Application of Combined Maxillary Skeletal Expander and Facemask Treatment with an Alternating Rapid Maxillary Expansion and Constriction Protocol in a Female Adolescent with a Class III Skeletal Relationship

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Recommended Citation
Hsu, Li-Fang; Yu, Kai-Wen; Liu, Chung-Ji; and Chang, Jenny Zwei-Chieng (2020) "Application of Combined Maxillary Skeletal Expander and Facemask Treatment with an Alternating Rapid Maxillary Expansion and Constriction Protocol in a Female Adolescent with a Class III Skeletal Relationship," Taiwanese Journal of Orthodontics: Vol. 30 : Iss. 1 , Article 5.
DOI: 10.30036/TJO.201803_30(1).0005
Available at: https://j.tjo.org.tw/tjo/vol30/iss1/5

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INTRODUCTION

The benefit of early treatment of Class III malocclusion has been an issue of long-term debate.\(^1\)\(^-\)\(^3\) Early treatment using facemasks before adolescence with or without rapid palatal expansion to protract the maxilla is supported by the literature, but the timing of treatment is crucial in obtaining optimal skeletal traction results, which is often suggested to be below 10 years of age.\(^4\)\(^,\)\(^5\) Controversy has also remained because of the unpredictability of mandibular growth, which may undermine the results of early treatment. To circumvent this problem of early treatment, attempts have been made to use bone-borne appliances instead of tooth-borne

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Case Report

APPLICATION OF COMBINED MAXILLARY SKELETAL EXPANDER AND FACEMASK TREATMENT WITH AN ALTERNATING RAPID MAXILLARY EXPANSION AND CONSTRUCTION PROTOCOL IN A FEMALE ADOLESCENT WITH A CLASS III SKELETAL RELATIONSHIP

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A 13-year-old female patient presented with a chief complaint of anterior crossbite and chin prognathism. She had a skeletal Class III relationship with a brachyfacial vertical pattern. Anterior crossbite exhibited maximum intercuspal–centric relation shift, leading to an edge-to-edge incisal position. On the basis of this patient’s chronological age, it was too late to perform conventional early treatment of Class III cases, which includes rapid palatal expansion combined with facemask or chincap therapy. After discussing treatment options with the patient and her parents, we decided to try combined maxillary skeletal expander and facemask treatment with an alternating rapid maxillary expansion and constriction protocol to facilitate mid-face protraction. After anterior crossbite correction, an upper 2 × 6 appliance was used for anterior teeth alignment. Active treatment time was 14 months and the patient achieved considerable maxillary traction as well as profile change. The patient and her parents were satisfied with the treatment result although the uncertain residual mandibular growth requires ongoing monitoring. (Taiwanese Journal of Orthodontics. 30(1): 43-55, 2018)

Keywords: maxillary skeletal expansion; facemask; alternating rapid maxillary expansion and constriction (Alt-RAMEC).
appliances for facemask traction, and positive results have been reported. This study reports the case of a 13-year-old female patient with a Class III relationship with both maxillary retrusion and chin prognathism, as well as maxillary transverse deficiency. She underwent maxillary skeletal expansion combined with facemask therapy to protract her maxilla in addition to treatment with an upper partial fixed appliance to align the front teeth. The results of skeletal expansion, maxillary protraction, and facial profile change were evident after treatment.

**DIAGNOSIS AND ETIOLOGY**

The patient presented to our department with her parents. Her chief complaint was anterior crossbite and chin prognathism. She denied any major systemic diseases or family history of Class III tendency. Dental history included regular dental check-ups, and fair oral hygiene status was found clinically.

The patient had a skeletal Class III relationship with a hypodivergent vertical pattern. A resting photo showed no lip incompetence or mentalis strain. A flat paranasal area and upturned nose were also noted. Reverse smile arc with little tooth show was also observed. The upper dental midline was coincident with the facial midline, whereas the lower dental midline shifted to L’t by approximately 2 mm. A lateral photo showed a concave profile with an acute nasolabial angle (Figure 1).

Upon intraoral examination, the patient exhibited anterior crossbite with deep overbite in the maximum intercusption (MIC) position; however, MIC-centric relation (MIC–CR) shift was found clinically. An edge-to-edge position was observed. Bilateral canine and molar relationships were Class III at both MIC and CR positions. The arch length discrepancies in the upper and lower arches were 1 mm and 0.5 mm, respectively. The curve of Spee was 2 mm. Transversely, a narrow upper arch with #15 palatal crossbite was found. No palpation pain or clicking sound was recorded in the temporomandibular joint upon clinical examination (Figure 2).

**RADIOGRAPHIC EXAMINATION**

Radiographic examination included lateral and postero-anterior (PA) cephalograms as well as panoramic views (Figure 3). Lateral cephalometric values (Table 1) confirmed a Class III skeletal relationship in both MIC and CR positions with a low mandibular plane angle. Proclined upper incisal and retroclined lower incisal angles were observed. According to the lateral cephalogram, the patient’s cervical vertebral maturation was Stage 3, indicating that she was undergoing a growth spurt. PA cephalometric values are shown in Table II. Although Ricketts analysis revealed the width differential of the maxilla to the mandible to be normal, mild transverse deficiency was found intraorally (Figure 4, Table 2). Panoramic radiography revealed normal dental and skeletal conditions with absence of an upper right third molar tooth germ and normal condylar head shapes with well-defined cortical margins.

![Figure 1. Pre-treatment extraoral photos.](image-url)
Figure 2. Pre-treatment intraoral photos.

Figure 3. Pre-treatment cephalometric radiographs at maximum intercuspation (A) and centric relation (B) positions, and a pre-treatment panoramic radiograph (C).
Table 1. Pre-treatment and post-treatment cephalometric measurements. Regarding the maximum intercuspation position, only measurements that differed from the centric relation position are shown.

<table>
<thead>
<tr>
<th>Maxillary skeletal relationship</th>
<th>Pre-treatment CR position</th>
<th>Pre-treatment MIC position</th>
<th>Post-treatment</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA (°)</td>
<td>79</td>
<td>80.3</td>
<td>82 ± 3.5</td>
<td></td>
</tr>
<tr>
<td>Nv-A (mm)</td>
<td>0.8</td>
<td>0.8</td>
<td>0 ± 2</td>
<td></td>
</tr>
<tr>
<td>Ar-A (mm)</td>
<td>76.1</td>
<td>79.3</td>
<td>93.1 ± 4.5</td>
<td></td>
</tr>
<tr>
<td>Mandibular skeletal relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNB (°)</td>
<td>82.3</td>
<td>84</td>
<td>81.1</td>
<td>77.7 ± 3.2</td>
</tr>
<tr>
<td>Nv-Pog (mm)</td>
<td>8.2</td>
<td>10.5</td>
<td>3.7</td>
<td>-5 ± 8</td>
</tr>
<tr>
<td>Ar-Gn (mm)</td>
<td>101.1</td>
<td>106</td>
<td>100.8</td>
<td>119 ± 5.8</td>
</tr>
<tr>
<td>Maxillo-mandibular relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANB (°)</td>
<td>-3.3</td>
<td>-6</td>
<td>-0.8</td>
<td>4 ± 1.8</td>
</tr>
<tr>
<td>Wits (mm)</td>
<td>-4.6</td>
<td>-8.5</td>
<td>-1.6</td>
<td>-1 ± 1</td>
</tr>
<tr>
<td>Vertical relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SN-MP (°)</td>
<td>24.4</td>
<td>23</td>
<td>27.6</td>
<td>33 ± 6</td>
</tr>
<tr>
<td>Gonial angle (°)</td>
<td>109.9</td>
<td>109.8</td>
<td>125.3 ± 6.7</td>
<td></td>
</tr>
<tr>
<td>Dental relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1-SN (°)</td>
<td>114.4</td>
<td>118.2</td>
<td>108.2 ± 5.4</td>
<td></td>
</tr>
<tr>
<td>L1-MP (°)</td>
<td>92.9</td>
<td>88.4</td>
<td>96.8 ± 6.4</td>
<td></td>
</tr>
<tr>
<td>UADH (mm)</td>
<td>23</td>
<td>23.5</td>
<td>29 ± 2</td>
<td></td>
</tr>
<tr>
<td>UPDH (mm)</td>
<td>21.7</td>
<td>21.5</td>
<td>20 ± 2</td>
<td></td>
</tr>
<tr>
<td>LADH (mm)</td>
<td>35.9</td>
<td>38.4</td>
<td>45 ± 3</td>
<td></td>
</tr>
<tr>
<td>LPDH (mm)</td>
<td>28.4</td>
<td>30.1</td>
<td>35 ± 3</td>
<td></td>
</tr>
<tr>
<td>Soft tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UL-E line (mm)</td>
<td>-2.2</td>
<td>-2.5</td>
<td>-1.5</td>
<td>1 ± 2</td>
</tr>
<tr>
<td>LL-E line (mm)</td>
<td>1</td>
<td>1.5</td>
<td>0.4</td>
<td>2 ± 2</td>
</tr>
<tr>
<td>FCA (°)</td>
<td>-3.1</td>
<td>-10</td>
<td>-0.8</td>
<td>9.7 ± 4.9</td>
</tr>
<tr>
<td>Nasolabial angle (°)</td>
<td>95.6</td>
<td>85</td>
<td>88.6</td>
<td>93.6 ± 9.8</td>
</tr>
</tbody>
</table>

Figure 4. Pre-treatment (A) and post-treatment (B) postero-anterior radiographs.
DIAGNOSIS

On the basis of clinical and cephalometric findings, the diagnosis was as follows:

1. Skeletal Class III relationship with retrusive maxilla and protrusive mandible
2. Hypodivergent vertical pattern
3. Dental Class III relationship with anterior crossbite
4. Proclined upper incisors
5. MIC–CR shift
6. Palatal crossbite of #15

TREATMENT OBJECTIVES AND TREATMENT PLAN

The treatment objectives for this patient, although somewhat controversial, were to maximize her maxillary growth and induce mandibular clockwise rotation to correct her skeletal problem and improve facial esthetics before completion of her residual mandibular growth.

1. Skeletal relationship: Correct Class III skeletal problem and hypodivergent facial pattern through growth modification
2. Dental relationship: Correct anterior crossbite; correct transverse deficiency; obtain adequate overbite and overjet; achieve Class I canine and molar relationship; if possible achieve overcorrection
3. Soft tissue: Correct concave facial profile; correct reverse smile arc and increase tooth show

To meet these objectives, we proposed the following treatment plan:

1. Maxillary screw-assisted expander to skeletally expand the maxilla
2. Upper partial fixed appliance for upper anterior tooth leveling and alignment
3. Facemask protraction on screw-retained maxillary appliance to maximize skeletal protraction and minimize dental side effects

TREATMENT ALTERNATIVES

The treatment alternative for this patient was to wait until growth was complete. The overall dental and skeletal problems could have been treated through surgical intervention. However, the patient and her parents wanted to try non-surgical growth modification at this time, although surgical correction may still be needed if the mandible has considerable growth after treatment. All risks and side effects were thoroughly explained to the patient and her parents before treatment began.

Table 2. Pre-treatment and post-treatment postero-anterior radiograph transverse measurements

<table>
<thead>
<tr>
<th></th>
<th>Pre-treatment</th>
<th>Post-treatment</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal width (N-N, mm)</td>
<td>27.3</td>
<td>29.5</td>
<td>27.7 ± 3</td>
</tr>
<tr>
<td>Maxillary width (J-J, mm)</td>
<td>62.5</td>
<td>65.3</td>
<td>65.0 ± 3</td>
</tr>
<tr>
<td>Maxillary intermolar width (mm)</td>
<td>50</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Mandibular width (Ag-Ag, mm)</td>
<td>76.7</td>
<td>77.3</td>
<td>80.5 ± 3</td>
</tr>
</tbody>
</table>
**TREATMENT PROGRESS**

Treatment began with the application of bands on the maxillary first molars followed by pick-up of the impression. A mini-screw-assisted maxillary skeletal expander (MSE, Biomaterials Korea Inc., Seoul, South Korea, designed by Dr. Won Moon) was soldered to the maxillary first molar bands. After the skeletal expander was cemented to the maxillary first molars, four mini-screws (1.5 × 11 mm, ACR screws, Biomaterials Korea Inc.) were inserted directly using a mini hand driver under local anesthesia. We used post-surgical PA film to verify bi-cortical engagement of the mini-implants. The expansion rate was 0.5 mm/day for the first week. After 1 week, diastema was observed and the rate of activation was changed to 0.25 mm/day for another two weeks. In addition, a facemask was used at the same time with a force level of 450 g/side. When the amount of desired expansion was achieved (Figure 5), we adapted an alternating rapid maxillary expansion and constriction (Alt-RAMEC) protocol to facilitate peri-maxillary suture loosening. We alternated between 1 week of expansion and 1 week of constriction for 8 weeks with the rate of 0.5 mm/day. Positive overjet was observed after 2 weeks of treatment without any fixed appliances, and the diastema gradually closed by itself. We also placed a bite turbo on the lingual side of her lower left lateral incisor to facilitate #22 to jump the crossbite. In the fifth month of treatment, we placed fixed appliances on her maxillary incisors for anterior alignment (Figure 6). In the 10th month of treatment, canine brackets were bonded to level her smile arc. After 14 months of treatment, the fixed appliances were removed, except the maxillary screw-retained expander with facemask hook. Night-time wear of the facemask continued for maintenance and to avoid relapse caused by residual mandibular growth.

**TREATMENT RESULT**

After 14 months of treatment, anterior crossbite and transverse insufficiency were corrected by the maxillary mini-screw-assisted expander and facemask treatment. Bilateral Class I molar relationship, Class I canine relationship on the right side, and Class II canine relationship on left side were achieved. Overjet was overcorrected to allow further residual mandibular growth after debonding (Figure 7). Improvement of the patient’s lateral profile was clearly observable on comparison of pre- and post-treatment photos, from concave to straight (Figure 8, 9).

Superimpositions of cephalometric tracings showed forward and downward movement of the maxillary bone. SNA angle and Ar-A length increased by 1.3° and 3.2 mm, respectively. The mandibular response to the treatment was backward rotation, which led to an increase in the mandibular plane angle of 4.6° compared with the MIC position. We observed some mandibular growth during treatment (Figure 10, 11A).

From regional superimpositions, the maxillary incisors extruded and flared forward by 3.8°, whereas the maxillary molar position was almost unchanged sagittally and vertically. On the mandibular arch, the lower incisors extruded and became retroclined; lower molar extrusion was caused by the facemask and bite-jumping (Figure 11B).

PA comparisons showed a substantial increase in skeletal width in the nasal, maxillary, and intermolar regions (Figure 12, Table 2). The skeletal expansion amount in these three regions was 2.2 mm, 2.8 mm, and 4.0 mm, respectively. The ratio of overall changes of maxillary to intermolar width was 70%. We also observed increased width and clearness of the nasal airway when pre- and post-treatment PA films were compared (Figure 4).
Figure 5. Maxillary skeletal expander. Maxillary occlusal view of pre-treatment and post-treatment expansion. The amount of expansion was less than usual because the maxillary width of the patient was not far from the ideal. The skeletal anchorage was used mainly for maxillary protraction.

Figure 6. Upper photos 1 month after treatment when the tooth jumped the crossbite. Lower photos 5 months after treatment.

Figure 7. Post-treatment intraoral photos. Upper maxillary skeletal expander with facemask hooks left in place for night-time facemask use.
Figure 8. Post-treatment extraoral photos.

Figure 9. Profile change from pre-treatment to post-treatment.

Figure 10. Post-treatment cephalometric and panoramic radiographs.
Figure 11. Cephalometric superimpositions. Overall superimposition registered at the cranial base and S point (A), maxillary superimposition using the structure method and mandibular superimposition registered on the anterior internal cortex of symphysis and mandibular lower border (B).

Figure 12. Parameters used for Table II. Postero-anterior transverse measurement. Nasal width = NR-NL (mm), maxillary width = JR – JL (mm), mandibular width = AgR - AgL.
DISCUSSION

Class III growth modification

Skeletal Class III malocclusion may comprise deficient maxillary growth, excessive mandibular growth, or a combination of both. Contemporary treatment modalities include the use of a chincap (chincup), facemask with or without palatal expansion, and intraoral Class III elastics with skeletal anchorage. The former two traditional modalities were used widely for a long time, whereas the third method arose after bone anchorage increased in popularity in orthodontics. Regarding the traditional methods, chincap therapy is indicated for hyperdivergent Class III patients with relatively normal maxillary growth. It causes backward and downward mandibular rotations and temporarily restricts mandibular growth. Sugawara et al. obtained long-term results of chincap therapy for Class III children and found that, although treatment results were satisfactory at the end of treatment, they were difficult to maintain afterwards because of catch-up growth of the mandible.

Conversely, facemask (reverse-pull headgear) treatment is believed to encourage maxillary growth, particularly at a younger age. Facemask treatment timing of approximately 10 years of age or younger has been recommended to obtain substantial treatment results, and simultaneous palatal expansion may provide greater skeletal effects. However, whether differences exist in maxillary sagittal correction between facemask cases with and without rapid palatal expansion (RPE) remains a matter of debate. Liou et al. recommended an Alt-RAMEC protocol to disarticulate the maxilla to promote maxillary growth. Recent clinical studies and systemic reviews have confirmed the effectiveness of the Alt-RAMEC protocol in stimulating maxillary growth combined with RPE and facemask treatment. The expected amount of maxillary protraction is typically between 2 and 4 mm, whereas Liou et al. reported more sagittal gain than traditional facemask treatment with the alt-RAMEC protocol. However, treatment timing in these case reports was still limited to pre-adolescence; the amount of maxillary skeletal protraction is questionable if the patient is treated after this age.

Bone-anchored maxillary protraction devices have been promoted after mini-implants recently became popular in orthodontics. Recent case reports regarding bone-anchored facemasks have consistently obtained promising skeletal effects with minimal dental changes; in a case report by Wilmes et al., hybrid hyrax combined with the alt-RAMEC protocol produced a 7-mm gain in Wits appraisal without dental side effects. Ngan et al. compared patients treated with bone-anchored RPE with facemasks and tooth-anchored facemasks, and found that the bone-anchored facemask group had less pronounced skeletal vertical change, whereas the tooth-anchored facemask group had more incisor proclination, molar relationship correction, and overjet reduction. Although the results indicated successful reduction of dental side effects, the age limit in these treatment groups was still confined to pre-adolescence.

In our case, the 13-year-old patient initially presented with severe jaw discrepancy because of both maxillary retrusion and mandibular prognathism, even at the CR position. The cervical vertebral maturation stage (CVMS) of the patient revealed that she had been undergoing a growth spurt and it was therefore too late for Class III growth modification according to the literature mentioned above. Therefore, we chose a bone-anchored rapid palatal expansion device (MSE), designed by Moon, to maximize the skeletal protraction and simultaneously correct the mild transverse discrepancy. The appliance was positioned more posteriorly compared with other skeletal expansion devices closer to the center of resistance of the maxilla, and the screws were bicortically engaged to facilitate the parallel expansion. Additional peri-maxillary suture stimulation and
maxillary protraction were attempted through expansion with the alt-RAMEC protocol. We adapted a less amount of activation (0.5mm /day) compared to the protocol proposed by Liu,\textsuperscript{18,19} to avoid bony anchorage loosening due to stress concentration. Regarding the treatment result, the overall superimposition revealed that her maxilla was substantially protracted forward and nasion growth had occurred. Some mandibular growth occurred during treatment, and her mandible exhibited clockwise rotations. Regional superimposition also revealed that maxillary dental side effects such as molar extrusion and incisor proclination, which have often been observed in traditional facemask treatment, were greatly reduced during treatment. The skeletal effect of the bone-anchored facemask combined with the Alt-RAMEC protocol seems to circumvent the age limit of traditional facemasks. However, additional clinical studies should be conducted to provide more solid evidence of this intervention.

Maxillary skeletal expansion

Maxillary skeletal expansion, or mini-implant-assisted rapid palatal expansion (MARPE), was first introduced a decade ago and has since been widely adopted. Cone-beam computed tomography images and radiographs of cases of MARPE have confirmed maxillary suture opening from late adolescence to adulthood. This skeletal expansion was not possible using traditional RPE, which causes more buccal dental tipping than skeletal correction.\textsuperscript{22,25-27} In our case, although the transverse discrepancy was mild and the inter-molar width expansion was only 4 mm, the proportion of skeletal expansion compared with dental expansion was approximately 70%, exceeding the average ratio of 40%-65% from previous studies.\textsuperscript{27,28} Traditional dental compensation in Class III patients with transverse deficiency often includes buccal inclination of maxillary buccal segments; however, in our case, the maxillary premolars were lingually inclined without any appliances being affixed, as a consequence of maxillary skeletal expansion.\textsuperscript{7}

Stability and post-pubertal mandibular growth

Sugawara followed 63 Class III patients receiving chin-cap treatment and compared them with untreated patients at different ages, and found that in both groups most mandibular growth occurred before the age of 14 years.\textsuperscript{3} However, the mandibular growth of Class III patients is highly variable, and late growth sometimes continues until the post-pubertal period.\textsuperscript{2,29} Regarding the long-term results of facemask treatment, Wells et al. reported a 25% to 30% relapse rate in a 10-year follow-up study,\textsuperscript{2} and Chen et al. reported unstable results in 4 out of 10 patients.\textsuperscript{14} Conversely, Mitani et al. studied post-pubertal mandibular growth of Class III and healthy patients, and found no differences in the amount of growth between the two groups.\textsuperscript{30} We can conclude that in most Class III patients, late mandibular growth may not differ from that in healthy patients, but some outliers may be observed. In our case, in pre-treatment, the skeletal maturation stage was CVMS 3, and in post-treatment, it was CVMS 4, indicating that the timing of our intervention coincided with a growth spurt to the post-pubertal stage. Thus, some residual growth of both the maxilla and mandible can be expected after treatment.\textsuperscript{3}

The current treatment outcome included considerable facial profile changes and FCA (Facial convexity angle) changed from -3.1°/-10° (CR/MIC) to -0.8° (Fig. 9, Table I). Midface projection improved greatly throughout the treatment. This result was primarily a consequence of maxillary downward forward protraction and minimal mandible downward backward displacement caused by extrusion of the lower teeth. Notably, the maxillary first molar almost retained its original position, and the incisor proclination was restricted to 3.8°. Smile arc and tooth show were also improved compared with pretreatment photos. Although the result was satisfactory, residual mandibular growth should be monitored.
CONCLUSION

In this case report, we presented the case of a 13-year-old Class III female patient treated using a maxillary skeletal expander with the Alt-RAMEC protocol and facemask protraction. The treatment was successful regarding the facial profile improvement; maxillary expansion and protraction was evident. Overcorrection of overjet was achieved in an effort to avoid relapse. However, long-term stability should be monitored owing to the patient’s skeletal age and the possibility of late mandibular growth.

CITATIONS