Case Report

Orthopedic Protraction with Skeletal Anchorage in a Patient with Maxillary Hypoplasia and Hypodontia

Beyza Hancioğlu Kircelli[a]; Zafer Özgür Pektaş[b]; Sina Uçkan[c]

Abstract: Multipurpose titanium miniplates were placed on the lateral nasal wall of the maxilla as anchorage for face mask protraction in an 11-year-old girl presenting with severe maxillary hypoplasia and hypodontia. Applying orthopedic forces directly to the maxilla resulted in an eight mm maxillary advancement. Intraosseous titanium screws were also placed on the palatal bone, near the alveolar crests, to provide anchorage for the expansion appliance. The maxilla was expanded from the median palatal suture, and seven mm of expansion was achieved across the buccal segments. No other tooth support was used for the expansion or the protraction of the maxilla. (*Angle Orthod* 2006;76:156–163.)

Key Words: Skeletal anchorage; Maxillary hypoplasia; Maxillary protraction; Face mask therapy; Miniplate

INTRODUCTION

Maxillary hypoplasia is characterized by deficiency of skeletal height, width, and anteroposterior relationships,[1] which requires multidirectional correction. The treatment of severe maxillary hypoplasia in a growing child commonly presents a challenging situation. Detrimental psychological effects depending on the physical deformity[2] and the functional deficiencies including mastication, speech abnormalities, and nasal pharyngeal airway constriction[3] necessitate an early intervention.

Distraction osteogenesis of the maxilla with rigid external devices is one of the treatment options that can be used in severe maxillary hypoplasia. In this process, the maxilla is distracted from the complete Le Fort I osteotomy line and the pterygomaxillary disjunction.[4] On the other hand, in the growing child, craniofacial sutures play a role as growth sites in the skull,[5] and they could be believed as natural distraction sides for stimulating further growth. Actually, face mask therapy in conjunction with rapid maxillary expansion[6–8] aims to stimulate maxillary growth at the sutural sites; however, conventional force application systems that attach elastic forces to the maxillary dentition makes it impossible to directly transfer forces to the circummaxillary sutures and to obtain major skeletal effects.[9]

For orthodontics, miniplates[10–12] and intraosseous screws[13–15] can be used as temporary rigid skeletal anchorage and have several advantages such as permitting immediate force application after soft tissue healing, ease of application, and cost.

In this case report, we present orthopedic protraction in a patient presenting with severe maxillary hypoplasia and hypodontia. The patient was treated with a face mask and rapid maxillary expansion, using only miniplates and intraosseous screws as anchorage in the maxilla.

CASE REPORT

An 11-year-old girl was referred with a complaint of "small and separated teeth" and "lower jaw projection." Medical history of the patient was noncontributory other than her parents were cousins. Furthermore, her elder brother presented with similar complaints of maxillary hypoplasia and hypodontia. Clinical and radiological examination revealed severe hypodontia and microdontia. Twenty-one of her permanent teeth were missing, whereas number 11, 21, 36, 46 existed in the dental arch and germs of the number 15, 37, and 47 could be detected on the panoramic radio-

[a] Instructor, Orthodontics, Adana Research and Teaching Center, Baskent University, Adana, Turkey.

[b] Instructor, Oral and Maxillofacial Surgery, Adana Research and Teaching Center, Baskent University, Adana, Turkey.

[c] Professor, Oral and Maxillofacial Surgery, Faculty of Dentistry, Baskent University, Ankara, Turkey.

Corresponding author: Beyza Hancioglu Kircelli, DDS, PhD, Orthodontics, Adana Research and Teaching Center, Baskent University, Dadaloglu mah. 39. sok. No.6 Yuregır, Adana 01250, Turkey
(e-mail: beyzakircelli@hotmail.com).

Accepted: January 2005. Submitted: December 2004.

FIGURE 1. Initial panoramic radiograph indicating hypodontia and microdontia.

graph (Figure 1). Furthermore, microdontia existed both in her primary and permanent dentition. The maxillary arch was deficient sagittally and transversally, so that there was an eight mm negative overjet and a bilateral buccal crossbite relationship with the lower jaw (Figure 2).

A depression of the midfacial structures included the maxillary and infraorbital regions with a relative prominence of the mandible, inadequate projection of the nasal tip and an old face appearance with an unesthetic smile constituted general features of the patient (Figure 3). She also had nasal respiratory problems causing mouth opening during sleep.

Lateral cephalometric (Figure 4) analysis indicated a Class III skeletal relationship because of retrusion of the maxilla. Cephalometric measurements indicated maxillary depth, 83° (normal, 90°; SD, −1.7); Nasion perpendicular to A, −seven mm; facial depth, 95° (normal, 87°; SD, 0.8); SNA, 71°; SNB angle, 81°; ANB, −10°; and convexity, −13 mm. The patient had a facial axis of 96° (normal, 90°; SD, −1.7), lower facial height of 41° (normal, 45°; SD, 1.2), total facial height of 56° (normal, 60°; SD, 1.9), and mandibular plane to FH of 23° (normal, 25°; SD, 1.1). Soft tissue analysis indicated decreased nasolabial angle of 95°, lower lip to E-line of zero mm and upper lip to E-line of −five mm.

Treatment objectives

- Coordination of dental arches both sagittally and transversally;
- Improvement of facial esthetics by advancing middle face anteriorly;
- Achievement of normal function both during mastication and respiration;
- Restoration of the dentition with a removable denture as she loses her primary teeth;
- Placement of dental implants after the cessation of skeletal growth.

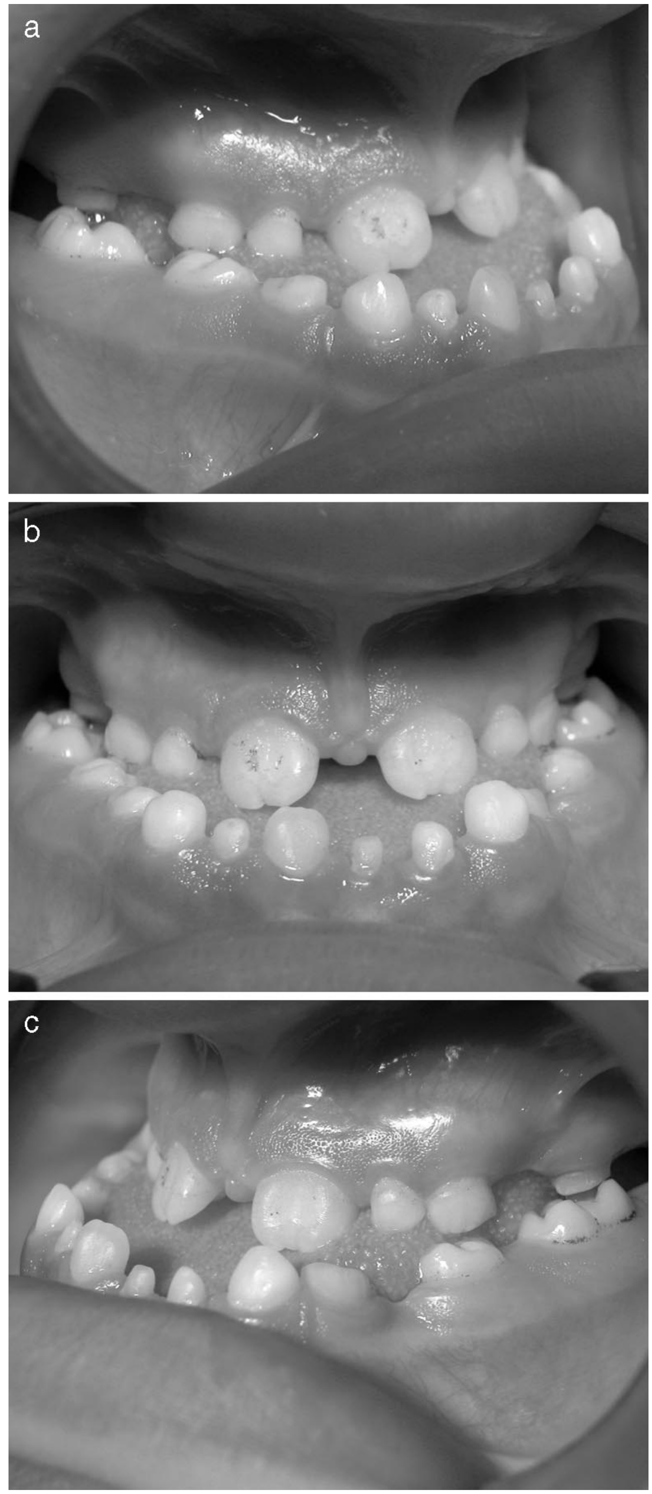

FIGURE 2. Intraoral pretreatment photographs demonstrating hypodontia, microdontia, negative overjet of eight mm, and bilateral crossbite relationship.

Treatment options

Three treatment options were considered for maxillary advancement. The first option was to delay treatment until growth has ceased and to correct the jaw

FIGURE 3. Initial extraoral frontal and profile view. Note depression of the maxillary and infraorbital regions.

FIGURE 4. Pretreatment lateral cephalometric radiograph.

relationship by orthognathic surgery. The second option was to apply rigid external distraction together with complete Le Fort I osteotomy. The third option was to try to take advantage of the sutural growth potential by applying extraoral force with a face mask via rigid skeletal anchors placed to the maxillary bone.

Treatment plan and progress

Because all three treatment options included surgical intervention, patient and parents chose the minimally invasive third option. They were also informed about the fact that if the advancement with a face mask was insufficient to correct the discrepancy, the treatment plan could be switched to the second option.

A titanium miniplate designed by Erverdi[16] (MPI, Tasarımmed, Istanbul, Turkey) (Figure 5a) was used as a rigid skeletal anchor to attach the elastic orthopedic forces to the maxilla. Multipurpose miniplates were to be placed on both sides of the apertura piriformis and on the lateral nasal wall of maxilla. Rapid maxillary expansion was also planned to correct the transversal maxillary deficiency and to disturb the circummaxillary sutures.[17] Because the maxillary dentition was insufficient, it was decided to place intraosseous titanium screws (two × eight mm IMF screws, Leibinger, Germany) (Figure 5b) on the palatal bone, near the alveolar crests, to provide anchorage for the expansion appliance.

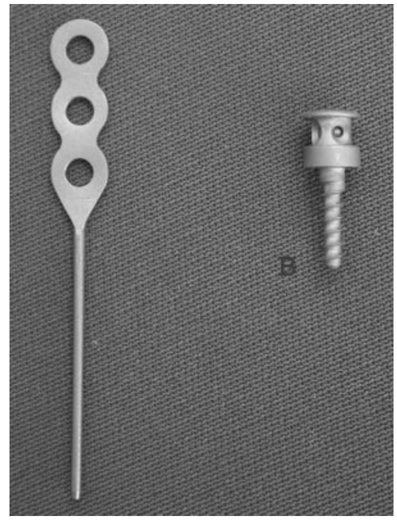

FIGURE 5. Multipurpose titanium miniplate (a) and intraosseous bone screw (b).

After routine surgical preparations, patient received general anesthesia. Bilateral mucosal incisions were made on labial sulcus between lateral incisor and first cuspid region. Then, mucosal flaps were carried inferiorly, the muscles and periosteum were incised and reflected superomedially, exposing the apertura piriformis and the lateral nasal wall of maxilla on both sides. Once an adequate space was achieved for miniplate placement, the nasal mucoperiosteum was elevated. Multipurpose miniplates were meticulously contoured to the bilateral lateral nasal wall, and straight extensions were bent to hook shape providing retention for face mask elastics and projected into the oral cavity through three mm mucoperiosteal incisions made inferiorly on the attached gingiva. Subsequently, for final stabilization of the bone plates three, 2.0 mm screws (five mm length) were placed with a 1.3 mm diameter drill under copious irrigation (Figure 6). Simultaneously, four intraosseous bone screws were placed in the anterior and posterior palatal region, close to the alveolar crests, bilaterally (Figure 7). After soft tissue healing, orthopedic forces were applied.

Construction of the intraosseous screw–supported expansion appliance

Impressions and stone casts were obtained with the IMF screws in place. The screws were blocked out with wax on the stone model, and an acrylic plate was prepared with an expansion screw in the midline. Appliance adaptation was checked intraorally and then connected to the IMF screw heads using cold curing,

FIGURE 6. Multipurpose miniplate with intraoral extension bent to hook shape placed to the lateral nasal wall of the maxilla.

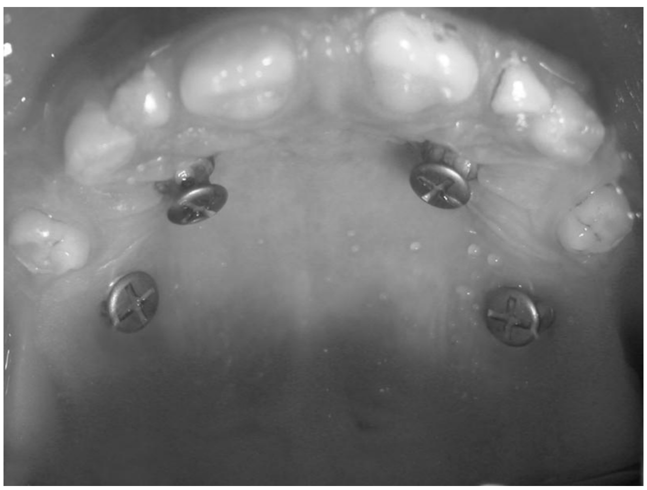

FIGURE 7. IMF screws placed in anterior and posterior palatal region.

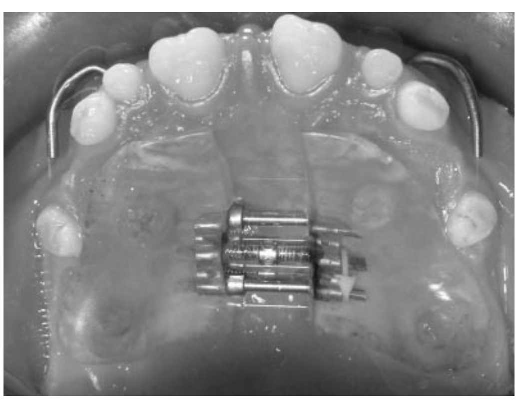

FIGURE 8. Intraosseous screw–supported maxillary expansion appliance.

methyl methacrylate–free acrylic resin (Ufi Gel hard, Voco GmbH, Cuxhaven, Germany). One of the parents was asked to activate the screw a quarter turn once a day (Figure 8).

FIGURE 9. Posttreatment lateral cephalometric radiograph with miniplates and IMF screws in place.

Procedures for the face mask therapy

An elastic force of approximately 150 g was applied bilaterally to the miniplate extensions after the adaptation of face mask (Leone spa, Firenze, Italy). After being sure of the stability, the force was increased gradually to 350 g. The direction of the force was adjusted approximately 30° to the occlusal plane, and the patient was asked to wear the face mask full time except during meals.

RESULTS

The application of the orthopedic forces via elastics directly to the anterior part of the maxillary bone by using miniplate anchorage resulted in a remarkable improvement in the middle face (Figure 9). Together with the maxillary bone advancement, significant enhancement in the soft tissue profile revealed improved facial esthetics (Figure 10). The maxilla was expanded from the median palatal suture, and seven mm of expansion was achieved across the buccal segments. Coordination of the dental arches both in the sagittal and transversal planes created improved physiological functions (Figure 11).

Pre- and posttreatment cephalometric radiographs were superimposed[18] to demonstrate the skeletal change (Figure 12). The maxilla was displaced eight mm anteriorly, the depth was increased by 9°, and Nasion perpendicular to A increased by eight mm. SNA increased by 7° and SNB decreased by 3°. The mandible rotated posteriorly, the facial axis decreased by 2°, and the facial depth decreased by 1°. Lower facial height remained unchanged, and total facial height increased by 1°. The palatal plane angle rotated 2° in a counterclockwise direction. PNS and ANS descended three and one mm, respectively. The soft tissue changes showed the nasal tip advanced five mm and the nasolabial angle increased 7°. The treatment results were achieved in 12 months.

FIGURE 10. Posttreatment extraoral frontal and lateral view showing a remarkable improvement in midface and soft tissue profile.

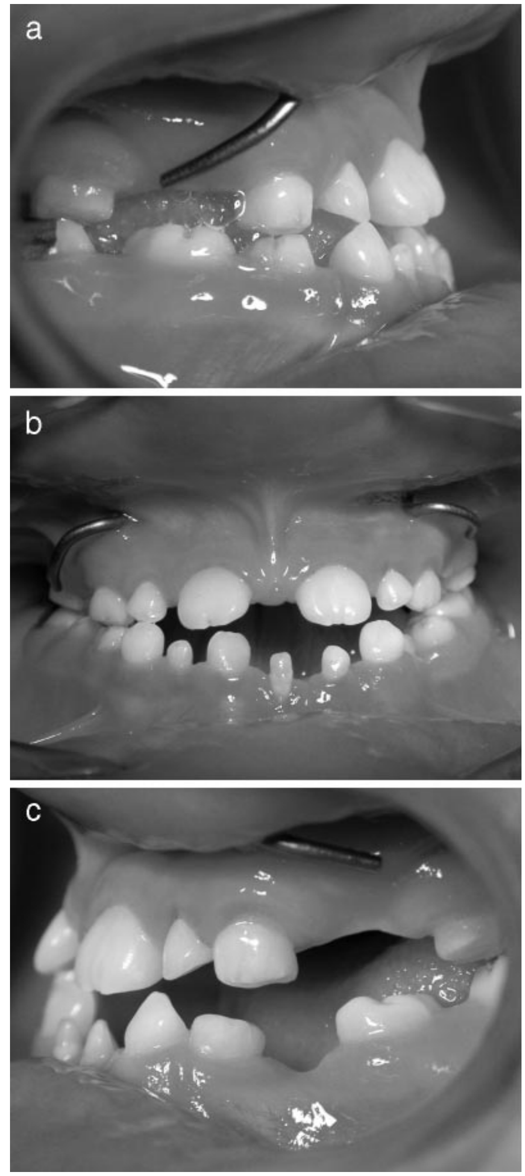

FIGURE 11. Posttreatment intraoral photographs.

DISCUSSION

Treatment of severe maxillary hypoplasia requires an early intervention because of the subsequent detrimental psychological and physical effects. In this 11-year-old patient with severe hypodontia and maxillary hypoplasia, we tried to take advantage of the sutural growth potential by transferring orthopedic forces directly to the sutural sites (eliminating the periodontal area) with rigid skeletal anchorage.

The two different anatomic sites considered for placement of the multipurpose miniplates were the inferior border of the zygomatic buttress[11,12] and lateral nasal wall of the maxilla. The lateral nasal wall of the maxilla was preferred because of its location anterior to all sutures that join the maxilla to the cranial base and also its anterior location with respect to the center of resistance of the maxilla (posterosuperior ridge of the pterygomaxillary fissure).[19]

In a biomechanical study[20] using finite element analysis, it was suggested that a 30° downward force applied at the upper canines is most appropriate for accelerating natural growth of the nasomaxillary complex. Placing miniplates on the lateral nasal wall of the maxilla gave us an opportunity to direct the force vector more closely to the center of resistance of the nasomaxillary complex. Moreover, the lateral nasal wall of maxilla was shown to provide adequate bone support for stabilization of the miniplates in Le Fort I osteotomies.[21] Also, it was reported that titanium miniplates placed on the thin maxillary bone could provide a stable skeletal anchorage in the rigid external distraction osteogenesis.[22–23] In this case, miniplates that were fixed to the lateral nasal wall of the maxilla, with three screws each (two mm), withstood extraoral traction force of 350 g.

It is well established that significant forward displacement of the nasomaxillary complex associated with sutural modification can be achieved by applying anteriorly directed extraoral forces.[24–28] As sutures unite bones and play a role as growth sites in the growing skull,[5] it could be assumed that a normal

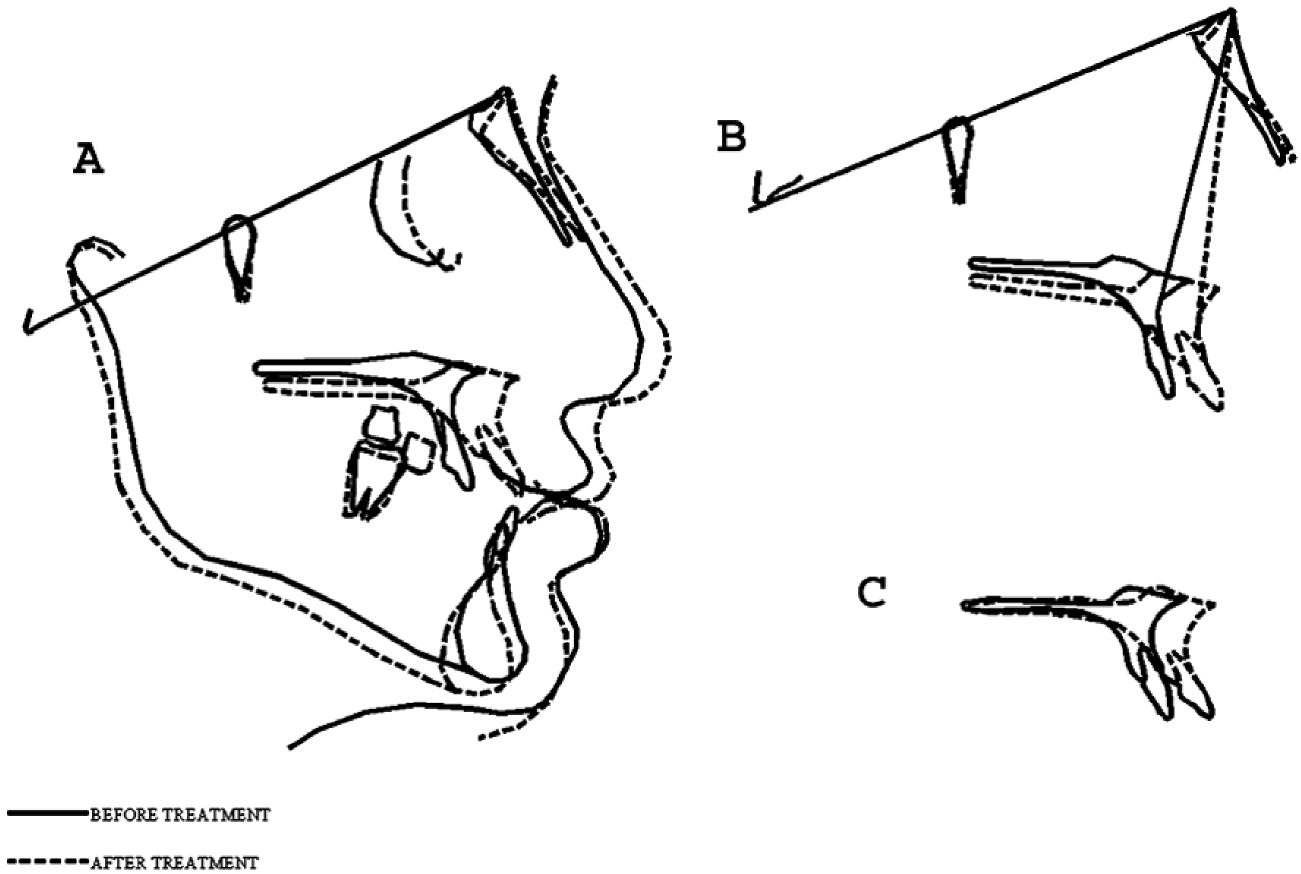

FIGURE 12. Pretreatment and posttreatment superimpositions (a) on Basion-Nasion at CC point demonstrating the overall skeletal change, (b) on Basion-Nasion at Nasion showing an eight mm maxillary advancement, and (c) on ANS-PNS at PNS indicating the dramatic sagittal growth of the palatal bone as a consequence of the treatment.

growing child has his or her ''natural osteotomy sites'' for distracting bones away from each other by applying orthopedic forces.

In an animal model, remarkable disarticulation of the circummaxillary sutures and remodeling of the bony surfaces was demonstrated using osseointegrated implants as an anchor for protraction of the maxillofacial complex.[29] Movassaghi et al[30] also distracted nasal bones from the frontal cranial segment and induced bone formation across the frontonasal suture in skeletally immature rabbits. They used titanium screws for the direct application of extrinsic forces. By using rigid skeletal anchorage, unlike tooth anchorage, applied forces are not dissipated in the periodontal area. Therefore, extraoral forces can be transferred directly to the sutural sites, and the skeletal effect can be maximized.[9] In this case, applying forces directly to lateral nasal wall of the maxilla resulted in an eight mm maxillary advancement. In addition, maxilla was expanded with an intraosseous miniscrew–supported appliance from the median palatal suture. No other tooth support or periodontal area was used for this expansion appliance, either.

Only a few attempts have been made to affect sutural sites directly by taking the advantage of rigid skeletal anchorage in conjunction with the face mask therapy. Kokich and Shapiro[31] applied extraoral protraction forces to purposefully ankylosed deciduous canines to transform the forces to the circummaxillary sutures. Their ''natural implants'' were able to demonstrate approximately four mm of maxillary protraction. Singer et al[32] used osseointegrated implants placed in the zygomatic buttress to obtain direct attachment to the maxilla and achieved four mm of maxillary movement. Enacar et al[33] treated a 10-year-old girl presenting with maxillary hypoplasia and severe oligodontia with a Petit face mask. They attached the protractive forces both to a titanium lag screw placed in the processus pterygoideus and to the rest of the anterior teeth. They achieved three mm displacement in the anterior nasal spine region. Hong et al[34] used an onplant on the palatal bone as an anchorage for the face mask treatment and showed 2.9 mm forward and downward displacement of the maxilla.

The reported overall maxillary advancement in those cases was less than our present case. This difference may be attributed to magnitude, direction, and duration of the applied force; required amount of maxillary advancement; and location of the rigid anchorage. Besides, in all those reported cases, the rigid anchorage means were attached to the maxillary dentition, and some part of the applied force could have been dissipated in the periodontal area.

On the other hand, one of the treatment option for this case was a rigid external distraction system. In a recent report,[35] rigid external distraction osteogenesis was performed in a six-year-, five-month-old patient presenting with maxillary retrusion and multiple missing permanent teeth. They achieved five mm advancement at point A, but they determined a 30% relapse after five months in postretention records. The eight mm horizontal advancement achieved in the present case encourages further clinical studies to determine which patients might benefit from sutural growth potential. Although the treatment time in our case is relatively long, the achieved result is totally physiologic in nature. Soft tissue and muscle adaptation occurs gradually in this time period. Besides, there is enough time to deposit new bone to the stretched sutural sides. According to these considerations, one can consider that relapse is a less likely possibility.

Certainly, the success of this treatment option is heavily dependent on patient compliance. The candidates for this approach should have cooperation through the treatment period. In this patient, we had no trouble with cooperation, and hence, she used the face mask full time during the treatment.

Besides, sutural growth activity is critical when applying orthopedic protraction via a direct skeletal anchorage. Thus, individuals presenting with craniosynostosis[36] are questionable candidates. Furthermore, the pubertal growth stage should be carefully evaluated. Earlier intervention might yield a better orthopedic response because sutural morphology becomes more complex with increasing age.[37]

CONCLUSIONS

- Orthopedic protraction with a face mask in conjunction with sole miniplate anchorage may offer a treatment alternative for the advancement of the hypoplastic maxilla in selected cases that still have sutural growth activity.
- Success with this treatment option is heavily dependent on excellent patient and parent cooperation, and the selection criteria must include patient compliance.
- Further studies on growth modification, with external forces using direct anchorage are required.

ACKNOWLEDGMENT

The authors would like to thank Dr. Soyupak for her grammatical contributions.

REFERENCES

1. Enlow DH. *Facial Growth,* 3rd ed. Philadelphia, Pa: WB Saunders; 1990.
2. Witzel MA, Vallino LD. Speech problems in patients with dentofacial and craniofacial deformities. In: Bell WH, ed. *Modern Practice in Orthognathic and Reconstructive Surgery,* vol 3. Philadelphia, Pa: WB Saunders; 1992:1686.
3. Kapp-Simon K. *Psychological Adaptation of Patients with Craniofacial Malformations. Psychological Aspects of Facial Form.* Monograph No. 11, Craniofacial Growth Series. Ann Arbor, Mich: Center for Human Growth and Development, University of Michigan; 1981:143–160.
4. Polley JW, Figuero AA. Management of severe maxillary deficiency in childhood and adolescence through distraction osteogenesis with an external, adjustable, rigid distraction device. *J Craniofac Surg.* 1997;8:181–185.
5. Enlow DH, Hans MG. *Essentials of Facial Growth.* Philadelphia, Pa: WB Saunders Company; 1996:79–110.
6. McNamara JA Jr. An orthopedic approach to the treatment of Class III malocclusion in young patients. *J Clin Orthod.* 1987;21:598–608.
7. Gallagher RW, Miranda F, Buschang PH. Maxillary protraction: treatment and post treatment effects. *Am J Orthod.* 1998;113:612–619.
8. Nartallo-Turley PE, Turley PK. Cephalometric effects of combined palatal expansion and facemask therapy on Class III malocclusion. *Angle Orthod.* 1998;68:217–224.
9. Proffit WR. Effects of orthodontic force on the maxilla and midface. In: Proffit WR, ed. *Contemporary Orthodontics*, 2nd ed. St Louis, Mo: Mosby Inc; 1993:281–284.
10. Jenner JD, Fitzpatrick BN. Skeletal anchorage utilizing bone plates. *Aust Orthod J.* 1985;9:231–233.
11. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open-bite correction. *Am J Orthod.* 1999;115:166–174.
12. Erverdi N, Keles A, Ravindra N. The use of skeletal anchorage in open bite treatment: a cephalometric evaluation. *Angle Orthod.* 2004;74:381–390.
13. Creekmore TD, Eklund MK. The possibility of skeletal anchorage. *J Clin Orthod.* 1983;17:266–269.
14. Kanomi R. Mini-implant for orthodontic anchorage. *J Clin Orthod.* 1997;31:763–767.
15. Gelgör IE, Büyükyılmaz T, Karaman AI, Dolanmaz D, Kalaycı A. Intraosseous screw-supported upper molar distalization. *Angle Orthod.* 2004;74:836–848.
16. Erverdi N. New generation open bite treatment with zygomatic anchorage. Lecture presented at: 79th Congress of the European Orthodontic Society; June 10–14, 2003; Prague, Czech Republic.
17. Haas AJ. Palatal expansion: just the beginning of dentofacial orthopedics. *Am J Orthod.* 1975;57:219–255.
18. Ricketts RM. A four-step method to distinguish orthodontic changes from natural growth. *J Clin Orthod.* 1975;9:208–228.
19. Tanne K, Matsubara S, Sakuda M. Location of the centre of resistance for the nasomaxillary complex studied in a three-dimensional finite element model. *Br J Orthod.* 1995; 22:227–232.
20. Miyasaka-Hiraga J, Tanne K, Nakamura S. Finite element analysis for stresses in the craniofacial sutures produced by

maxillary protraction forces applied at the upper canines. *Br J Orthod.* 1994;21:343–348.

21. Peterson LJ. *Principles of Oral and Maxillofacial Surgery.* Vol 3. Philadelphia, Pa: JB Lippincott Company; 1992: 1370–1373.
22. Yamamoto J, Sawaki Y, Ohkubo H, Ueda M. Maxillary advancement by distraction osteogenesis using osseointegrated implants. *J Craniomaxillofac Surg.* 1997;25:186–191.
23. Swennen G, Dujardin T, Goris A, De Mey A, Malevez C. Maxillary distraction osteogenesis: a method with skeletal anchorage. *J Craniofac Surg.* 2000;11:120–127.
24. Dellinger EL. A preliminary study of anterior maxillary displacement. *Am J Orthod.* 1973;63:509–516.
25. Kambara T. Dentofacial changes produced by extraoral forward force in Macaca irus. *Am J Orthod.* 1977;71:249–277.
26. Nanda R. Protraction of maxilla in rhesus monkeys by controlled extraoral forces. *Am J Orthod.* 1978;74:121–141.
27. Jackson GW, Kokich VG, Shapiro PA. Experimental and post experimental response to anteriorly directed extraoral force in young *Macaca nemestrina*. *Am J Orthod.* 1979;75: 318–333.
28. Nanda R, Hickory W. Zygomaticomaxillary suture adaptations incident to anteriorly-directed forces in Rhesus monkeys. *Angle Orthod.* 1984;54:199–210.
29. Smalley WM, Shapiro PA, Hohl TH, Kokich VG, Brånemark PI. Osseointegrated titanium implants for maxillofacial protraction in monkeys. *Am J Orthod.* 1988;94:285–295.
30. Movassaghi K, Altobelli DE, Zhou H. Frontonasal suture expansion in the Rabbit using titanium screws. *J Oral Maxillofac Surg.* 1995;53:1033–1042.
31. Kokich VG, Shapiro PA, Oswald R, Koskinen-Moffett L, Clarren SK. Ankylosed teeth as abutments for maxillary protraction: a case report. *Am J Orthod.* 1985;88:303–307.
32. Singer SL, Henry PJ, Rosenberg I. Osseointegrated implants as an adjunct to face mask therapy: a case report. *Angle Orthod.* 2000;70:253–262.
33. Enacar A, Giray B, Pehlivanoglu M, Iplikcioglu H. Facemask therapy with rigid anchorage in a patient with maxillary hypoplasia and severe oligodontia. *Am J Orthod.* 2003;123: 571–577.
34. Hong H, Ngan P, Li HG, Qi LG, Wei SHY. Use of onplants as stable anchorage for facemask treatment: a case report. *Angle Orthod.* 2005;75:402–409.
35. Kitai N, Kawasaki K, Yasuda Y, Kogo M, Murakami S, Kreiborg S, Takada K. Rigid external distraction osteogenesis for a patient with maxillary hypoplasia and oligodontia. *Cleft Palate Craniofac J.* 2003;40:207–213.
36. Proffit WR. Premature fusion of cranial and facial sutures: The craniosynostosis syndromes. In: Proffit WR, White RP Jr, Sarver DM, eds. *Contemporary Treatment of Dentofacial Deformity.* Philadelphia, Pa: Mosby Yearbook; 2003:37–41.
37. Melsen B, Melsen F. The postnatal development of the palatomaxillary region studied on human autopsy material. *Am J Orthod.* 1982;82:329–342.