Maxillary protraction with miniplates providing skeletal anchorage in a growing Class III patient

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Maxillary protraction headgear has been used in the treatment of Class III malocclusion with maxillary deficiency. However, loss of dental anchorage has been reported with tooth-borne anchorage such as lingual arches and expansion devices. This side effect can be minimized with skeletal anchorage devices such as implants, onplants, mini-implants, and miniplates. The use of miniplates for maxillary protraction in the mixed dentition has not been reported in the literature. This case report describes the treatment of an 8-year-old girl with a Class III malocclusion and maxillary deficiency. Miniplates were used as skeletal anchorage for maxillary protraction followed by phase 2 orthodontic treatment with fixed appliances. Skeletal, dental, and facial changes in response to orthopedic and orthodontic treatment are reported to illustrate the esthetics, function, and stability of treatment with this new technique. (Am J Orthod Dentofacial Orthop 2011;139:99-112)

Maxillary protraction headgear has been used in the treatment of Class III patients with maxillary retrusion. Clinical studies have shown that 2 to 4 mm of maxillary advancement can be obtained with 8 to 12 months of maxillary protraction. This is the result of a combination of forward movement of the maxilla, downward and backward rotation of the mandible, labial tipping of the maxillary incisors, and lingual tipping of the mandibular incisors.[1-5] Most of these studies used tooth-borne anchorage devices such as a lingual arch, quad helix, or maxillary expansion appliance.[1-3] The disadvantages of tooth-borne anchorage devices are loss of anchorage, especially when preservation of arch length is necessary, and the inability to apply orthopedic force to the maxilla directly. Many investigators have attempted to design an absolute anchorage system for maxillary protraction including the use of intentionally ankylosed maxillary deciduous canines, osseointegrated titanium implants, onplants, miniscrews, and miniplates.[6-9] Each implant system has strengths and weaknesses. Miniplates, for example, have been used with success for a variety of orthodontic anchorage needs including intrusion of posterior molars, correction of anterior open bite, retracting mandibular molars, and treatment of patients with maxillary hypoplasia.[10] Surgical or titanium miniplates are gaining popularity as an orthodontic implant anchor because they have been proven safe and effective for fractures and osteotomies, and they can be placed above the tooth roots to facilitate orthodontic tooth movement. The use of miniplates in the treatment of maxillary hypoplasia in growing Class III patients has not been reported in the literature. This case report illustrates the use of surgical miniplates as anchorage for maxillary protraction in the mixed dentition.

DIAGNOSIS AND ETIOLOGY

The patient, an 8-year-old girl, came to the Kangnung National University Orthodontic Clinic in Gangneung, South Korea, with a chief concern of "my bite is not right." Clinically, she had a concave facial profile, and acute nasolabial angle, and a protrusive mandible

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Fig 1. Pretreatment photographs.

(Fig 1). Intraorally, she had an anterior crossbite and a low anterior tongue posture. The maxillary right first deciduous molar and left second deciduous molar had exfoliated prematurely, and midarch crowding was noted on the dental casts and panoramic radiograph. The cephalometric radiograph and tracing showed a skeletal Class III malocclusion with maxillary deficiency, mandibular prognathism (ANB, −2.2°), and a normal mandibular plane angle (FMA, 23°). The maxillary incisors were proclined (U1 to FH, 109°), and the mandibular incisors were retroclined (IMPA, 86°), compensating for the skeletal malocclusion (Figs 2 and 3, Table). There was no family history of mandibular prognathism.

TREATMENT OBJECTIVES

In determining our treatment objectives, we asked the patient whether she was willing to undergo a surgical operation. She was willing if necessary. For that reason, our treatment consisted of phase 1 orthopedic treatment to protract the maxilla with a skeletal anchorage system. Surgical miniplates were used as anchorage instead of the conventional tooth-borne appliances to prevent possible mesial movement of the posterior dentition. The objective of this early phase of treatment was to induce harmonious growth of the maxilla with improvement in facial esthetics. Overcorrection of the maxilla to an overjet of 3 to 4 mm was desirable to anticipate excessive growth of the mandible during the pubertal growth spurt. The patient was followed for a period of time to determine whether the malocclusion could be camouflaged by orthodontic tooth movement. The phase 2 treatment was initiated at 11 years of age for 18 months to correct the remaining crowding, overjet, and overbite problems. The patient was placed in retention for 27 months after fixed appliance therapy to determine the stability of treatment without orthognathic surgery.

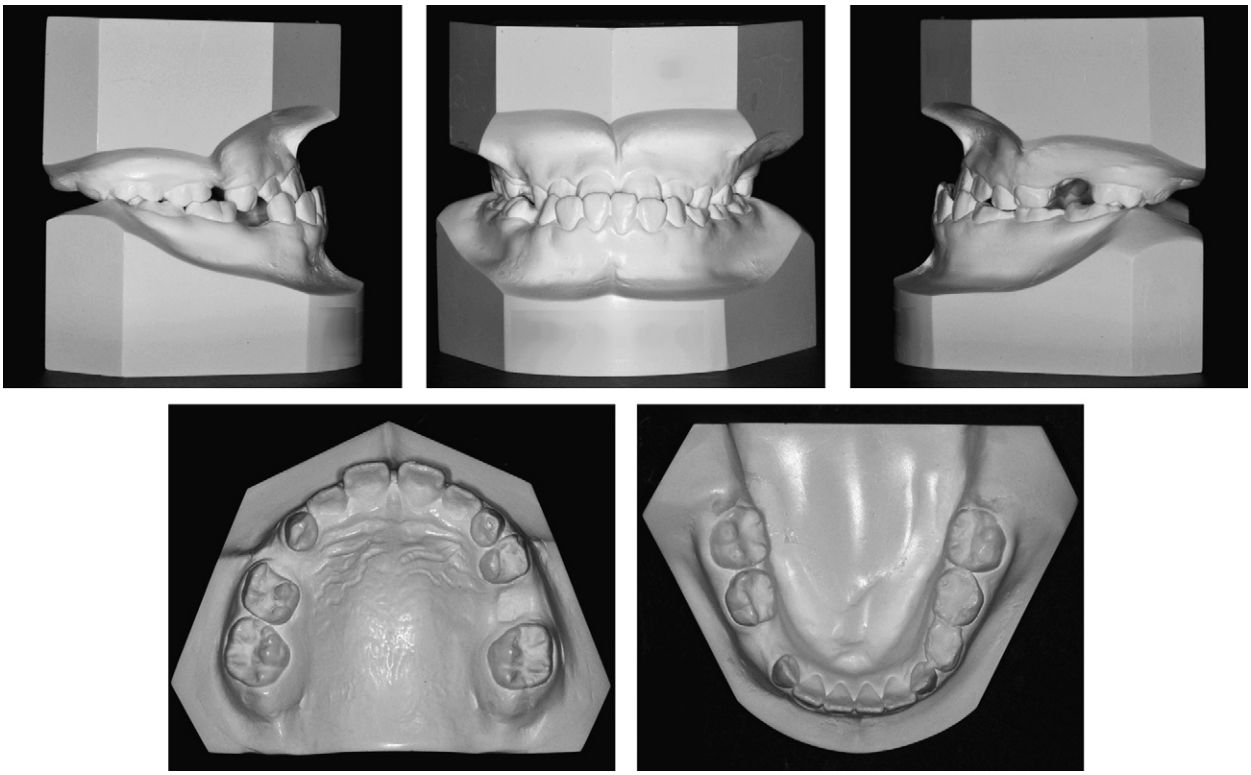


Fig 2. Pretreatment dental casts.

TREATMENT ALTERNATIVES

Based on the objectives, 2 treatment options were proposed. The first option was an early phase of orthopedic treatment to induce harmonious skeletal growth and improve facial esthetics followed by phase 2 treatment to correct the remaining crowding, overjet, and overbite problems. This option would not eliminate the necessity for orthognathic surgery. The patient would be followed to determine the stability of treatment. The second option would be to wait until all growth was completed and determine whether the malocclusion could be camouflaged by orthodontic treatment or a combination of surgical and orthodontic treatment.

TREATMENT PROGRESS

Phase 1 treatment was started at age 8 years 4 months with a maxillary removable appliance to regain space lost from the early loss of the deciduous molars (Fig 4). After 6 months of observation, a surgical miniplate was placed. Local infiltration anesthesia was administered to the maxillary left and right buccal vestibular areas after surgical disinfection. A vestibular incision around the canine area was performed. After an atraumatic subperiosteal dissection to the infrazygomatic crest, a curvilinear miniplate was adapted, bent to the zygomatic buttress's bony surface, and fixated with 3 self-tapping miniscrews per side (Fig 5, *A*). From our experience, at least 3 to 4 screws should be placed to resist the maxillary protraction force of about 300 to 400 cN per side. Screw placement should be in a posterior-superior direction to prevent damage to the premolar tooth follicles (Fig 5, *B*). The end of the miniplate entered the oral cavity between the canine and first premolar area in the keratinized attached gingiva to prevent gingival irritation. The oral portion of the miniplate was modified into a hook for elastic traction.

Maxillary protraction was started 2 weeks after placement of the miniplates, with a force of 300cN per side applied 12 to 14 hours per day (Fig 6). Within 10 months of treatment, a three quarters premolar width Class II molar relationship was established. Thereafter, the patient's wearing of protraction headgear was limited to nighttime only as a retainer for 10 months. The plates were removed after the facemask treatment. A mucoperiosteal incision and a subperiosteal dissection were performed to expose the miniplate. The monocortical screws were removed first, and the miniplate was then

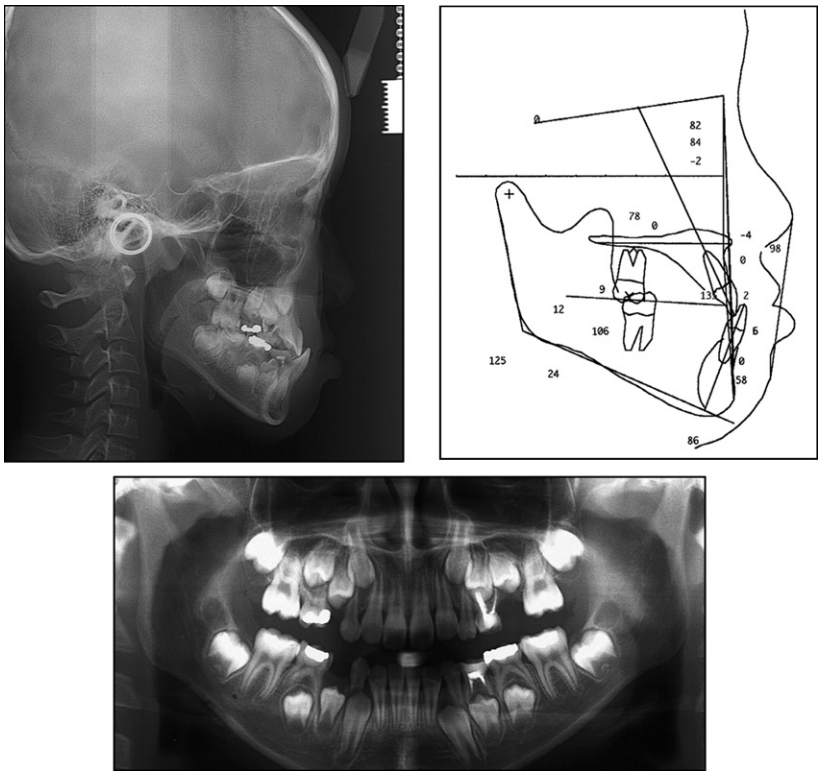


Fig 3. Pretreatment radiographs and tracing.

Table. Cephalometric measurements at pretreatment, after protraction headgear treatment, after fixed appliance treatment, and 27 months after removal of the fixed appliance

Measurement	*Pretreatment*	*After protraction headgear treatment*	*After fixed appliance treatment*	*27 months after fixed appliance treatment*
SNA (°)	81.8	89.1	91.3	92.3
SNB (°)	84.0	82.4	87.4	89.4
ANB (°)	−2.2	6.7	3.9	3.0
SNO (°)	63.0	70.0	67.0	70.0
A to N⊥ FH (mm)	0	8.1	7.7	9.1
Angle of convexity (NAPog) (°)	−4.1	12.8	7.4	5.4
Mandibular length (Co-Pog) (mm)	106.5	113.1	120.1	122.7
Midfacial length (Co-A) (mm)	77.9	89.0	90.8	93.6
MP-FH (°)	24.0	25.3	22.4	19.4
PP-FH (°)	0.4	−2.9	0.0	−1.5
U1-FH (°)	109.8	109.0	118.4	122.8
IMPA (°)	86.1	92.5	93.3	92.6
Nasolabial angle (°)	97.6	105.2	92.7	97.8
UL-RE line (mm)	−0.8	4.8	2.6	0.7
LL-RE line (mm)	5.4	5.5	6.9	5.5

detached because often new bone is deposited next to the plate. The surgical site was then closed and sutured.

Progress records taken at age 10 years 7 months showed favorable growth between the maxilla and the mandible, and the malocclusion could be camouflaged by orthodontic treatment. The patient was treated with fixed appliances for 18 months to establish a good molar relationship and correct the midline discrepancy. A maxillary circumferential retainer and a mandibular lingual fixed retainer were placed after appliance removal. The patient was instructed to wear the retainer at night for 10 to 12 hours.

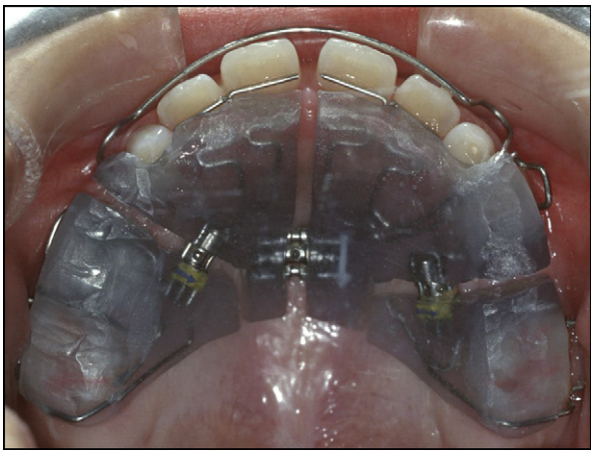
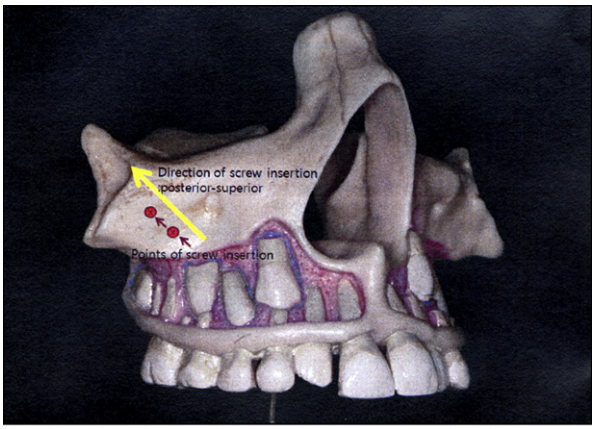


Fig 4. Phase 1 treatment included a maxillary removable appliance to regain space lost by early loss of the deciduous molars.



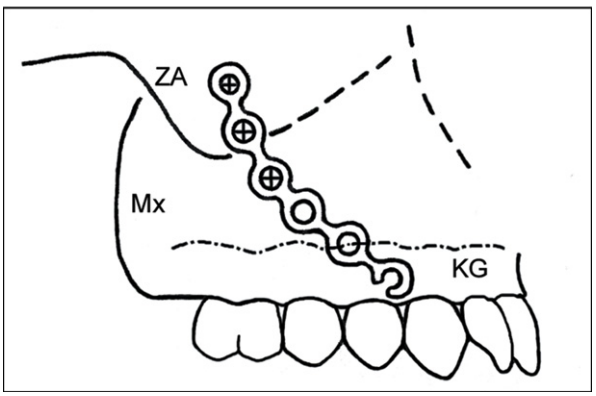
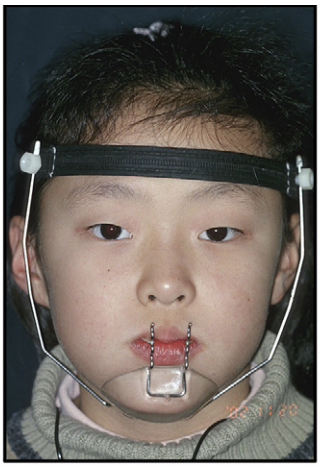


Fig 5. **A**, After atraumatic subperiosteal dissection to the infrazygomatic crest, a curvilinear miniplate was adapted, bent to the zygomatic buttress bony surface, and fixated with 3 self-tapping miniscrews; **B**, screws should be placed in a posterior-superior direction to prevent damage to the premolar tooth follicles.



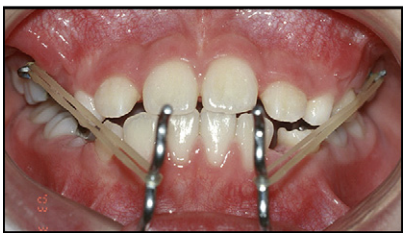


Fig 6. Maxillary protraction was started 2 weeks after placement of the miniplates.

TREATMENT RESULTS

Figures 7 through 9 show the results 14 months after protraction headgear treatment. The malocclusion was overcorrected to a Class II molar relationship to compensate for future excessive mandibular growth. Superimposition of pretreatment and posttreatment cephalometric tracings showed 8.1 mm of forward movement of A-point (A-point to N⊥FH) and 3.3° of counterclockwise tipping of the palatal plane (Fig 10). The ANB angle changed from −2.2° to + 6.7°. The SNO, or angle between the anterior cranial base and orbitale, changed from 63° to 70°. Labial tipping of the maxillary incisors and lingual tipping of the mandibular incisors, which are typically observed after tooth-borne protraction, were not seen with the miniplates.

Figures 11 through 14 show the results after phase 2 fixed appliance treatment at age 12 years 6 months. The ANB angle was reduced from 6.7° to 3.9°, indicating normalization of the jaw relationship after overcorrection in the phase 1 treatment. Class I canine and molar relationships were obtained, and overjet and overbite were returned to normal after phase 2 treatment. Superimposition of the postprotraction and posttreatment radiographs showed differential forward growth of the maxilla and the mandible,

Fig 7. Progress photographs after 14 months of protraction headgear treatment.

and compensation of the incisors to the skeletal growth (Fig 15).

Figures 16 and 17 show the patient at age 14 years 9 months, 27 months after the removal of the orthodontic appliances. During the retention period, the maxilla and the mandible showed relatively harmonious growth, maintaining an ANB difference of 3°. The angle of convexity was reduced from 7.4° to 5.4°. Superimposition of the posttreatment and postretention cephalometric tracings (Fig 18) showed continuous dental compensation to the skeletal discrepancy was observed with proclination of the maxillary incisors and slight retroclination of the mandibular incisors. Despite the mild lip protrusion and 0.5 mm of midline deviation, the patient was pleased with the final results without orthognathic surgery.

DISCUSSION

The success of orthodontic treatment in patients with a developing Class III malocclusion depends on individual growth and timing of orthodontic or orthopedic intervention. Patients with pseudo-Class III malocclusions and a mandibular shift can be successfully managed with routine orthodontic appliances, and the results can be maintained in the long term.[11,12] In these patients, anterior crossbites are corrected by proclining the maxillary incisors and retracting the mandibular incisors. For patients with moderate to severe Class III malocclusions, the decision of whether to treat early or to wait until the end of growth is difficult. Moreover, to what extent the growth modification can be successful is challenging. It is therefore important to

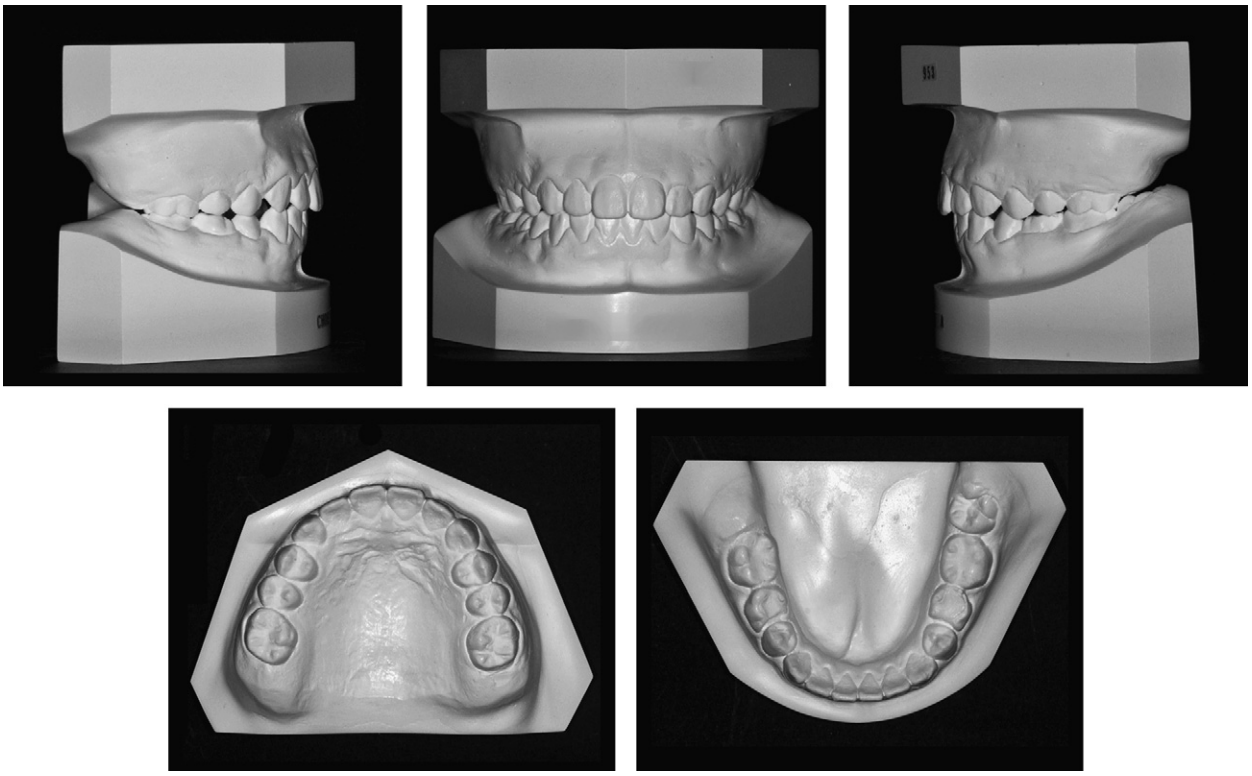


Fig 8. Progress dental casts after 14 months of protraction headgear treatment.

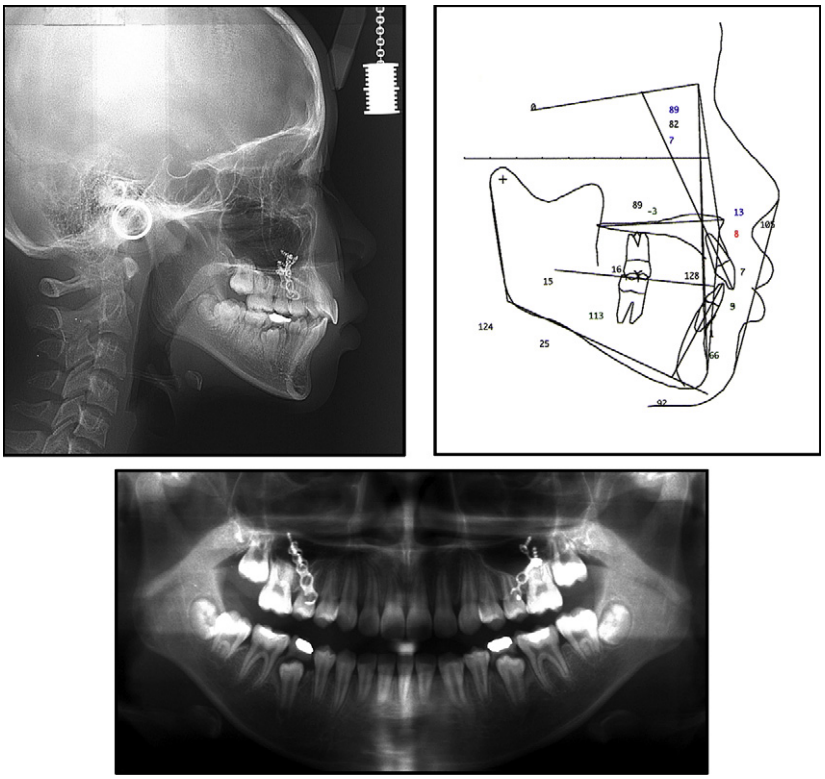


Fig 9. Progress radiographs and cephalometric tracing after 14 months of protraction headgear treatment.

Fig 10. Superimposed pretreatment and progress cephalometric tracings.

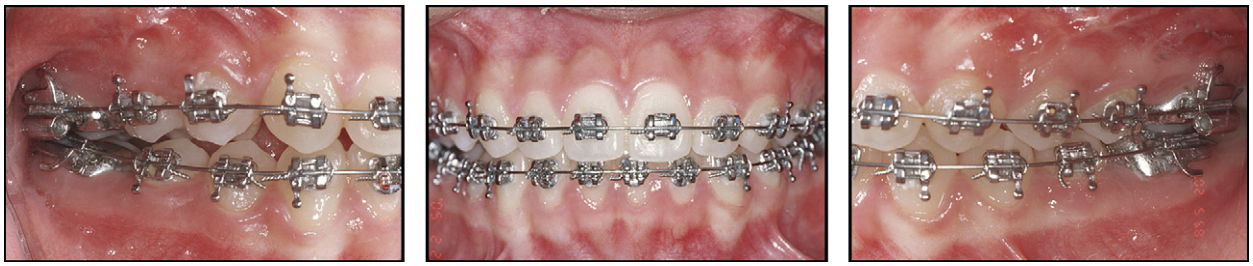


Fig 11. Intraoral photographs near the end of phase 2 fixed appliance treatment.

diagnose the degree of skeletal discrepancy to develop the appropriate treatment plan.[13]

A combination of maxillary protraction and rapid maxillary expansion has been used to treat young Class III patients with maxillary deficiency. Facemask therapy is usually managed with 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 resistance of the maxilla, which is located between the mesiobuccal cusp of the maxillary molar and infraorbitale. As a result, bone remodeling occurs not only at the circummaxillary sutures, but also within the periodontal ligament. Another side effect of protracting along the occlusal plane is the loss of arch length due to mesial movement of the posterior teeth, especially in the mixed dentition or inpatients with several congenitally missing teeth. The advantage of using surgical miniplates as anchorage is that the maxilla moves forward with no apparent tooth movement, as demonstrated in this case report. To date, this skeletal anchorage system has been used in more than 30 orthodontic patients in our clinic. Our clinical experience shows that the skeletal changes with this system are much greater than those of the conventional rapid maxillary expansion appliance and protraction headgear combination.[14-16] The

Fig 12. Posttreatment photographs after phase 2 fixed appliance treatment.

change in SNO (angle between the anterior cranial base and orbitale) (Table) suggests that maxillary protraction with skeletal anchorage might have a greater effect on the midface than the tooth-borne device.

In several reports about miniplates for maxillary protraction, 3 self-tapping monocortical screws were adequate for resisting an orthopedic force of 400 to 500 g per side.[17-21] Screw placement should be in a posterior-superior direction to avoid damage to the premolar tooth follicles. Figure 5, *B*, showed that placement of screws in a posterior-superior direction in the infrazygomatic area was far from the developing permanent teeth. Studies have shown that the bone quality in the infrazygomatic crest is generally good and provides sufficient anchorage for maintenance of the surgical screws during loading.[21,22] It is recommended that the plate should be positioned so that the screws will align with the direction of the orthopedic force, which was 30° downward from the occlusal plane. The end of the miniplate should enter the oral cavity between the canine and the first premolar in the keratinized attached gingiva to prevent gingival irritation. The exposed miniplate can be shaped as a hook for elastic traction. Facemask treatment should begin after 1 week. A study showed that immediate loading of surgical screws with known forces increases the bone density surrounding the screws.[22]

In this case report, the miniplates were removed after 10 months of active maxillary protraction and 10 months of nighttime protraction for retention. The advantage of using skeletal anchorage vs tooth-borne anchorage is the ability to apply orthopedic force for a longer time without causing root resorption. The additional 10 months of nighttime protraction minimized relapse after orthopedic treatment. A study showed that results are more stable with retention devices such as the Frankel FR-III or nighttime facemask wear after maxillary protraction.[23]

Maxillary protraction along the occlusal plane is usually accompanied by counterclockwise rotation of

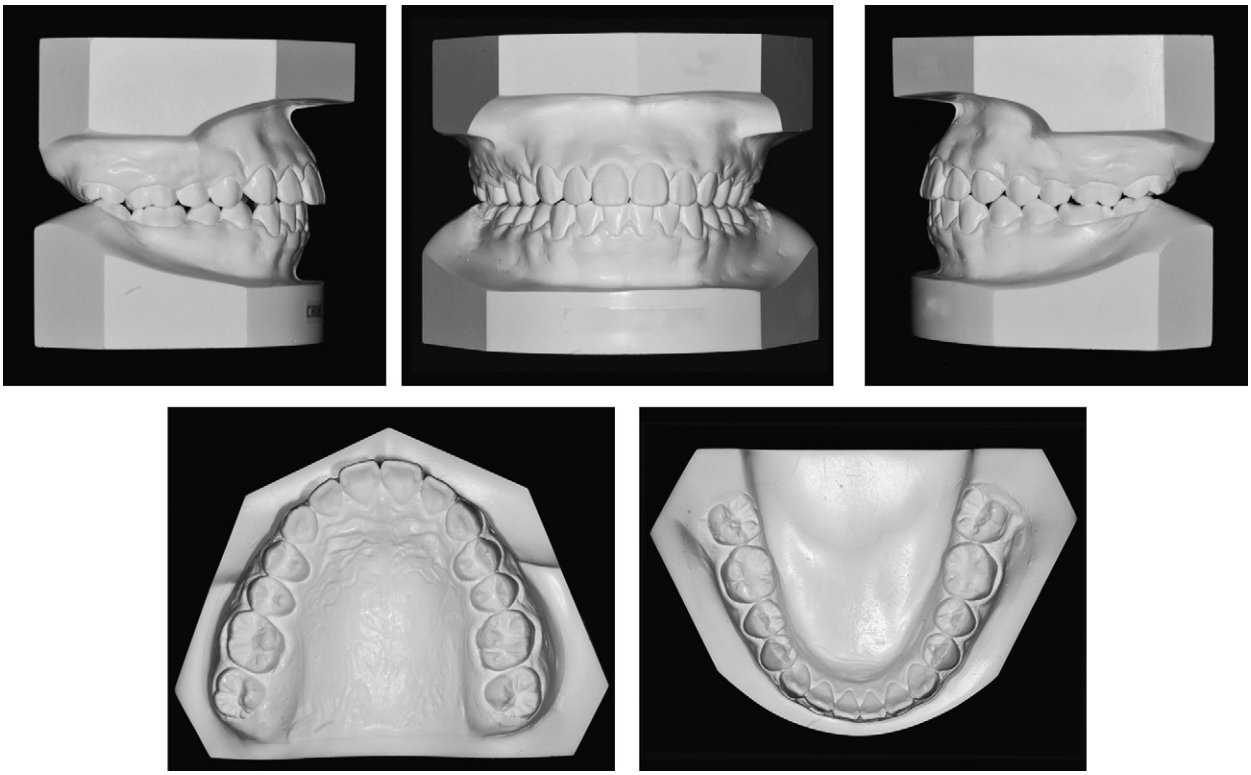


Fig 13. Posttreatment dental casts after phase 2 fixed appliance treatment.

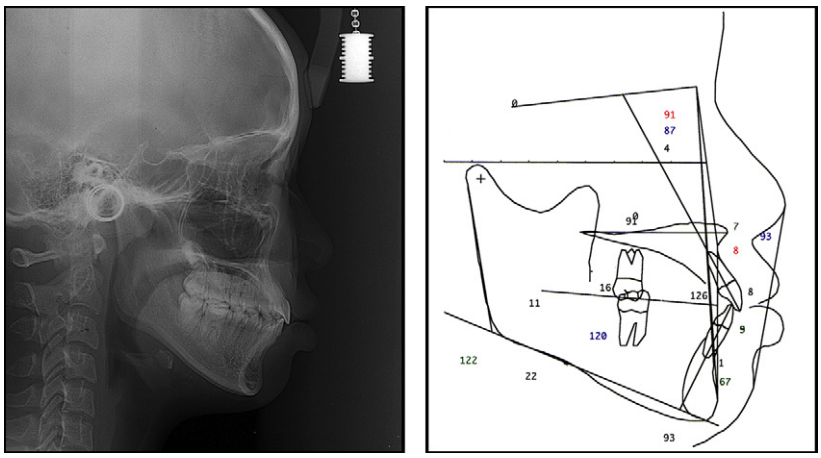


Fig 14. Posttreatment radiograph and tracing after phase 2 fixed appliance treatment.

the palatal plane, and downward and backward rotation of the mandible, resulting in tentative improvement of the skeletal relationship.[14-16] However, vertical relapse is often seen after removal of the appliance, when the mandible rotates upward and forward during the posttreatment period. This can be minimized by protracting the maxilla at the level of the center of resistance of the maxilla. The placement of the

Fig 15. Superimposition of postprotraction and posttreatment cephalometric tracings.

miniplate in the infrazygomatic area allows maxillary protraction to be performed above the occlusal plane. In this case report, a 3.3° counterclockwise tipping of the palatal plane and slight increases in the mandibular plane and lower face height were observed. Keles et al[24] suggested modification of the facemask to allow maxillary protraction at the level of the center of resistance of the maxilla. A long-term study suggested that the palatal plane will return to baseline value.[25] In this case report, the palatal and mandibular plane angles returned to their pretreatment levels 27 months after removal of the appliances.

Our patient was treated early, before the pubertal growth spurt to take advantage of the patent circumaxillary sutures. Disproportionate growth between the maxilla and the mandible was observed after treatment. The mandible outgrew the maxilla significantly more than the typical 2:1 ratio. These observations suggest that overcorrection of the maxilla is advisable in patients with moderate to severe skeletal Class III malocclusion to anticipate excessive growth of the mandible during the pubertal growth period.

One of the most important factors for successful maxillary protraction treatment is to determine the optimal time to start treatment. Although at least 1 study suggested that it is a viable option to perform maxillary protraction in older patients until age 13 or 14,[1] most studies suggest that protraction headgear therapy is more effective in the deciduous and early mixed dentitions.[3,15] This case report demonstrates that miniplates can be used as skeletal anchorage in the mixed dentition with stable results 27 months after retention. The decision to perform early orthopedic treatment or wait until growth is complete is not easy. The advantages of early treatment include minimizing dental compensation and overclosure of the mandible, which can lead to better facial esthetics and self-esteem during this important growth period. On the other hand, the patient might still have to undergo a surgical procedure after early orthopedic and orthodontic treatment, and the treatment time with mandibular surgery alone would be shorter.

In the future, the use of miniplates could provide a window of opportunity for maxillary protraction in older patients when greater anchorage is needed for distraction of maxillary sutures. Further studies can look into the ideal age-dependent force levels and the ideal force vectors in patients with deepbite or open bite. In addition, the limits of skeletal anchorage protraction therapy need to be evaluated to develop the differential indication against midface distraction osteogenesis.

CONCLUSIONS

Maxillary protraction with miniplates as anchorage is a viable skeletal anchorage system when critical

Fig 16. Postretention photographs 27 months after appliance removal.

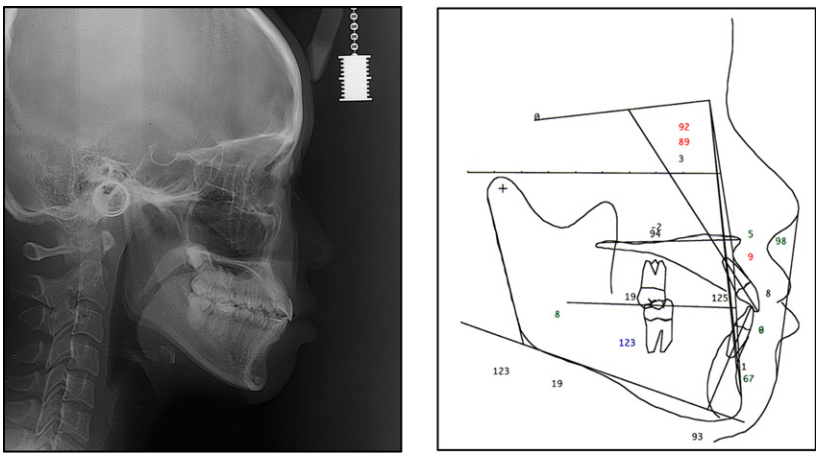


Fig 17. Postretention radiograph and cephalometric tracing 27 months after appliance removal.

Fig 18. Superimposition of posttreatment and postretention cephalometric tracings.

anchorage is demanded for orthodontic or orthopedic treatment. This system is particularly useful in patients in the mixed dentition, those with oligodontia, or older patients when greater anchorage is needed. Undesirable effects of conventional facemask therapy were either reduced or eliminated with miniplates. Because of its relatively simple design, this method is comfortable for patients, maintenance of good oral hygiene is easy, and the appliance does not invade the tongue space.

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