orthodontic tooth movement. When we set a suitable and precise treatment plan at the beginning, then we can have the opportunity to achieve the patients’ satisfaction successfully.\textsuperscript{18,19}

**CONCLUSION**

The risk-benefit balance for the patients needs to be considered. We used 3D images simulation to make treatment plan, and applied surgery-first approach with SMMRA to achieve his chief complaint and successfully improved his OSA, dental occlusion and facial esthetic.

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