

Maxillary molar intrusion with zygomatic anchorage in open bite treatment: lateral and oblique cephalometric evaluation

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Abstract

Purpose We aimed to use lateral and oblique radiographs to evaluate dental and skeletal changes arising from maxillary molar intrusion with zygomatic anchorage in open bite patients.

Methods We conducted a pilot study including nine patients (six females and three males; mean age, 18.7 ± 5.1 years) with skeletal open bite treated with titanium miniplates for posterior dentoalveolar intrusion. Lateral and oblique (right and left, 45°) radiographs were obtained before (T1) and 6 months after intrusion (T2). A paired *t* test was used for statistical evaluation.

Results The maxillary posterior teeth were intruded 2.03 ± 0.87 mm ($p < 0.01$) with $450 \times g$ of force, which resulted in counterclockwise rotation of the mandible (1.57° , $p = 0.02$) and clockwise rotation of the occlusal plane ($4.27 \pm 2.66^\circ$, $p = 0.01$). Anterior facial height decreased by a mean of 1.79 ± 1.51 mm ($p < 0.01$). No significant change in the palatal plane or in anteroposterior molar movement was observed.

Conclusion The oblique radiograph at 45° was useful for the assessment of molar intrusion and anteroposterior displacement. The treatment of anterior open bite with skeletal

anchorage provided intrusion of molars and counterclockwise rotation of the mandible, resulting in open bite closure.

Keywords Miniplates · Open bite · Orthodontic anchorage techniques · Tooth intrusion

Introduction

Anterior open bite is a malocclusion that is difficult to treat in orthodontics [1–7]. Its etiology involves skeletal, dental, and functional factors, as well as deleterious habits [1, 5]. The morphology of this malocclusion is generally characterized by increased vertical dimension, excessive eruption of posterior teeth, and increased mandibular plane angle [2, 3, 5, 8–10].

Several orthodontic treatments for open bite have been suggested, involving extrusive forces on anterior teeth or intrusive forces on posterior teeth [5]. Extrusion of anterior teeth is a common method to treat open bite; however, it is less stable than dental intrusion [11], impairs esthetic treatment, and is contraindicated in patients with skeletal open bite [1, 4, 12]. Treatments with bite block, high-pull headgear, and functional appliances have been used to promote dentoalveolar intrusion and control of vertical growth [5]. These devices have been effective in the treatment of open bite; however, malocclusion correction was primarily achieved by extrusion of incisors and prevention of the eruption of posterior teeth [2], which is not effective in adult patients [13]. Intrusion of molars with conventional orthodontics is difficult [8, 10].

Orthognathic surgery and skeletal anchorage have been used to treat open bite in adult patients [1–4, 8, 10, 12]. With skeletal anchorage, the correction of anterior open bite is achieved by the intrusion of upper molars [2, 3, 6, 12]. Kuroda et al. [4] demonstrated the advantages of this treatment compared with orthognathic surgery.

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Lateral cephalometric radiography is the most widely used method for the evaluation of molar intrusion [2, 4, 7–9]; however, there are limitations to the analysis of tooth movement in this type of radiography due to distortions and superimposition of bilateral structures in the same plane [14]. Oblique cephalometric radiography minimizes superimposition of contralateral structures, allowing each side to be visualized individually [15].

The aim of this pilot study was to use lateral and oblique cephalometric radiography to evaluate changes in the mandibular plane angle and in the positioning of maxillary molars arising from maxillary posterior tooth intrusion with miniplates in patients with open bite.

Materials and methods

This prospective pilot study was carried out at the Department of Orthodontics, Araraquara School of Dentistry, UNESP—Univ Estadual Paulista Júlio de Mesquita Filho, after approval by the ethics committee of the institution. The sample comprised nine patients (six females and three males; mean age, 18.7 ± 5.1 years) with skeletal anterior open bite, class I or class II jaw-based relationships. Skeletal growth was assessed by the analysis of cervical vertebral maturation (CVM). All patients presented at least CS5 stage [16]. Growing patients (CVM < CS5), class III patients, and those who had undergone previous orthodontic treatment were excluded.

Surgical procedure

Patients underwent surgery for the placement of two miniplates. A 2.0 cm incision was made along the zygomatic buttress region, and the zygomatic process was exposed with a mucoperiosteal flap. Y- or T-shaped miniplates were adjusted to the zygomatic buttress and then fixed with monocortical screws (5 or 7 mm), with the straight arm of the miniplate exposed to the oral cavity (Fig. 1a). The incision was then

sutured. Patients were instructed about the postoperative care and hygiene of the miniplates. After the orthodontic treatment, miniplates were removed with similar surgical procedures.

Orthodontic treatment

Prior to miniplate placement, bands were cemented to upper molars and brackets and were bonded (Roth prescription, 0.022 in. slot—ABZIL, SP, Brazil) to premolars. The posterior teeth were stabilized with 0.021 × 0.025 in. sectional stainless steel wire and with a transpalatal arch made with 0.9 mm stainless steel wire to prevent buccal tipping (Fig. 1b). Two weeks post-surgery, elastic chains were placed bilaterally, applying an intrusive force of 450–500 × g each side, and exchanged every 15–20 days. The protocol was continued until the intrusion of posterior teeth and open bite correction were achieved. After the intrusion phase, the molars were stabilized with wire ligation between the miniplates and the molar tube. The anterior teeth were bonded, and conventional orthodontic treatment was performed.

Radiographic analysis

Oblique (right and left) and lateral cephalometric radiographs were taken immediately before intrusion (T1) and 6 months after intrusion (T2). The radiographs were digitized and imported via Radiocef Plus® software (Radio Memory Ltda., Belo Horizonte, MG, Brazil), in which anatomical landmarks were determined (Tables 1 and 2).

The palatal plane (ANS-PNS), occlusal plane (Mc-U1i), mandibular plane (Go Me), posterior vertical plane (S-Go), anterior vertical plane (N-Me), and SN line were determined on lateral radiographs (Fig. 2). The SN line drawn in radiograph T1 was transferred to the radiograph obtained in T2, with miniplates and the skull base used as references, as proposed by Björk [17].

Oblique radiographs were used to obtain the cephalometric tracings and to determine the vertical position of the molar

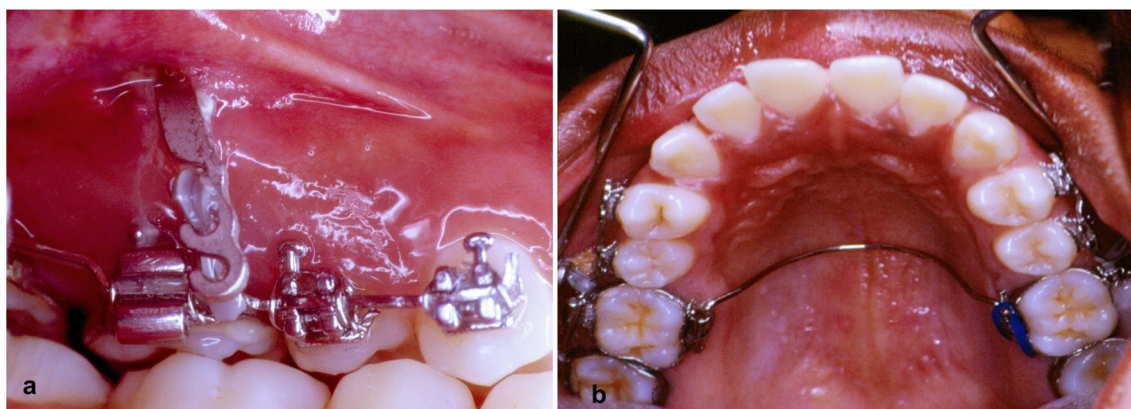


Fig. 1 Skeletal anchorage system used for intrusion. Miniplate and segmented posterior orthodontic device (a) and transpalatal arch (b)

Table 1 Definitions of landmarks based on lateral cephalometric analysis

Landmarks	Abbreviation	Description
1. Saddle point	S	Center of the sella turcica, it is the midpoint of the sella turcica bone concavity
2. Nasion point	N	Intersection of the internasal suture with the frontonasal suture
3. Anterior nasal spine point	ANS	Tip of anterior nasal spine
4. Posterior nasal spine point	PNS	Tip of posterior nasal spine
5. Upper central incisor point	U1i	Tip of the upper central incisor
6. Cusp tips point	Mc	Mesiobuccal cusp tip of the upper first molar
7. Gonion point	Go	Lowest and most posterior point on the contour of the gonial angle
8. Menton point	Me	Lowest point on the contour of the symphysis

cusp (Cusp-V), the anteroposterior position of the molar cusp (Cusp-AP), mesial molar tipping, the posterior occlusal plane angle (OcPl angle), the anteroposterior position of the molar root apex (Apex-AP), and the vertical position of the molar root apex (Apex-V; Fig. 3). The palatal plane (MxA MxP) drawn in T1 was transferred to the radiograph obtained in T2, with miniplates and structures of the skull base and maxilla used as references, as proposed by Sakima et al. [14].

Statistical analysis

The study variables were analyzed with the use of SPSS 16.0 software (SPSS Inc., Chicago, IL, USA). The measurements were performed twice by the same examiner, with a minimum interval of 15 days. Reliability was confirmed by the intraclass correlation coefficient (ICC), which ranged between 0.72 (molar tipping) and 0.99 (cusp V). The Shapiro-Wilk test was used to confirm the normal distribution of data. A paired *t* test was used to evaluate pretreatment and posttreatment differences, with a significance level of 0.05.

Results

Intrusion of upper molars and open bite correction were observed in treated patients. Correction was achieved by the 1.57° counterclockwise rotation of the mandible (*p*=0.02). The occlusal plane showed a mean clockwise rotation of 4.27° (*p*=0.01), and decreased anterior facial height of 1.79 mm (*p*<0.01) was observed in the lateral radiograph. Changes in posterior facial height and the palatal plane were not statistically significant. Changes in tooth position analyzed by oblique radiography showed intrusion of upper molars (average of 2.03 mm, *p*<0.01) when measured on the mesiobuccal cusp and a mean of 1.79 mm (*p*<0.01) when measured on the molar mesiobuccal root apex. In this analysis, no significant movement was observed in the anteroposterior direction of first molars. The mesial molar tipping and

posterior occlusal plane showed no significant changes. The results of the treatment are shown in Table 3 for lateral radiographs and in Table 4 for oblique radiographs.

Discussion

Lateral cephalometric radiography is currently the most widely used method for the evaluation of molar intrusion [2, 4, 7–9]. Panoramic radiography has already been used for this purpose because there is no superimposition of structures as found in lateral radiographs [12]. However, despite offering images for easy identification, panoramic radiographs show image distortion and lack of standardization in the positioning of the patient [18]. Oblique radiographs use standardization of patient position by cephalostat, minimizing superimposition of anatomical structures, allowing for better visualization of structures at each side of the face [14, 15]. The superimposition of oblique radiographs is a valid and reproducible method that can contribute to a more accurate assessment of changes in the positioning of posterior teeth [14]. In this study, skull base structures and miniplates were used as stable references for the superimposition of radiographs. The advantage of using oblique radiography in this study overcame the small

Table 2 Definition of landmarks based on oblique cephalometric analysis

Landmarks	Definition
1. Point MC	Mesiobuccal cusp tip of the upper first molar
2. Point IM	Midpoint of the implant determined in palatal plane built
3. Point MxA	Anterior fiducial point determined in the anterior maxilla region at palatal plane level built in T1
4. Point MxP	Posterior fiducial point determined in the anterior maxilla region at palatal plane level built in T1
5. Point PC	Buccal cusp tip of the upper first premolar
6. Point MA	Point at the root apex of the upper first molar

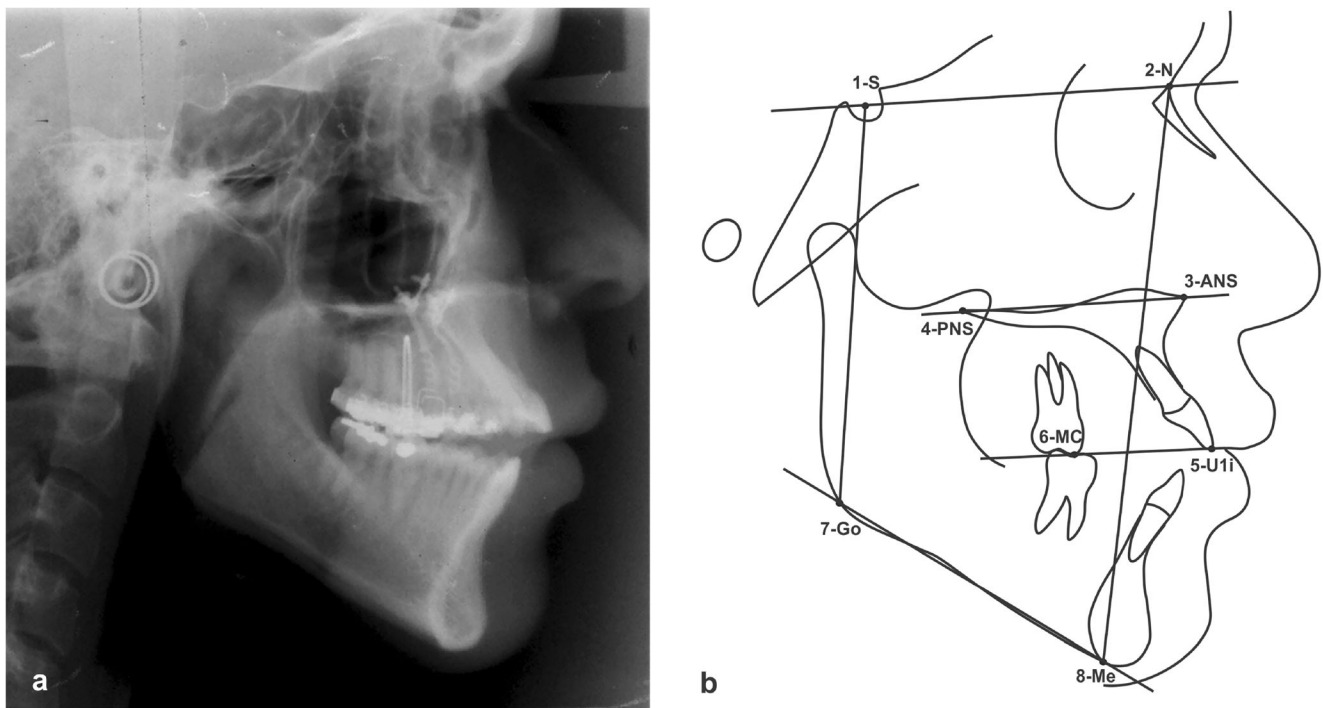


Fig. 2 Lateral cephalometric radiograph (a). Cephalometric tracing and landmarks used to evaluate changes in skeletal and dental structures (b)

sample size used, once it was possible to analyze the effects of the mechanics in the right and left sides of the posterior teeth individually.

Intrusion of 2.03 mm ($p < 0.01$) in the upper molars after approximately 6 months of treatment was observed in oblique radiographs. Similar results were found in the literature; however, these works used lateral radiography to assess molar intrusion [2, 7, 8, 12]. Despite the agreement in upper molar intrusion, the treatments varied in time, applied force, and the

type of device used, where an appliance with acrylic occlusal coverage [3, 8] works as a bite block, enhancing intrusion. Higher intrusion in less time was observed when corticotomy was associated with intrusion with skeletal anchorage [9]. In this study, no changes in the palatal plane angle or anteroposterior positioning of molars were observed, confirming the movement of pure intrusion. The use of oblique radiographs allowed for the assessment of vertical and anteroposterior displacement of the right and left molars

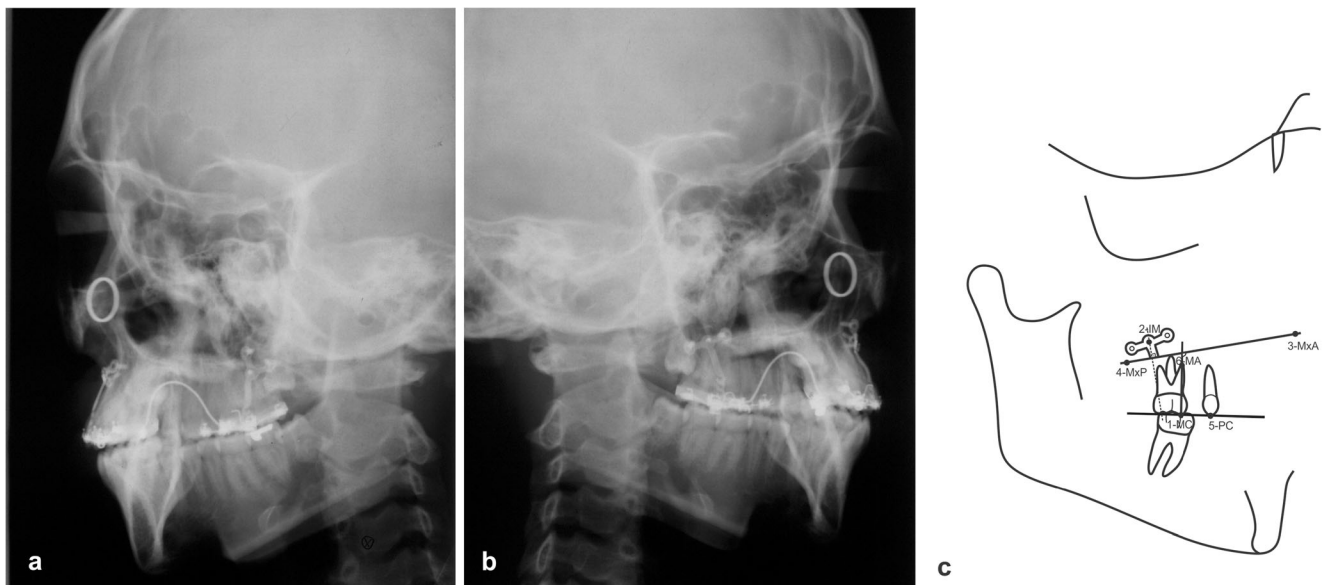


Fig. 3 Oblique cephalometric radiograph: right side (a) and left side (b). Cephalometric tracing and landmarks used to evaluate changes in skeletal and dental structures (c)

Table 3 Comparison between angular and linear variables obtained from lateral cephalometric radiograph before (T1) and after (T2) intrusion (paired *t* test)

Variable	Mean±standard deviation			<i>t</i>	<i>p</i>	95 % confidence interval of difference	
	T1	T2	T2 - T1			Lower	Upper
SN^ANS-PNS (°)	4.36±1.93	3.82±2.16	-0.54±1.00	-1.63	0.14	-1.31	0.23
SN^GoMe (°)	35.44±3.42	33.87±3.18	-1.57±1.02	-4.62	0.02 ^a	-2.35	-0.79
SN^Mc-Uli (°)	7.31±4.65	11.58±4.42	4.27±2.66	4.81	0.01 ^a	2.23	6.31
S-Go (mm)	83.98±7.76	84.30±7.25	0.32±1.46	0.66	0.52	-0.80	1.45
N-Me (mm)	128.41±11.00	126.62±11.31	-1.79±1.51	-3.56	0.00 ^a	-2.95	-0.63

SN^ANS-PNS angle formed by SN and palatal plane, SN^GoMe angle formed by SN and mandibular plane, SN^Mc-Uli angle formed by SN and occlusal plane, S-Go distance from S to Go, N-Me distance from N to Me

^aSignificant value

individually and overcame this restriction in lateral cephalometric radiographs.

The decrease in the mandibular plane angle of 1.57° (*p*=0.02) and lower facial height of 1.79 mm (*p*<0.01) with no change in posterior facial height indicated the counterclockwise rotation of the mandible due to upper molar intrusion, which led to bite closure. Our results were consistent with the findings of other authors who also observed counterclockwise rotation of the mandible [2, 4, 8, 12]. Erverdi et al. reported extrusion of the upper and lower incisors in bite closure [2]. The authors performed segmented mechanics in the anterior region, which may have caused extrusion. In our work, orthodontic mechanics was not performed on anterior teeth during the intrusion phase, and assessing extrusion of these teeth was not the objective of this study; however, other studies reported no extrusion of incisors after molar intrusion [4, 8].

The occlusal plane showed clockwise rotation of 4.27° (*p*=0.01) as a result of molar intrusion when observed in the lateral cephalometric radiograph; however, the oblique radiograph showed no significant change. This difference can be explained by the

different reference points used for each type of radiograph. On the lateral radiograph, the occlusal plane was measured from the upper molar cusp to the incisal edge of the upper incisor, and because no orthodontic mechanics was applied to the incisors, the occlusal plane clockwise rotation was justified by the molar intrusion. In the oblique radiograph, the occlusal plane was measured from the molar cusp to the first premolar cusp. Because these teeth were subjected to the same intrusion protocol, the absence of rotation observed only confirmed the uniform intrusion movement over these teeth, as they were splinted by a rigid steel wire. Similar results were observed by Akay et al. [9], who reported uniform intrusion among posterior teeth. The clockwise rotation of the occlusal plane is consistent with some previous work reported in the literature [2, 9]; however, counterclockwise rotation of the occlusal plane has also been reported [7, 12].

Different forces have been applied over the posterior teeth, directing their intrusion. There is no consensus in the literature on the ideal force applied for this purpose. In our study, a force of approximately 450×*g* was applied to the first molar on each side, similar to that reported in other studies in the literature [3,

Table 4 Comparison between angular and linear variables obtained in oblique cephalometric radiograph before (T1) and after (T2) intrusion (paired *t* test)

Variable	Mean±standard deviation			<i>t</i>	<i>p</i>	95 % confidence interval of difference	
	T1	T2	T2-T1			Lower	Upper
Cusp-AP (mm)	4.20±3.46	4.78±3.49	0.58±1.76	1.40	0.17	-0.29	1.46
Cusp-V (mm)	25.08±2.55	23.05±2.55	-2.03±0.87	-9.91	0.00 ^a	-2.47	-1.60
Mesial molar tipping (°)	95.53±5.82	95.37±8.16	-0.16±6.83	-0.09	0.92	-3.56	3.24
OcPl angle (°)	8.50±4.55	8.63±5.62	0.13±5.67	0.09	0.92	-2.69	2.95
Apex-AP (mm)	5.98±2.31	6.16±2.52	0.18±1.12	0.67	0.51	-0.38	0.74
Apex-V (mm)	6.41±2.93	4.62±3.27	-1.79±0.92	-8.16	0.00 ^a	-2.25	-1.33

AP anteroposterior direction of movement, V vertical direction of movement

^aSignificant value

7, 8]. However, smaller forces of between 100×g and 300×g have been used for intrusion of the maxillary molars [9, 10]. The application of an intrusive force to the buccal sides of posterior teeth will tip molars buccally and impair intrusion. To minimize buccal tipping, we used transpalatal arches made with 0.9 mm stainless steel wire, as proposed by Erverdi et al. [2]. Titanium miniscrews installed in the palate are another way to reduce buccal tipping [9].

Intrusive forces in molars with zygomatic anchorage can lead to resorption at the root apex; however, this seems to be clinically insignificant [19]. This study did not assess the root length of the intruded teeth; however, differences between the means of intrusion measures of the mesial cusp (−2.03 mm, $p < 0.01$) and the apex of the mesiobuccal root of the maxillary first molar (−1.79 mm, $p < 0.01$) were observed, which suggests possible root resorption in the mesiobuccal root of this tooth.

Intrusion of posterior teeth can also be achieved by the use of miniscrews [6]; however, treatment with miniplates is more versatile because they can be inserted far from tooth roots, avoiding root damage and interference in tooth movement [5]. Miniplates are generally well-tolerated by patients [20] and have high success rates when used for orthodontic anchorage [20–23].

Posterior intrusion with skeletal anchorage is a simpler method for open bite correction compared with orthognathic surgery; however, surgical treatment seems to be more appropriate for patients with class III mandibular excess and long face with open bite because the counterclockwise rotation of the mandible due to molar intrusion would worsen the sagittal relationship, and only orthognathic surgery is able to reduce the size of the mandible [4].

Despite the new information provided by this study via the use of oblique radiographs, the findings reported are limited by the small sample size and the short follow-up period. Therefore, further, more comprehensive studies with larger samples should be conducted to prove the effectiveness and long-term stability of skeletal anchorage in the treatment of anterior open bite.

Conclusion

Oblique radiography at 45° is useful in assessing changes in molar position, mainly when the assessment of each side individually is desired. In this study, the treatment of anterior open bite with skeletal anchorage provided intrusion of molars without changing the palatal plane angle. Counterclockwise rotation of the mandible, clockwise rotation of the occlusal plane, and decreased anterior facial height lead to open bite correction. No change in

anteroposterior positioning and mesial tipping of molars was observed in this study.

Conflict of interest The authors declare that they have no conflict of interest.

References

- Baek MS, Choi YJ, Yu HS, Lee KJ, Kwak J, Park YC (2010) Long-term stability of anterior open-bite treatment by intrusion of maxillary posterior teeth. *Am J Orthod Dentofacial Orthop* 138(396):e1–e9
- Erverdi N, Keles A, Nanda R (2004) The use of skeletal anchorage in open bite treatment: a cephalometric evaluation. *Angle Orthod* 74: 381–390
- Erverdi N, Usumez S, Solak A (2006) New generation open-bite treatment with zygomatic anchorage. *Angle Orthod* 76:519–526
- Kuroda S, Sakai Y, Tamamura N, Deguchi T, Takano-Yamamoto T (2007) Treatment of severe anterior open bite with skeletal anchorage in adults: comparison with orthognathic surgery outcomes. *Am J Orthod Dentofacial Orthop* 132:599–605
- Reichert I, Figel P, Winchester L (2013) Orthodontic treatment of anterior open bite: a review article—is surgery always necessary? *Oral Maxillofac Surg*. doi:10.1007/s10006-013-0430-5
- Togawa R, Iino S, Miyawaki S (2010) Skeletal class III and open bite treated with bilateral sagittal split osteotomy and molar intrusion using titanium screws. *Angle Orthod* 80:1176–1184
- Erverdi N, Usumez S, Solak A, Koldas T (2007) Noncompliance open-bite treatment with zygomatic anchorage. *Angle Orthod* 77: 986–990
- Akan S, Kocadereli I, Aktas A, Tasar F (2013) Effects of maxillary molar intrusion with zygomatic anchorage on the stomatognathic system in anterior open bite patients. *Eur J Orthod* 35:93–102
- Akay MC, Aras A, Gumbay T, Akyalcin S, Koyuncue BO (2009) Enhanced effect of combined treatment with corticotomy and skeletal anchorage in open bite correction. *J Oral Maxillofac Surg* 67:563–569
- Seres L, Kocsis A (2009) Closure of severe skeletal anterior open bite with zygomatic anchorage. *J Craniofac Surg* 20:478–482
- Reitan K, Rygh P (1994) Biomechanical principles and reactions. In: Graber TM, Vanarsdall RL (eds) *Orthodontics—current principles and techniques*, 2nd edn. Mosby, St. Louis, pp 168–169
- Sherwood KH, Burch JG, Thompson WJ (2002) Closing anterior open bites by intruding molars with titanium miniplate anchorage. *Am J Orthod Dentofacial Orthop* 122:593–600
- Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H (1999) Skeletal anchorage system for open-bite correction. *Am J Orthod Dentofacial Orthop* 115:166–174
- Sakima MT, Sakima CG, Melsen B (2004) The validity of superimposing oblique cephalometric radiographs to assess tooth movement: an implant study. *Am J Orthod Dentofacial Orthop* 126:344–353
- Chow A, Lee HF, Trahar M, Kawamoto H, Vastardis H, Ting K (2008) Cephalometric evaluation of the craniofacial complex in patients treated with an intraoral distraction osteogenesis device: a long-term study. *Am J Orthod Dentofacial Orthop* 134:724–731
- Baccetti T, Franchi L, McNamara JA Jr (2005) The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Semin Orthod* 11:119–129

17. Bjork A (1969) Prediction of mandibular growth rotation. *Am J Orthod* 55:585–599
18. Wyatt DL, Farman AG, Orbell GM, Silveira AM, Scarfe WC (1995) Accuracy of dimensional and angular measurements from panoramic and lateral oblique radiographs. *Dentomaxillofac Radiol* 24:225–231
19. Ari-Demirkaya A, Masry MA, Erverdi N (2005) Apical root resorption of maxillary first molars after intrusion with zygomatic skeletal anchorage. *Angle Orthod* 75:761–767
20. Cornelis MA, Scheffler NR, Nyssen-Behets C, De Clerck HJ, Tulloch JF (2008) Patients' and orthodontists' perceptions of miniplates used for temporary skeletal anchorage: a prospective study. *Am J Orthod Dentofacial Orthop* 133:18–24
21. Eroglu T, Kaya B, Cetinsahin A, Arman A, Uckan S (2010) Success of zygomatic plate-screw anchorage system. *J Oral Maxillofac Surg* 68:602–605
22. Choi BH, Zhu SJ, Kim YH (2005) A clinical evaluation of titanium miniplates as anchors for orthodontic treatment. *Am J Orthod Dentofacial Orthop* 128:382–384
23. Chen YJ, Chang HH, Huang CY, Hung HC, Lai EH, Yao CC (2007) A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. *Clin Oral Implants Res* 18:768–775