Maxillary protraction using miniplates as skeletal anchorage

ABSTRACT
Protraction facemasks have been used in the treatment of Class III malocclusion with maxillary deficiency. However, loss of dental anchorage has been reported with the use of tooth-borne anchorage devices such as lingual arches or maxillary expansion appliances. This side-effect can be minimized using temporary skeletal anchorage devices, such as mini-implants or miniplates. This case report describes the treatment of a 12-year-old girl with a Class III malocclusion and a maxillary deficiency. Miniplates were used as a skeletal anchorage system for maxillary protraction followed by a phase II orthodontic treatment with a fixed appliance. Skeletal, dental and facial changes in response to orthopedic and orthodontic treatment are reported to illustrate the esthetics, functionality, and stability of treatment with this technique.

Key words: Bone plates; Esthetics, dental; Fracture fixation; Malocclusion; Orthodontic anchorage procedures

Introduction
Growing patients who present with a skeletal Class III malocclusion and a hypoplastic maxilla can be treated orthopedically with a protraction facemask. The success of the treatment depends on the patency of the maxillary sutures and the availability of anchorage for maxillary orthopedic procedures. With increasing age, the midpalatal suture becomes increasingly tortuous and interdigitated. Several studies have reported on undesirable effects when using tooth-borne anchorage devices such as maxillary expansion appliances, Nance and lingual arches. These side-effects include excessive forward movement of the maxillary molars, maxillary incisors and extrusion of the maxillary molars.

Osseointegrated implants have been used as an adjunct to facemask therapy. Having been shown as biologically compatible with applied orthodontic forces, implants were also demonstrated to resist orthopedic forces in animal and clinical studies. Adolescent patients usually have a complete set of permanent dentition with no available site for implant placement. Several investigators have used alternative implant sites such as the retromolar area and palatal region. Umemori et al. applied titanium miniplates to the mandibular corpus area and used them as anchorage for the intrusion of the mandibular posterior segment. Block and Hoffman reported on the use of onplant, a subperiosteal disk as anchorage in experiments with dogs and monkeys. Hong et al.

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reported on the use of onplant to protract the maxilla with little loss in anchorage. The zygomatic buttress is an excellent area for placement of implants. The fixture is placed on basal rather than alveolar bone, and there are no adjacent tooth structures. Erverdi et al. 15 used zygomatic anchorage for the treatment of anterior open bite. Singer et al. 7 placed an implant in the zygomatic buttress area and used it as anchorage for facemask therapy. Miniplates have been used as skeletal anchorage for a wide range of applications 16-18. The success rate of miniplates is reported to be more than 80%. 19-21. The stability of connecting two mini-implants with a miniplate has been investigated 22. These miniplates were found to produce high pull-out force, stiffness, and yield force to resist pulling force and deformation in vitro. Several reports have been published on the use of miniplates for treatment of patients with maxillary hypoplasia 23-25. The present case report illustrates the use of miniplates for treatment of a Class III patient with a skeletal open bite tendency. Skeletal, dental and facial changes in response to orthopedic and orthodontic treatment are reported to illustrate the esthetics, functionality and stability of this treatment modality.

Diagnosis

A 12-year-old girl presented with a skeletal Class III malocclusion, a concave facial profile due to a combination of a retruded maxilla and protruded mandible and a 3-mm functional deviation of the mandibular midline to the right (Fig 1). Intraoral examination revealed a 1-mm reverse overjet, Class III molar relationship and congenital absence of the mandibular right and left second premolars (Fig 1). Cephalometric analysis showed an ANB angle of -0.6°, an angle of convexity of -0.8°, a decrease in maxillary length (79.6 mm) and an increase in mandibular length (114.1 mm). Vertically, the patient presented with an increase in the mandibular plane angle (MP/FH=38.6°). Dentally, the incisors were compensated to the skeletal malocclusion. The maxillary incisors to the Frankfort plane (U1/FH) angle was 112° and the mandibular incisors to the mandibular plane (IMPA) angle was 83° (Table). There was no family history of Class III malocclusion.

Treatment objectives

Based on the above diagnosis, the treatment objective was to normalize the skeletal discrepancy, correct the reverse overjet, establish a functional occlusion, prepare the patient for prosthetic replacement of the congenital missing mandibular premolars, and improve facial esthetics.

Treatment plan

The treatment plan for this patient included protraction of the maxilla, comprehensive orthodontic treatment with a fixed appliance, and eventually prosthetic treatment for the congenitally absent mandibular right and left second premolars. After due consideration of the subject’s age and the patency of the circum-maxillary sutures, the patient was informed that maxillary protraction in conjunction with a tooth-borne anchorage device such as a maxillary expansion appliance might result in significant dental side-effects rather than skeletal advancement of the maxilla. The patient consented to the placement of surgical miniplates as skeletal anchorage to minimize forward movement of the maxillary molars, maxillary incisors and extrusion of the molars. It was also decided that the mandibular second deciduous molars be retained during the maxillary protraction phase of treatment to prevent alveolar atrophy.
Thus, the implants were to be placed so as to replace the missing second premolar after all growth was complete.

**Alternative treatment plan**

An alternative treatment plan offered to the patient included removal of two lower retained second deciduous molars and closure of the space by losing anchorage from behind (with/without extraction of premolars in the upper arch). This option could reduce the complexity and duration of the treatment, and eliminate implant replacement for the congenitally missing premolars.

**Treatment progress**

After local infiltration anesthesia and surgical disinfection, a vestibular incision around the canine area was performed. After performing an atraumatic subperiosteal dissection of the infrayygomatic crest area, curvilinear type surgical miniplates (OsteMed Corp., Addison [TX], USA) were fixated with three self-tapping miniscrews on both sides of the infrayygomatic crest area. The end of the miniplate was exposed between the canine and the first premolar area and modified as a hook (Fig 2). Maxillary protraction was started 3 weeks later with a force of 300 cN to each side, and applied 12 to 14 hours per day. After 7.5 months of protraction therapy, an improvement of facial esthetics and occlusion was noted (Fig 3). The functional deviation of the mandible was eliminated. The dental midline was coincident after correction of the anterior occlusal interferences. Analysis of the post-treatment cephalometric radiograph showed that the position of the maxilla (SNA) had improved from 75.7° to 77.8°. The position of the mandible (SNB) had decreased from 76.2° to 73.6°. The angle of convexity was improved from -0.8° to 8.5°. The mandibular plane angle increased from 38.6° to 40.9°, and the maxillary incisors proclined from 112.0° to 113.7° (Table). Superimposition of the pre- and post-facemask treatment radiographs showed a forward and downward movement of the maxilla, which is usually only obtained with protraction headgear therapy in a much younger age-group. Yet there was relatively little dental tooth movement (Fig 4).

Comprehensive orthodontic treatment with a fixed

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Norm</th>
<th>Pretreatment (at 12 years)</th>
<th>After protraction headgear treatment (at 13 years)</th>
<th>After fixed appliance treatment (at 14 years and 2 months)</th>
<th>After 30 months of retention (at 16 years and 8 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA ('')</td>
<td>80.1</td>
<td>75.7</td>
<td>77.8</td>
<td>77.3</td>
<td>78.7</td>
</tr>
<tr>
<td>SNB ('')</td>
<td>77.5</td>
<td>76.2</td>
<td>73.6</td>
<td>73.5</td>
<td>75.5</td>
</tr>
<tr>
<td>ANB ('')</td>
<td>3.6</td>
<td>-0.6</td>
<td>4.1</td>
<td>3.8</td>
<td>3.3</td>
</tr>
<tr>
<td>A to N perpendicular to FH (mm)</td>
<td>-0.4</td>
<td>-7.7</td>
<td>-3.9</td>
<td>-3.9</td>
<td>-3.2</td>
</tr>
<tr>
<td>Angle of convexity (NAPog) ('')</td>
<td>0.0</td>
<td>-0.8</td>
<td>8.5</td>
<td>6.9</td>
<td>6.7</td>
</tr>
<tr>
<td>Mandibular length (Co-Pog) [mm]</td>
<td>110.5</td>
<td>114.1</td>
<td>115.2</td>
<td>117.3</td>
<td>120.3</td>
</tr>
<tr>
<td>Midfacial length (Co-A) [mm]</td>
<td>87.8</td>
<td>79.6</td>
<td>84.3</td>
<td>83.0</td>
<td>83.2</td>
</tr>
<tr>
<td>MP to FH ('')</td>
<td>27.2</td>
<td>38.6</td>
<td>40.9</td>
<td>41.1</td>
<td>41.1</td>
</tr>
<tr>
<td>PP to FH ('')</td>
<td>0.6</td>
<td>4.7</td>
<td>5.4</td>
<td>3.3</td>
<td>2.1</td>
</tr>
<tr>
<td>N to ANS (mm)</td>
<td>56.4</td>
<td>58.2</td>
<td>60.4</td>
<td>60.7</td>
<td>61.1</td>
</tr>
<tr>
<td>ANS to Me (mm)</td>
<td>65.4</td>
<td>73.2</td>
<td>75.4</td>
<td>77.4</td>
<td>78.1</td>
</tr>
<tr>
<td>U1 to FH ('')</td>
<td>116.6</td>
<td>112.0</td>
<td>113.7</td>
<td>108.9</td>
<td>110.4</td>
</tr>
<tr>
<td>IMPA ('')</td>
<td>84.0</td>
<td>83.0</td>
<td>72.8</td>
<td>81.3</td>
<td>82.3</td>
</tr>
<tr>
<td>Nasolabial angle ('')</td>
<td>105.0</td>
<td>93.5</td>
<td>91.2</td>
<td>99.0</td>
<td>92.2</td>
</tr>
<tr>
<td>UL to E-line (mm)</td>
<td>-3.3</td>
<td>-3.9</td>
<td>-2.3</td>
<td>0.1</td>
<td>-0.9</td>
</tr>
<tr>
<td>LL to E-line (mm)</td>
<td>-2.5</td>
<td>1.3</td>
<td>2.1</td>
<td>3.5</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Appliance was initiated immediately after completion of the facemask treatment. The protraction headgear was used at night for 2 months during this second phase of treatment, so as to maintain the forward position of the maxilla. After 12 months of fixed appliance treatment, the facial esthetics had improved and a functional occlusion was established (Fig 5). Moreover, the overbite and overjet were improved and the midlines were coincident. The spaces for the congenitally absent mandibular second premolars were maintained and patient was referred to the Department of Prosthetics for placement of implants. Superimposition of the pre- and post-second-phase treatment cephalometric radiographs revealed that the skeletal change during this comprehensive protraction facemask therapy was stable (Fig 6 and Table).

During the 30-month post-retention observation period, the patient showed a slight decrease in overjet due to additional mandibular growth. No changes were noted in the horizontal and vertical movement of Point A, and upper and lower incisor positions remained relatively stable (Fig 7 and Table).

**Discussion**

The success of orthodontic treatment in patients developing...
Class III malocclusion depends on individual growth and the
timing of orthodontic and/or orthopedic interventions. In
childhood (with early mixed dentition), sutural expansion
can be accomplished with almost any type of expansion
device. By early adolescence or early permanent dentition,
terdigitation of spicules extending into sutures is such
that a jackscrew with considerable force is required to create
micro-fractures, before the sutures can be disarticulated.
By the late teens (after puberty), interdigitation and areas
of bony bridging across the sutures make it impossible to
attain maxillary expansion or skeletal protraction using
only tooth-borne anchorage devices. A combination of
maxillary protraction and rapid maxillary expansion has
been used to treat young patients with Class III maxillary
deficiency. The protraction headgear or facemask
therapy is usually carried out using tooth-borne anchorage
devices, such as lingual arches and expansion appliances.
Orthopedic force on the nasomaxillary complex is
directed along the occlusal plane rather than at the center
of maxillary resistance, which is located between the mesial
buccal cusp of the maxillary molar and the infraorbitale. As
a result, bone remodeling occurs not only at the circum-
maxillary sutures but also within the periodontal tissues.
Another side-effect of protraction along the occlusal plane
is the tipping of the palatal plane and extrusion of the
maxillary molars. The advantage of using surgical miniplates
as anchorage is that the maxillary complex moves with no
apparent tooth movement. Due to the age of the patient
and the possible side-effects associated with tooth-borne
anchorage appliance for maxillary protraction, in the
present case, skeletal anchorage was used instead of tooth-
borne anchorage. After 7.5 months of protraction therapy,
significant forward movement of the maxilla was obtained
with relatively little forward movement of the maxillary
molars and incisors. Vertically, extrusion of the maxillary
molars was minimized during the protraction therapy (Fig 4).

Proper placement of the miniplate and surgical screws
are important in the success of orthopedic protraction. In a
previous study, a Y-shaped miniplate was shown to produce
minimal stress during maxillary protraction. Three to
four surgical screws are usually adequate in resisting an
orthopedic force of 400 to 500 cN per side. The direction
of screw placement should be in a postero-superior
direction to avoid damage to the premolar tooth germs.
The placement of screws in a posterior-superior direction
in the infrrazygomatic area should be well away from the
developing tooth germs. Studies have also shown that
the bone quality in the infrrazygomatic crest or the piriform
aperture area are generally good and have sufficient
anchorage for the maintenance of surgical screws during
loading. The plate should be positioned so that the screws
line up with the direction or line of action of the orthopedic
force, which is 30° downward from the occlusal plane.
The end of the miniplate is exposed between the canine and

Figure 6 Superimposition of cephalometric tracings after maxillary
protraction and second-phase treatment

Figure 7 Facial and intraoral photographs of the patients
(at 16 years and 8 months) after 30 months of retention and
superimpositions of cephalometric tracings after second-phase
treatment and after 30 months of retention
first premolar area (located over the keratinized attached gingiva) in order to prevent gingival irritation, and modified as a hook for elastic traction. Facemask treatment is started when the patient returns to the oral surgery clinic for the postoperation check-up. It was shown that immediate loading of surgical screws with known forces increases bone density surrounding the screws 17.

In the present case report, facemask therapy was stopped after 7.5 months of active maxillary protraction and 2 months of night-time wearing was deemed necessary during comprehensive orthodontic treatment, so as to maintain the forward position of the maxilla. The advantage of using skeletal versus tooth-borne anchorage is the ability to apply orthopedic force for a longer period of time without causing root resorption 18.

Maxillary protraction along the occlusal plane is usually accompanied by counterclockwise rotation of the palatal plane and downward and backward rotation of the mandible, which result in a tentative improvement of the skeletal relationship 13-5-7. However, vertical relapse is often noted after removal of the appliance, in which case the mandible rotates upward and forward post-treatment. This can be minimized by protracting the maxilla at the level of its center of resistance. The placement of a miniplate in the infrayygomatic area allows maxillary protraction to be performed above the occlusal plane. In the present case, a 0.7° counterclockwise tipping of the palatal plane, a slight increase in the mandibular plane, and a lower facial height were observed. Keles et al. 6 suggested modification of the facemask to allow maxillary protraction at the level of its center of resistance. Long-term assessment suggests that the palatal plane returns to its baseline state 3. In a long-term study with protraction facemasks, the palatal and mandibular plane angles returned to pretreatment values 48 months after removal of the appliances 29.

The patient described here was treated during the pubertal growth period, to take advantage of patent maxillary circum-maxillary sutures. Disproportionate growth between the maxilla and the mandible was anticipated after treatment, and it was suggested that the maxilla be over-corrected to anticipate excessive growth of the mandible during the remaining growth period. In future, the use of miniplates may provide a window of opportunity for performing maxillary protraction in older patients, whenever greater anchorage is needed for distraction of maxillary sutures. Further studies can look into the ideal age-dependent force levels and the optimal force vectors for patients with a deep or open bite. In addition, the limits of skeletal anchorage protraction therapy need to be evaluated, with a view to develop differential indications to deal with midface distraction osteogenesis.

**Conclusion**

Maxillary protraction using miniplates as anchorage is a viable skeletal system when critical anchorage is demanded for orthodontic or orthopedic treatment. This system is particularly useful in older patients, when greater anchorage is needed due to interdigitation of the maxillary sutures, and in patients with skeletal open bite tendency in whom bite opening should be avoided.

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**References**

9. Smalley WM, Shapiro PA, Hohl TH, Kokich VG, Brånenmark PI. Osseointegrated titanium implants for maxillofacial protraction.


