Original Article

The Use of Skeletal Anchorage in Open Bite Treatment: A Cephalometric Evaluation

Nejat Erverdi, DDS, PhD[a]; Ahmet Keles, DDS, DMSc[b]; Ravindra Nanda, BDS, MDS, PhD[c]

Abstract: The aims of the present study were to assess the effectiveness of skeletal anchorage for intrusion of maxillary posterior teeth, to correct open bite malocclusion, and to evaluate the usage of
?1 titanium miniplates for orthodontic anchorage. Anterior open bite is one of the most difficult malocclusions to treat orthodontically. Currently, surgical impaction of the maxillary posterior segment is considered to be the most effective treatment option in adult patients. Various studies have reported the use of implants as anchorage units at different sites of midfacial bones for orthodontic tooth movement. The zygomatic buttress area could be a valuable anchorage site to achieve intrusion of maxillary posterior teeth. Ten patients, 17 to 23 years old and characterized with an anterior open bite and excessive maxillary posterior growth, were included in this preliminary study. Titanium miniplates were fixed bilaterally to the zygomatic buttress area, and a force was applied bilaterally with nine mm Ni-Ti coil springs between the vertical extension of the miniplate and the first molar buccal tube. The results showed that, with the help of skeletal anchorage, maxillary posterior teeth were intruded effectively. As compared with an osteotomy, this min-
?12 imally invasive surgical procedure eased treatment and reduced treatment time and did not require headgear wear or anterior box elastics for anterior open bite correction. In conclusion, the zygomatic area was found to be a useful anchorage site for intrusion of the molars in a short period of time. (*Angle Orthod* 2003; 73:000–000.)

Key Words: Anchorage; Sketal anchorage; Open bite; Dental implant; Miniplate

INTRODUCTION

Anterior open bite is one of the most difficult malocclusions to treat and maintain in orthodontics. The morphologic pattern in anterior open bite is characterized by longer vertical dimensions, an increase in development of the maxillary posterior dentoalveolar structure and a steep mandibular plane.[1–3] The surgical correction of skeletal open bite often requires maxillary impaction to achieve counterclockwise rotation of the mandible and subsequent reduction of anterior facial height.[4] The complexity, the risks, and the cost factor of surgical treatment have initiated a search for alternative clinical procedures.

Bite-blocks with repelling magnets[5–7] or spring-loaded bite-blocks[8] have been applied to achieve dentoalveolar intrusion of the maxillary posterior segments. Fixed mechanics and vertical elastics have also been used to treat anterior open bite.[9–12] Face mask designs have been developed for posterior dentoalveolar intrusion.[13] These procedures have been effective in passive intrusion of the maxillary posterior segment[5–7,13,14] or in anterior dentoalveolar extrusion.[9–12] In all these treatment modalities, however, the correction was achieved primarily through extrusion of incisors or by preventing passive eruption of posterior teeth.

Recent studies have used osseointegrated implants and screws as anchorage units for orthodontic purposes.[15–21] In patients not in need of implants for prosthetic reasons, investigators have used the retromolar area,[22] palatal region,[23–30] or alveolar areas[31] to attach various screws and plates solely for the purpose of orthodontic movement of teeth or segments.

Ohmae et al,[32] using an animal model, and Umemori et al[33] in humans, applied titanium mini plates to the mandibular corpus area and used them as anchorage for intrusion of the mandibular posterior dentoalveolar segment for correction of anterior open bite. Sugawara et al[34] used a specially designed skeletal anchorage system (SAS) for correction of anterior open bite by intruding the mandibular molars in humans. Melsen et al,[35] De Clerck et al,[36] Erverdi

[a] Professor and Chair, Department of Orthodontics, School of Dentistry, Marmara University, Nisantasi, Istanbul, Turkey.
[b] Director of Orthodontic Clinic, Department of Orthodontics, University of Connecticut Health Center, Farmington, Conn.
[c] Professor and Chairman, Department of Orthodontics, University of Connecticut Health Center, Farmington, Conn.
Corresponding author: Ahmet Keles, Director of Orthodontic Clinic, Department of Orthodontics, University of Connecticut Health Center, 263 Farmington Ave, Farmington, CT 06030 (e-mail: keles@ortodonti.com).

Accepted: July 2003. Submitted: June 2003.
© 2003 by The EH Angle Education and Research Foundation, Inc.

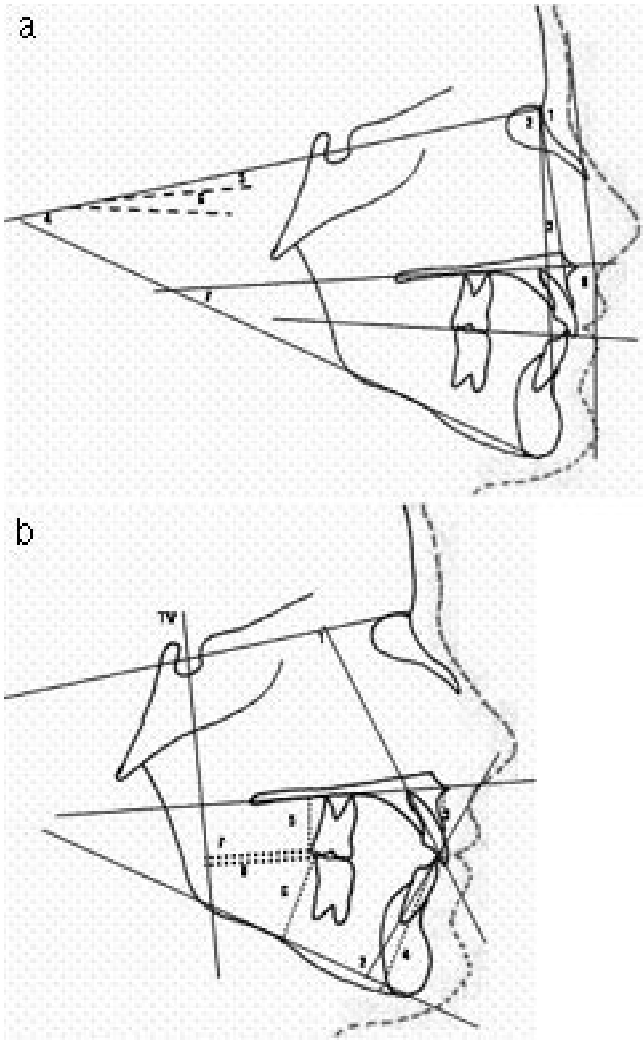

FIGURE 1. (a) Skeletal measurements used in the evaluation of lateral cephalograms. (1) SNA, (2) SNB, (3) ANB, (4) GoMeSN, (5) palatal plane-SN, (6) occlusal plane-SN, (7) palatal plane–mandible plane, (8) glabella-SN-pogonion, and (9) gnathion-TH. (b) Dental measurements used in the evaluation of lateral cephalograms. (1) U1-SN, (2) IMPA, (3) U1-PP (mm), (4) L1-MP (mm), (5) U6-PP (mm), (6) L6-MP (mm), (7) U6-TV, (8) L6-TV, (9) U1-TH, (10) U1-TV, (11) overjet, and (12) overbite.

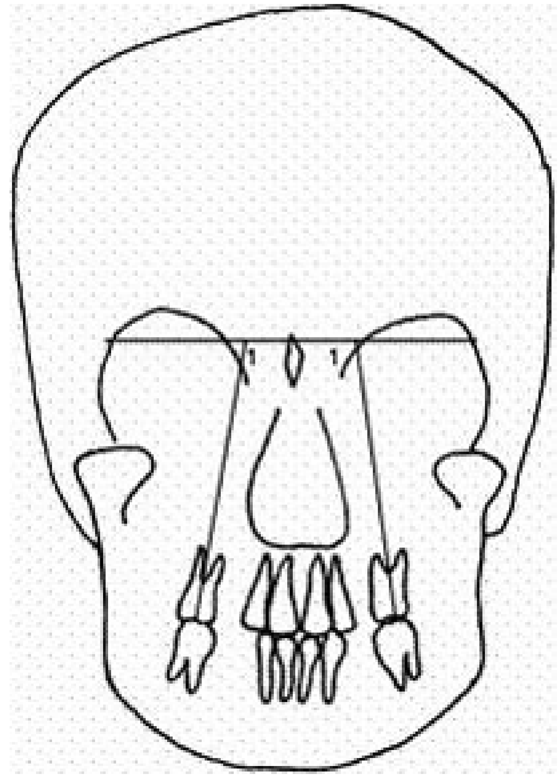

FIGURE 2. Measurement used in the evaluation of posteroanterior radiographs. (1) Upper molar–lateral oblique plane measurement (U6-Ref. P).

et al,[37] and Sherwood et al[38] reported zygomatic anchorage as an alternative form of maxillary posterior anchorage.

Studies[35–38] have shown that the zygomatic buttress area could be a valuable anchorage site to get effective intrusion of the maxillary posterior segment. This preliminary study reports the results of the use of zygomatic buttress anchorage to intrude the maxillary buccal dentoalveolar segment to correct skeletal open bite in nongrowing patients.

MATERIALS AND METHODS

Case selection

This preliminary study involved 10 patients 17 to 23 years of age. Five of the patients had Class I occlusion, and the other five patients had a Class II malocclusion. Six patients were treated with upper first premolar extractions, and the other four patients were treated with a nonextraction treatment approach. A mean of −0.6 mm anterior open bite was present. Lateral cephalograms and posteroanterior radiographs were taken before and after the treatment. Twenty-four measurements were made on each lateral cephalogram to assess the dental, skeletal, and soft tissue changes, and one measurement was made on the posteroanterior cephalograms to assess the buccal tipping of maxillary molars. (Figures 1a,b and 2). ?2

Surgical method

The surgical method as described by Erverdi et al[37] was used. After rinsing the mouth for one minute with 0.2% chlorhexidine gluconate, a local anesthetic was infiltrated bilaterally at the zygomatic process areas. Initially, we used a horizontal sulcular incision as in the surgical method (Figure 3a,b); currently we use a vertical incision instead to simplify the surgical operation, reduce the size of the scar tissue, and enhance the healing process. A one-cm vertical incision was made along the zygomatic buttress and ending at the mucogingival junction. By means of blunt dissection, the zygomatic process of the maxilla was totally exposed.

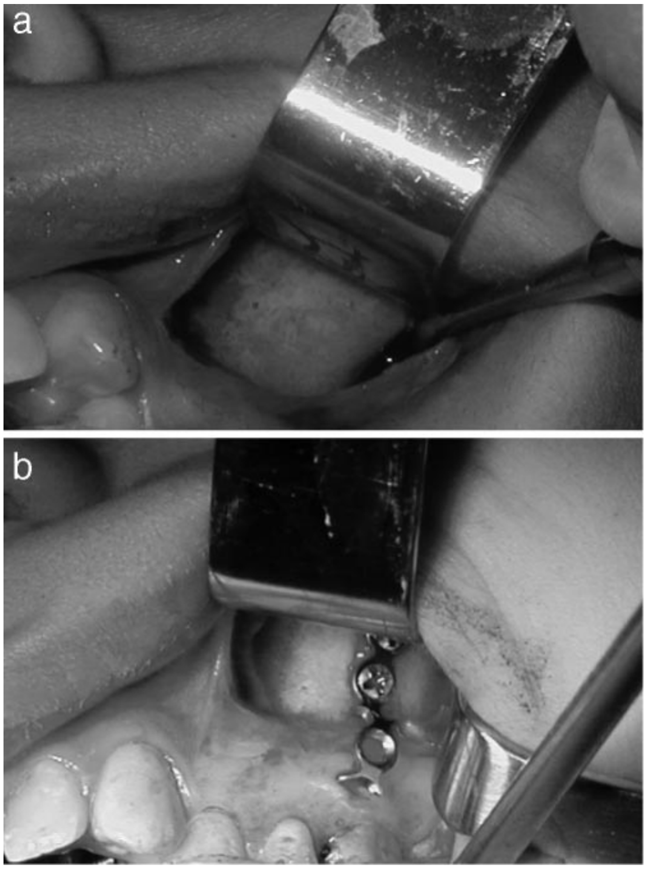

FIGURE 3. (a) The mucoperiosteal flap was elevated to reach the zygomatic process of the maxilla. (b) Fixation of the plate to the zygomatic process.

FIGURE 4. Poster anterior radiograph, showing the orientation of the titanium miniplates and the TPA.

An I-shaped titanium miniplate (Leibinger, Mühlheim-Stelten, Germany) was adjusted to fit the contour of the lower face of each zygomatic process and fixed by two bone screws (length seven mm), with the long arm exposed to the oral cavity from the incised wound. Initially, we intended to use long screws (seven mm) to stabilize the
?13 plates. Presently, however, we use five-mm screws, which are long enough to keep the plate in place. The last helix
?5 of the screw was exposed to the oral cavity from the mucogingival junction. This surgical method was chosen to reduce the inflammation and minimize discomfort to the patient caused by the movement of the cheeks. The exposed hole in the plate was used to directly receive the intrusive force. The wound was closed and sutured. During the healing period, instructions were given to the patients on how to clean the wound area. Four to seven days later the sutures were removed and force was applied to the miniplates. Figure 4 shows an anteroposterior radiograph, the location of ?6

TABLE 1. Comparison of Initial and Final Skeletal Measurements

	Initial		Final		Difference		Wilcoxon	
	Mean	SD	Mean	SD	D	SD	*P*	Significance[a]
SNA	74.2	1.9	75.2	2.04	1	0.94	.023	*
SNB	70.3	3.9	72.1	4.09	1.8	0.91	.004	**
ANB	4.1	2.68	2.70	3.26	−1.40	0.84	.003	**
GoGnSN	46.5	6.04	44.80	6.76	−1.7	2.01	.01	**
PP-SN	8.70	2.94	8.9	2.3	0.2	0.94	.480	NS
Occ.P-SN	18.1	3.69	21.2	3.93	3.1	1.28	.005	**
PP-MP	36.9	5.44	34.7	4.59	−2.2	1.2	.007	**
Gl-Sn-Pg	162.1	9.38	164.7	9.98	2.6	1.50	.007	**
TH-Gn	120.45	3.4	119.35	3.06	−1.1	0.61	.07	**

[a] NS indicates not significant; * $P < .05$, ** $P < .01$, *** $P < .001$.

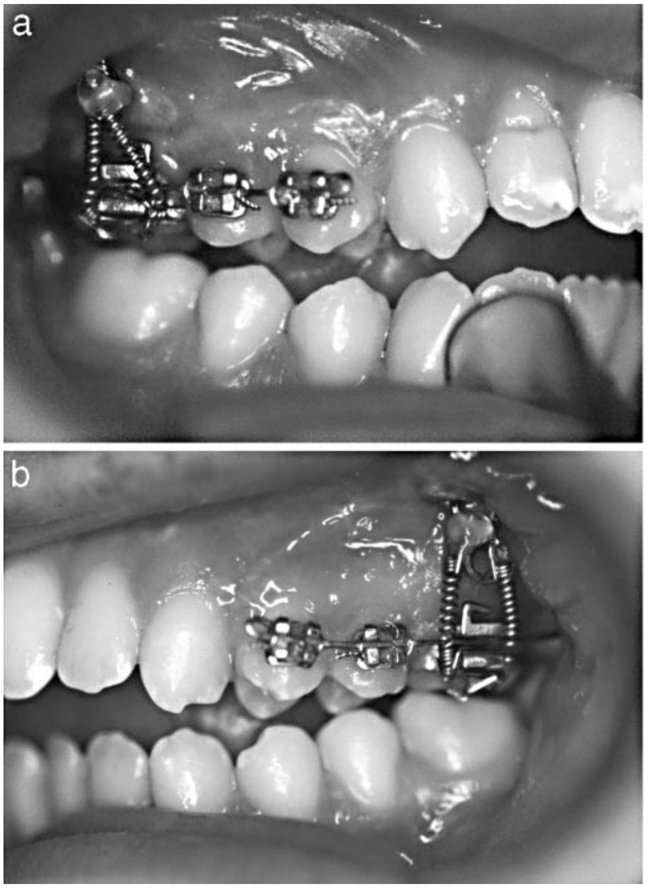

FIGURE 5. (a, b) Intrusive force application to the posterior teeth with the Ni-Ti coil springs (right and left).

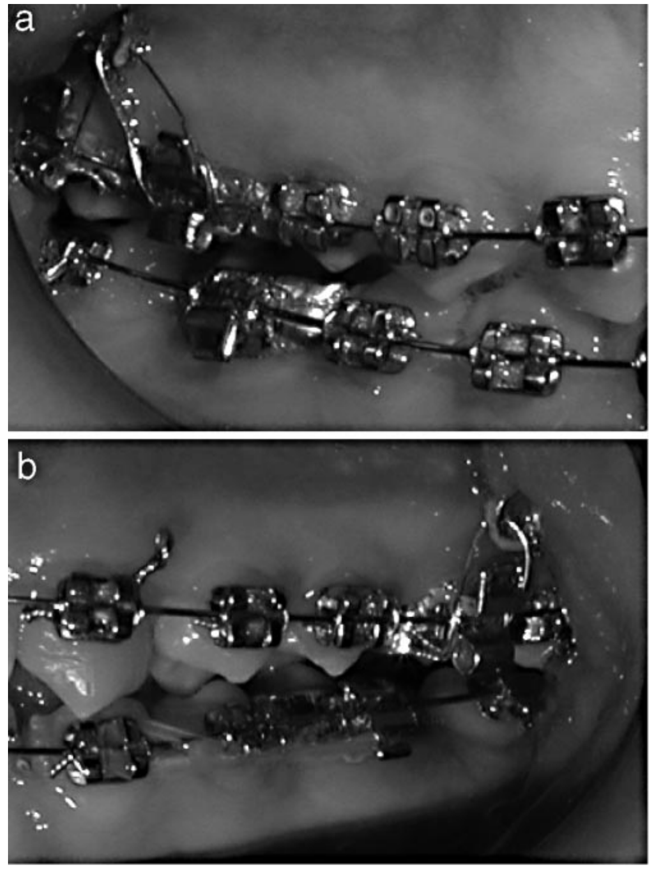

FIGURE 7. (a, b) Retention of intrusion of molars with passive wire ligation from the headgear tube to the zygomatic implants.

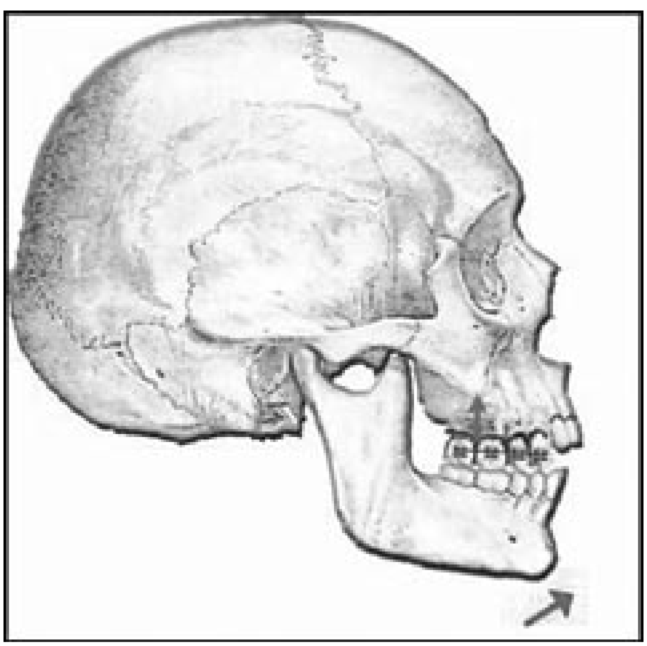

FIGURE 6. Biomechanics of the force system.

the plates, and application of closed coil springs to deliver an intrusive force.

Orthodontic treatment

All patients received a transpalatal arch constructed from 0.9 mm stainless steel round wire and adapted three mm away from the palate. The anterior and posterior teeth were aligned with the help of two posterior and one anterior segmental wire. After the initial alignment, nine-mm Ni-Ti coil springs were placed bilaterally between the hole of the mini plate and the first molar buccal tube (Figure 5a,b). The anterior open bite was corrected in a mean of 5.1 months. The biomechanics of the force system is presented in Figure 6.

Molar intrusion was retained with vertical wire ligation between the tube of the molar bands and the miniplates throughout the subsequent orthodontic treatment (Figure 7a,b). One month before debonding, the plates were removed. The total treatment duration was a mean of 18.3 months.

TABLE 2. Comparison of Initial and Final Dental Measurements

	Initial		Final		Difference		Wilcoxon	
	Mean	SD	Mean	SD	D	SD	*P*	Significance[a]
U1-SN	106.7	6.32	97.1	7.4	−9.6	8.9	.008	**
IMPA	93.30	5.1	89	7.61	−4.3	3.09	.005	**
U1-PP (mm)	31.9	2.07	33	2.49	1.1	0.87	.015	**
L1-MP (mm)	39.9	7.69	41	8.58	1.1	1.41	.021	*
U6-PP (mm)	26.4	1.64	23.8	2.74	−2.6	1.39	.005	**
L6-MP (mm)	32.8	2.78	31.7	3.1	−0.10	0.73	.65	NS
U6-TV	22.6	3.83	24.8	4.15	2.2	2.2	.27	NS
L6-TV	22.3	4.71	23.4	4.1	1.1	0.99	.016	*
U1-TH	79.45	3.04	80.15	2.94	0.7	0.25	.004	**
U1-TV	63.45	2.16	61.6	2.07	−1.85	0.43	.004	**
LI-TH	78.35	3.01	77.45	2.96	−0.9	0.45	.007	**
LI-TV	53.86	1.07	53.63	1.07	−0.2	0.55	.16	NS
Overjet	5.4	2.95	3.4	0.84	−2.0	2.53	.023	*
Overbite	−0.6	2.27	3.1	0.99	3.7	2.4	.011	*
U6-Ref. P (angle)	106.5	2.36	109.3	3.59	2.8	1.68	.004	**

[a] NS indicates not significant; * $P < .05$, ** $P < .01$, *** $P < .001$.

RESULTS

Our results showed that the anterior open bite was corrected in all our patients. The correction was achieved with a clockwise rotation of the mandible (an average of 1.7° [$P < .01$]), maxillary molar intrusion (an average of 2.6 mm [$P < .01$]), maxillary incisor retroclination and extrusion (an average of 9.6° [$P < .01$]), and extrusion of 1.1 mm ($P < .01$). The mandibular incisors were extruded an average of 1.1 mm ($P < .01$) because of the leveling of the dentition in the mandible. The orientation of the palatal plane did not change, however, and the occlusal plane rotated in a clockwise direction a mean angle of 3.1° ($P < .01$). The measurement made on the posteroanterior cephalograms showed that the maxillary molars were slightly tipped buccally, an average of 2.8° ($P < .01$). A radiographic analysis of the treatment results is presented in Tables 1 and 2.

?3 ?4

Synopsis of patient treatment

SE was an 18 years 1 month–old female individual who presented with a symmetrical frontal facial appearance, a

FIGURE 8. (a) Initial extraoral frontal view of the patient. (b) Initial extraoral smiling view of the patient. (c) Initial extraoral profile view of the patient.

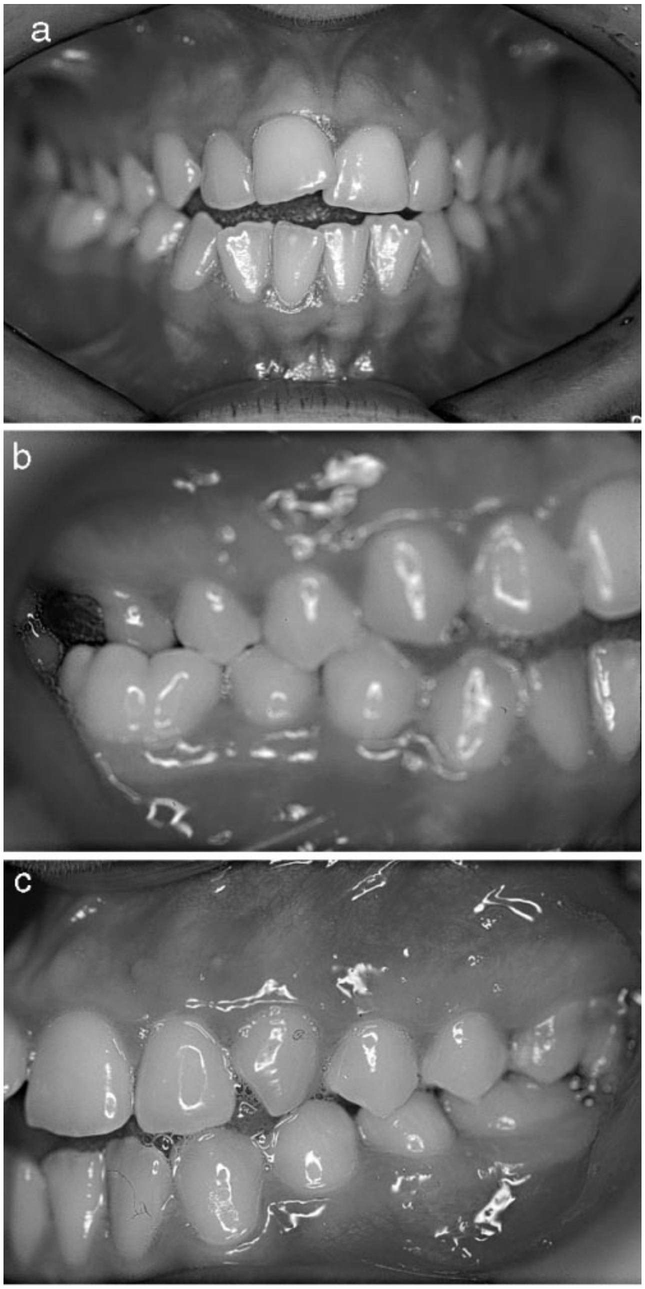

FIGURE 9. (a) Initial intraoral frontal view of the patient. (b) Initial intraoral right view of the patient. (c) Initial intraoral left view of the patient.

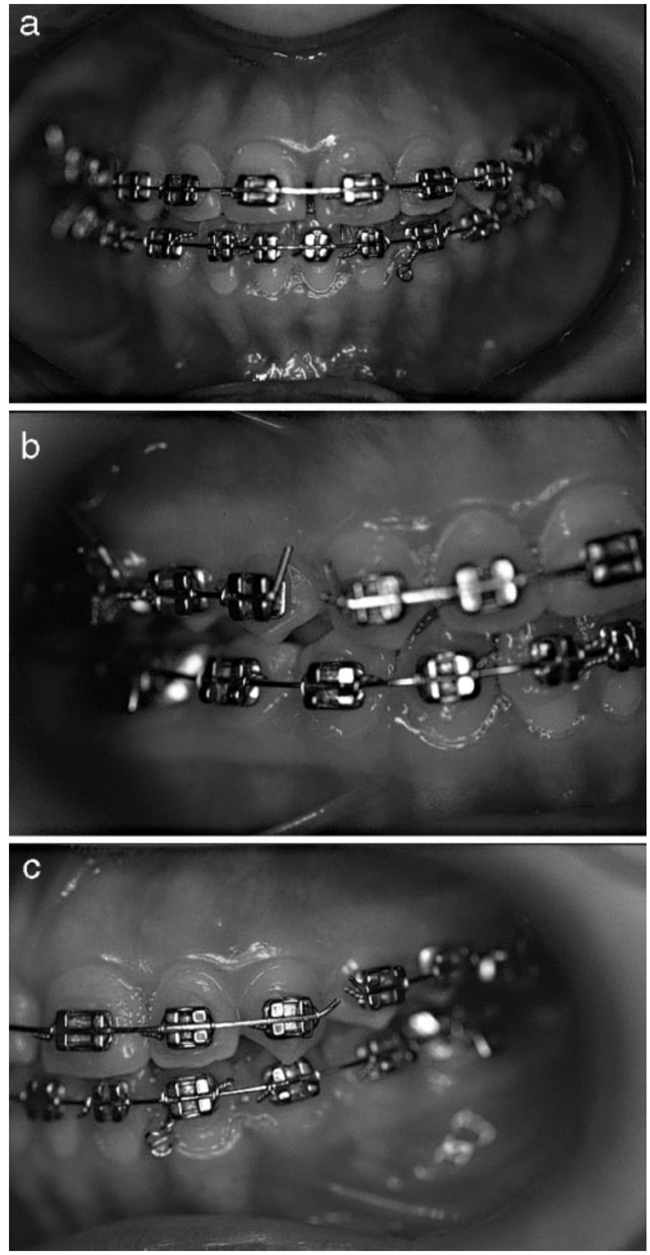

FIGURE 10. (a–c) Three-mm anterior open bite was eliminated, and two-mm anterior overbite was achieved (frontal, right, left).

''gummy'' smile in the posterior region, and a slightly convex profile (Figure 8a–c). Intraorally, she presented with a Class I molar and canine relationship with a maxillary dentoalveolar constriction and three mm of anterior open bite (Figure 9a–c). Our treatment plan was to use skeletal anchorage for molar intrusion and fixed appliance therapy. The results showed that a 3.0-mm anterior open bite was corrected and 2.0 mm of overbite was achieved in five months (Figure 10a–c). Because of the force application on the buccal side of the posterior segment, the dental posterior maxillary constriction was eliminated. After achieving good interdigitation, ideal overbite and overjet were achieved and the braces were removed.

At the end of the treatment the patient's smile and profile were significantly improved. The posterior gummy smile was eliminated. Extraoral and intraoral pictures of the patient at the end of fixed orthodontic therapy are presented in Figures 11a–c and 12a–c. Initial and final lateral cephalometric radiographs and superimpositions showed the im-

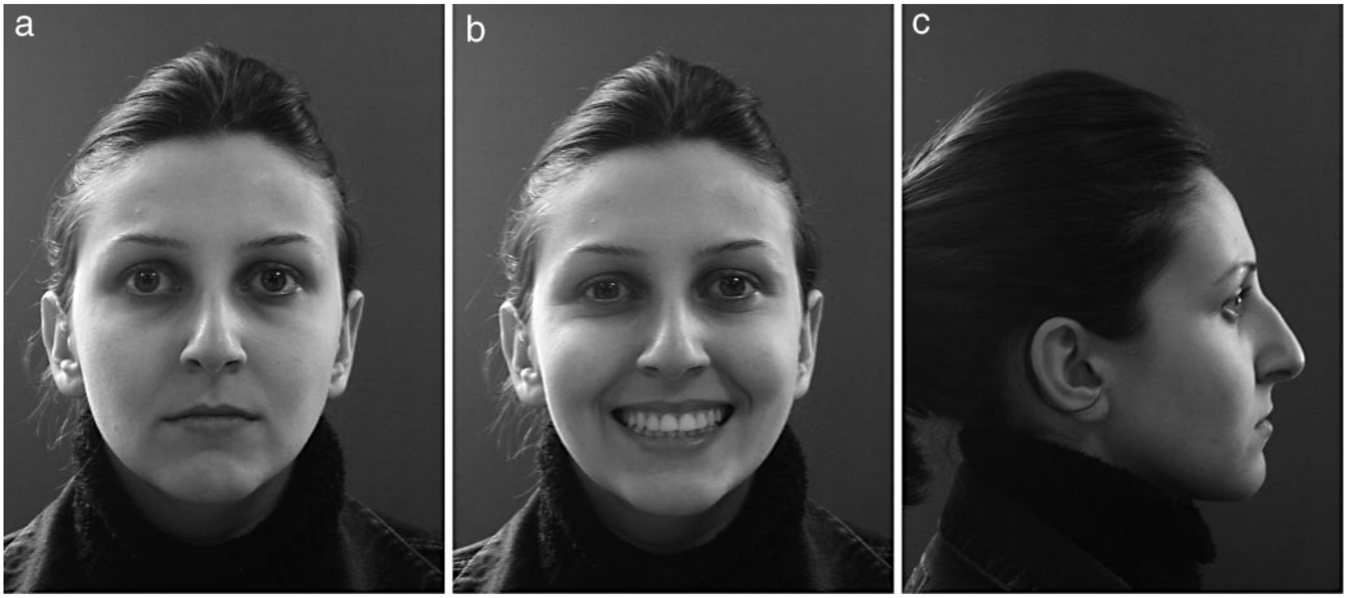

FIGURE 11. (a) Final extraoral frontal view of the patient. (b) Final extraoral smiling view of the patient. (c) Final extraoral profile view of the patient.

provement of the anterior open bite, clockwise occlusal plane rotation, and intrusion of the maxillary molars (Figures 13a–c). The initial and final panoramic radiographs showed a flattening of the maxillary occlusal plane (Figure 14a,b).

DISCUSSION

The present study shows that the use of zygomatic miniplates is an effective and minimally invasive surgical procedure to correct skeletal anterior open bites. The benefits of this treatment as an alternative to conventional orthodontic appliances such as extraoral appliances[13,39] (headgear) and/or intraoral mechanics[9–11] (anterior box elastics) are significant.

To improve the esthetics and achieve stable treatment results in the anterior open bite, high angle growth pattern, and excessive posterior growth patient, molar intrusion should be the treatment goal. The literature shows that overerupted posterior teeth are significant contributors to anterior open bite.[1–3] Investigators have used occlusal blocks and repelling magnets[6–7] to slow dentoalveolar posterior growth and intrude the maxillary posterior teeth to correct anterior open bite.

Kim[11] criticized the use of headgear for molar intrusion. He advocated extraction of the second and third molars and application of multiloop arches and anterior elastics to upright mesially tipped molars. However, their findings showed uprighting of the maxillary molars but not intrusion. In another study, the investigators evaluated the changes in dentofacial structures of open bite patients treated with mesially accentuated–curved and mandibular reverse–curved nickel titanium archwires and intermaxillary elastics. The results of this study show that the bite closure was achieved primarily by extrusion of the mandibular incisors and uprighting of the maxillary incisors.[12] Although the configuration of the archwires in the molar region was aimed at intruding and uprighting the molars, no molar intrusion took place. Instead, the molars were extruded while being uprighted. This technique closed the anterior open bite mainly by extruding the anterior segment.

The present study showed that 3.7 mm of anterior open bite was corrected by 2.6 mm maxillary molar intrusion, 1.1 mm maxillary and mandibular incisor extrusion, 3.1° clockwise rotation of the maxillary occlusal plane, and 1.7° counterclockwise rotation of the mandible. In summary, 40% of the anterior open bite correction was achieved with autorotation of the mandible and 60% with extrusion of the incisors. The smile and the profile of the patients were improved, and good function and esthetics were achieved in a short period of time.

Dental implants have been used successfully for fixed orthodontic anchorage.[23–30] Our study, along with other recent studies, shows that mini plates provide stable anchorage for orthodontic tooth movement, especially for the correction of anterior open bites.[33–38]

Before intrusive force application, the molars were connected with a TPA that was constructed three mm away from the palatal tissue to avoid impeachment of the wire in the tissues during the intrusion phase. This modification could also exert an intrusive force of the tongue against the TPA and molars. Also introduce the abbreviation TPA with its expansion. ?7

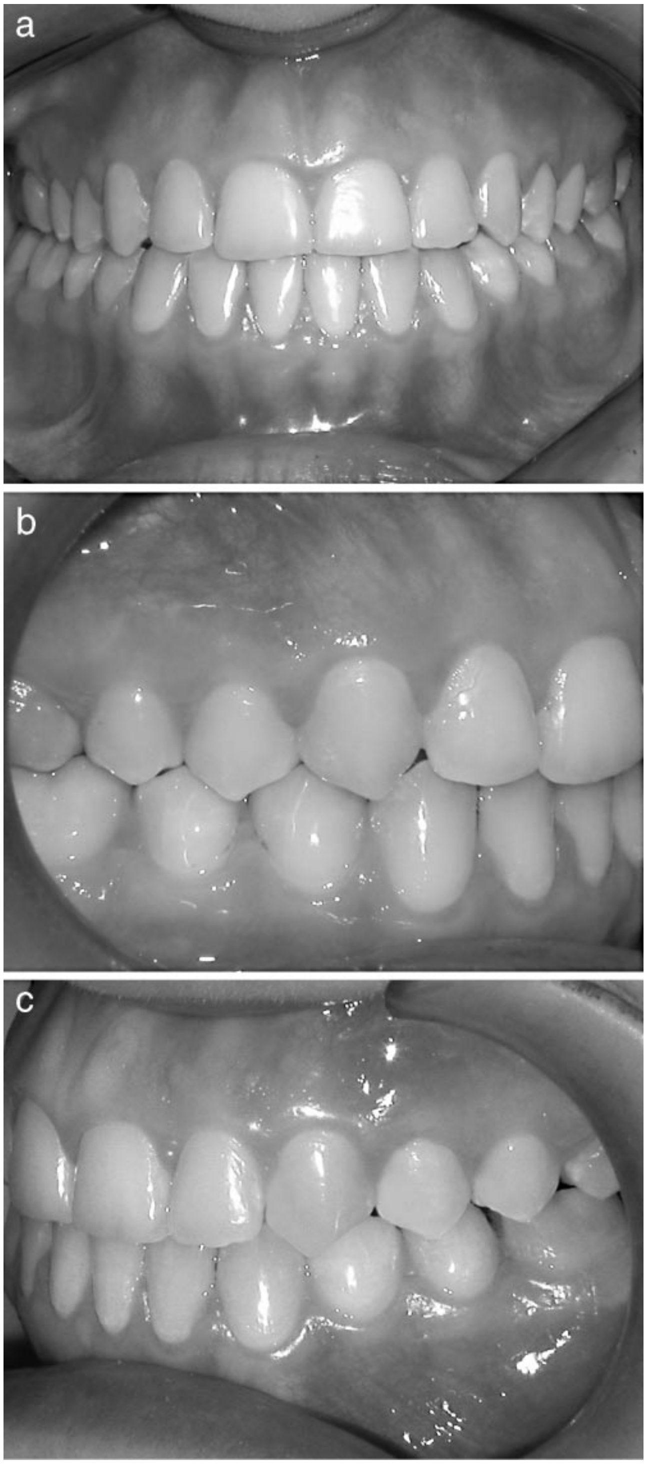

FIGURE 12. (a) Final intraoral frontal view of the patient at the end of the treatment. (b) Final intraoral right view of the patient. (c) Final intraoral left view of the patient.

Most of the anterior open bite patients treated needed posterior maxillary dental expansion. Our finding shows maxillary dental constriction was corrected by uprighting the posterior teeth with the application of an intrusive force. The maxillary occlusal plane rotated in a clockwise direction. For patients who do not present with maxillary posterior dental constriction, a rigid posterior acrylic cap splint type of appliance can be used to resist the moment generated by the intrusive force.

Some patients experienced some tissue inflammation at the implant site because of plaque accumulation and irritation of the cheeks by the implant. We recommended good oral hygiene and oral rinses with chlorhexidine. We modified the incision technique to reduce postoperative patient discomfort and enhance the healing process. The modification consisted of using a vertical instead of a horizontal incision. For increased patient comfort and reduced soft tissue irritation, specially designed plates can be used with better adaptation to the anatomical structures instead of the conventional titanium mini plates.

CONCLUSIONS

Contemporary orthodontic treatment requires a short treatment time and minimal patient cooperation. This preliminary investigation showed that skeletal anchorage can be used effectively for anterior open bite correction in nongrowing patients. Minimal patient cooperation was required (no headgear, no anterior box elastics), except for good oral hygiene. A minimally invasive and simple technique facilitated the surgical procedure and reduced the operation time.

Skeletal anchorage has become an important contemporary tool in orthodontics, and the findings of our preliminary study are promising for future investigations. Long-term follow-up should be carried out to assess the stability of the treatment results.

REFERENCES

1. Proffit W, Fields H. *Contemporary Orthodontics.* 2nd ed. St Louis, Mo: Mosby; 1993:128–446. ?8
2. Sassouni V. A classification of skeletal facial types. *Am J Orthod.* 1969;55:109–123.
3. Schudy FF. The rotation of the mandible resulting from growth: its implication in orthodontic treatment. *Angle Orthod.* 1965;35:36–50.
4. Lawy DM, Heggie AA, Crawfrod EC, Ruljancich MK. A review of the management of anterior open bite malocclusion. *Aust Orthod J.* 1990;11:147–160.
5. Dellinger EL. A clinical assessment of the active vertical corrector. A nonsurgical alternative for skeletal open bite treatment. *Am J Orthod Dentofacial Orthop.* 1986;89:428–436.
6. Kalra V, Burstone CJ, Nanda R. Effects of a fixed magnetic appliance on the dentofacial complex. *Am J Orthod Dentofacial Orthop.* 1989;95:467–478.
7. Kiliaridis S, Egermark B, Thilander B. Anterior open bite treatment with magnets. *Eur J Orthod* 1990;12:447–457.
8. Woodside DG, Aronson L. Progressive increase in lower anterior face height and the use of posterior occlusal bite-blocks in this management. In: Graber LW, ed. *Orthodontics: State of the Art, Essence of the Science.* St Louis, MO: Mosby; 1997:200–221.
9. Nielsen L. Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment. *Angle Orthod.* 1991;61:247–260.

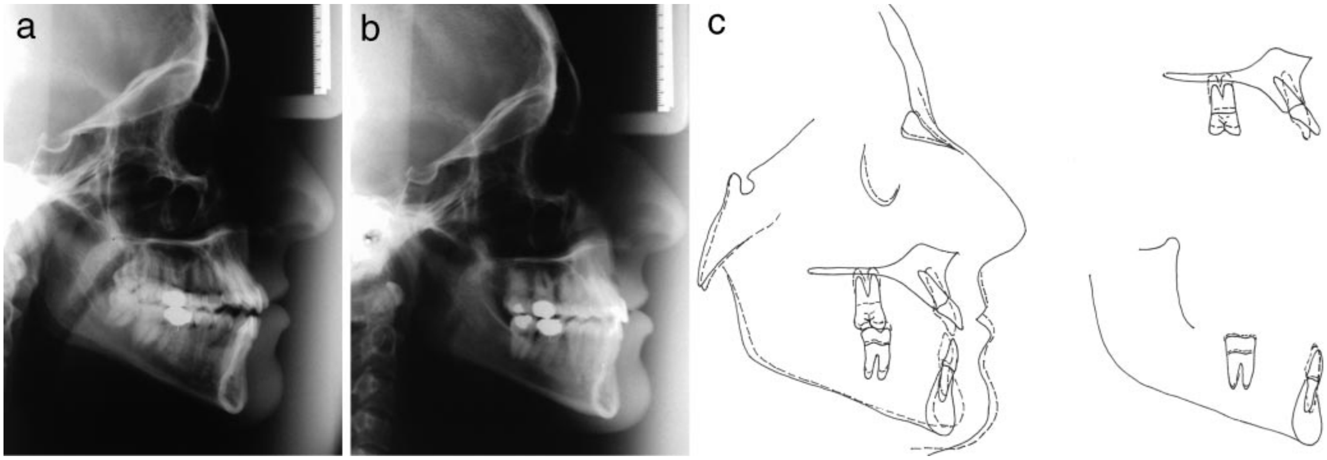

FIGURE 13. (a) Initial cephalometric radiographs of the patient. (b) Final cephalometric radiographs of the patient. (c) Cephalometric superimposition of the patient.

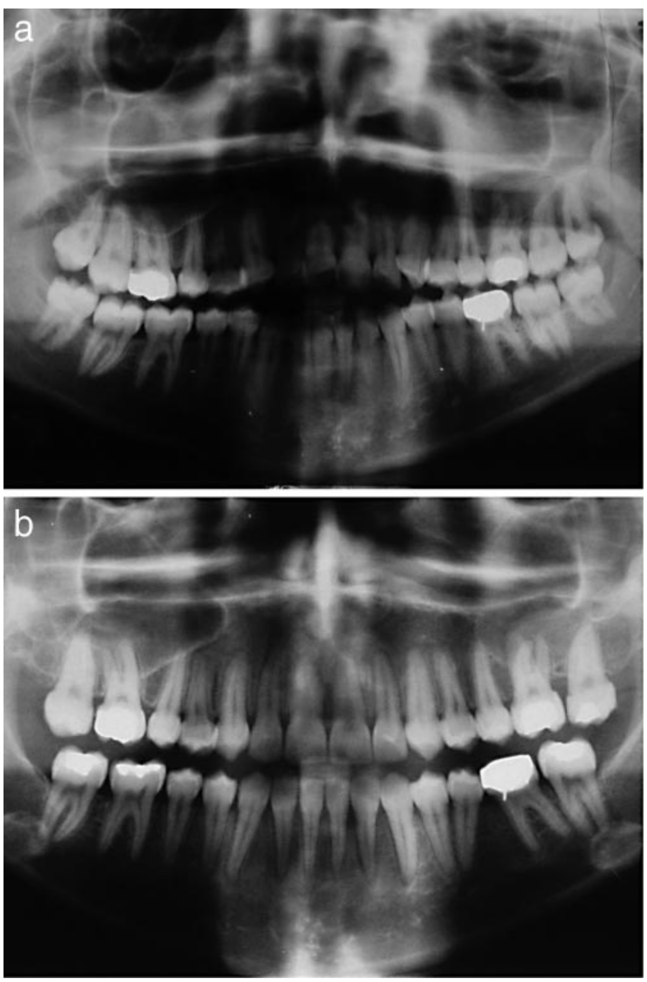

FIGURE 14. (a) Panoramic radiograph of the patient at the beginning of the treatment. (b) Panoramic radiograph of the patient at the end of the orthodontic treatment.

10. Rinchuse DJ. Vertical elastics for correction of anterior open bite. *J Clin Orthod.* 1994;28:284.
11. Kim YH. Anterior open bite and its treatment with multiloop edgewise archwire. *Angle Orthod.* 1997;57:171–178.
12. Küçükkeleş N, Acar A, Demirkaya A, Evrenol B, Enacar A. Cephalometric evaluation of open bite treatment with NiTi archwires and anterior elastics. *Am J Orthod Dentofacial Orthop.* 1999;116:555–562.
13. Alcan T, Keles A, Erverdi N. The effects of a modified protraction headgear on maxilla. *Am J Orthod Dentofacial Orthop.* 2000;117:27–38.
14. Stellzig A, Steegmayer G, Basdra EK. Elastic activator for treatment of open bite. *Br J Orthod.* 1999;26:89–92.
15. Ödman J, Lekholm U, Jemt T, Branemark P-I, Thilander B. Osseointegrated titanium implants—a new approach in orthodontic treatment. *Eur J Orthodont.* 1988;10:98–105.
16. Roberts WE, Smith R, Zilberman Y, Mozsary PG, Smith RS. Osseous adaptation to continuous loading of rigid endosseous implants. *Am J Orthod.* 1984;86:95–111.
17. Roberts WE, Helm FR, Marshall KJ, Gonglof RK. Rigid endosseous implants for orthodontic and orthopedic anchorage. *Angle Orthod.* 1989;59:247–256.
18. Roberts WE, Marshall KJ, Mozsary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. *Angle Orthod.* 1990;60:135–152.
19. Turley PK, Kean C, Sehur J, Stefanac J, Gray J, Hennes J, Poon LC. Orthodontic force application to titanium endosseous implants. *Angle Orthod.* 1988;58:151–162.
20. Van Roekel NB. The use of Branemark system implants for orthodontic anchorage: report of case. *Int J Oral Maxillofac Implants.* 1989;4:341–344.
21. Costa A, Raffainl M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. *Int J Adult Orthod Orthognath Surgery.* 1998:13:201–209. ?9
22. Higuchi KW, Slack JM. The use of titanium fixtures for intraoral anchorage to facilitate orthodontic tooth movement. *Int J Oral Maxillofac Implants.* 1991;6:338–344.
23. Abels N, Schiel HJ, Hery-Langer G, Neugebauer J, Engel M. Bone condensing in the placement of endosteal palatal implants: a case report. *Int J Oral Maxillofac Implants.* 1999;14:849–852.
24. Bernhatr T, Vollgruber A, Gahleitner A, Dörtbudak O, Haas R. Alternative to median region of the palate for placement of an orthodontic implant. *Clin Oral Implants Res.* 2000;11:595–601. ?10
25. Glatzmaier J, Wehrbein H, Diedrich P. Die Entwicklung eines

resorbierbaren Implantatsystems zur orthodontischen Verankerung. *Fortschr Kieferorthop.* 1995;56:175–181.
26. Triaca A, Antonini M, Wintermantel E. Ein neues Titan-Flachschraubenimplantat zur Verankerung am anterioren Gaumen. *Inf Orthod Orthop.* 1992;24:251–257.
27. Turley PK, Shapiro PA, Moffett BC. The loading of bioglass-coated aluminum oxide implants to produce sutural expansion of the maxillary complex in the pigtail monkey (Macaca nemestrina). *Arch Oral Biol.* 1980;25:459–469.
28. Wehrbein H. Enossale Titanimplantate als orthodontische Verankerungselemente. Experimentelle Untersuchungen und klinische Anwendung. *Fortschr Kieferorthop.* 1994;5:236–250.
?11
29. Wehrbein H, Glatzmaier J, Mundwiller U, Diedrich P. The orthosystem: a new implant system for orthodontic anchorage in the palate. *J Orofac Orthop.* 1996;57:142–153.
30. Tosun T, Keles A, Erverdi N. Method for the placement of palatal implants. *Int J Oral Maxillofac Implants.* 2002;17:95–100.
31. Freudenthaler JW, Haas R, Bantleon H-P. Bicortical titanium screws for critical orthodontic anchorage in the mandible: a preliminary report on clinical applications. *Clin Oral Implants Res.* 2001;12:358–363.
32. Ohmae M, Saito S, Morohashi T, et al. A clinical and histological evaluation of titanium mini-implants as anchors for orthodontic intrusion in the beagle dog. *Am J Orthod Dentofacial Orthop.* 2001;119:489–497.
33. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open bite correction. *Am J Orthod Dentofacial Orthop.* 1999;115:166–174.
34. Sugawara J, Baik UB, Umemori M, Takahashi I, Nagasaka H, Kawamura H, Mitani H. Treatment and posttreatment dentoalveolar changes following intrusion of mandibular molars with application of a skeletal anchorage system (SAS) for open bite correction. *Int J Adult Orthod Orthognath Surgery.* 2002;17:243–245.
35. Melsen B, Petersen JK, Costa A. Zygoma ligatures: an alternative form of maxillary anchorage. *J Clin Orthod.* 1998;32:154–158.
36. De Clerck H, Geerinckx V, Siciliano S. The Zygoma Anchorage System. *J Clin Orthod.* 2002;36:455–459.
37. Erverdi N, Tosun T, Keles A. A new anchorage site for the treatment of anterior open bite: zygomatic anchorage case report. *World J Orthod.* 2002;43:147–153.
38. Sherwood K, Burch J, Thompson W. Closing anterior open bites by intruding molars with titanium miniplate anchorage. *Am J Orthod Dentofacial Orthop.* 2002;122:593–600.
39. Abdullatif H, Keles A. A new method for correction of anterior open bite. *World J Orthod.* 2001;2:232–243.