

Cephalometric Assessment of Changes in Vertical Facial Height Following Extraction of Mandibular Second Premolars in Adult Long-face Patients with Skeletal Open Bite: A Case Series

Mohammad Behnaz¹, Kazem Dalaie², Simasadat Seyedsalehi³, Shiva Shekarian⁴

ABSTRACT

Aim: Anterior open bite has a multifactorial etiology and high tendency to relapse. Thus, treatment of this malocclusion is challenging. Extraction has been proposed by some researchers for correction of skeletal anterior open bite. This study aimed to assess cephalometric changes of vertical facial height in patients with skeletal open bite following extraction of mandibular second premolars.

Materials and methods: Thirteen adult patients with a mean age of 24.08 years underwent extraction of second premolars and orthodontic treatment for correction of skeletal anterior open bite. Lateral cephalograms of patients were evaluated at baseline, immediately after treatment, and 1 year after treatment. Some cephalometric parameters such as the sum of posterior angles, sella-nasion-mandibular plane (SN-MP), anterior facial height (LAFH), upper 1-sella-nasion (U1-SN), incisor mandibular plane angle (IMPA), and overbite were measured and compared at different time points. Cephalometric data were analyzed using SPSS via the repeated measures ANOVA.

Results: Treatment resulted in positive overbite, which remained stable at 2 years after treatment. The sum of posterior angles, the Jarabak SN-MP, LAFH, sella-nasion-B point (SNB), A point-nasion-B point (ANB), U1-SN, and IMPA also showed statistically significant changes (P < 0.05).

Conclusion: Open bite closure in patients was mainly due to relative extrusion and retrusion of anterior teeth in both jaws. The results of 24-month follow-up showed stability of treatment, although longer follow-ups are required to reach a definite judgment.

Clinical significance: This treatment can help long-face patients who are not candidate of orthognathic surgery because of complicated systemic conditions or those patients who do not want to have any surgery.

Keywords: Adult patient, Anterior open bite, Premolar extraction, Vertical facial height, Wedge effect.

Journal of Contemporary Dentistry (2019): 10.5005/jp-journals-10031-1254

INTRODUCTION

Open bite is among the most common dental anomalies. Anterior open bite is defined as absence of contact between the maxillary and mandibular anterior teeth while other teeth are in occlusion. This anomaly is more common in the primary dentition period, however, it may continue to adulthood. Treatment of open bite, especially in the permanent dentition period, is highly challenging for orthodontists.

The prevalence of anterior open bite ranges from 1.5 to 10% in different age groups. Open bite is a multifactorial condition and understanding its etiology plays an important role in its diagnosis and treatment. Researchers have mentioned several causes for this anomaly. Some have reported genetics as well as environmental and behavioral factors to be responsible for development of open bite.³ Many researchers believe that nonnutritive sucking habits are the main causes of anterior open bite. The following factors are the main local or environmental parameters responsible for the development of open bite at a young age:

- Nonnutritive sucking habits (such as thumbsucking or paci er)^{4,5}
- Abnormal size, position, or function of the tongue
- Mouth breathing (which may be due to enlargement of lymph nodes)⁶

Correction of open bite is a complex procedure due to the high risk of relapse (25-38%), particularly in adults since the skeletal growth and development of the jaws has terminated. In some cases, prevention of overgrowth of the maxilla and its rotation

^{1,2,4} Department of Orthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

³ Orthodontics Department, Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

⁴ Corresponding Author: Shiva Shekarian, Department of Orthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran, Phone: +98 9358028440, e-mail: shiva.shekarian1992@gmail.com

How to cite this article: Behnaz M, Dalaie K, Seyedsalehi S, et al. Cephalometric Assessment of Changes in Vertical Facial Height Following Extraction of Mandibular Second Premolars in Adult Long-face Patients with Skeletal Open Bite: A Case Series. J Contemp Dent 2019;9(2):95-100.

Source of support: Shahid Beheshti University of Medical Sciences

Conflict of interest: None

the posterior area or prevention of overeruption of posterior teeth during the growth spurt fails due to the remaining growth.

Most dentists believe that treatment of anterior open bite is more difficult and its course of treatment in long term is less predictable compared to treatment of other dentofacial deformities.⁸ The most important factor with regard to different modalities for treatment of anterior open bite is stability of treatment results in long term, which is challenging. At present,

therapeutic procedures performed for treatment of this condition may vary from using a simple removable orthodontic appliance to orthognathic surgery depending on the severity of open bite.

© The Author(s). 2019 Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted use, distribution, and non-commercial reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by-nc/4.0/>) applies to the data made available in this article, unless otherwise stated.

Therapeutic interventions for treatment of anterior open bite also vary depending on the dentition stage. Therapeutic strategies are divided into three categories of treatment in the primary dentition period, the mixed dentition period, and the permanent dentition period. Simple orthodontic treatments are not available for treatment of open bite in this period. In very severe cases, orthodontic treatment is not sufficient alone and the patient must undergo a surgical procedure as well. Maxillary surgeries are often performed to achieve adequate facial height in long-face patients, while mandibular surgeries are performed to correct the anterior posterior dimension of the face.

Several strategies have been suggested for treatment of open bite with moderate severity in the permanent dentition period. Several studies have reported orthodontic treatment with and without tooth extraction for correction of open bite with variable results in this respect. Some researchers prefer the correction of open bite with tooth extraction; however, some others believe that the effect of tooth extraction on closure of open bite is not significantly different from the outcome of nonextraction treatments. On the other hand, long-term treatments is a highly debated topic.

Selection of a suitable treatment done by taking into account the dental factors.

This study aimed to assess cephalometric facial height of patients with skeletal anterior extraction of mandibular second premolars.

MATERIALS AND METHODS

This study was conducted on 13 open bite of 24.08 years (range 19–28 years), mixed dentition period. According to a study, mean difference in the lower anterior facial height before and after treatment was considered 71.39 ± 2.31 and 75.35. Accordingly, we divided eight samples to find this difference by 5% error rate.

All patients underwent fixed orthodontic extraction of mandibular second premolars or second premolars. All patients were referred to an orthodontist. Extractions in each jaw were performed before applying fixed orthodontic appliance of the respective jaw. The treatment was started by extraction of maxillary second premolars (maxillary first premolars were extracted in 11 and maxillary second premolars were extracted in two patients) and after that, leveling and alignment of maxillary teeth were started. After a couple of months, mandibular second premolars were extracted before applying fixed orthodontic appliances.

The inclusion and exclusion criteria were as follows:

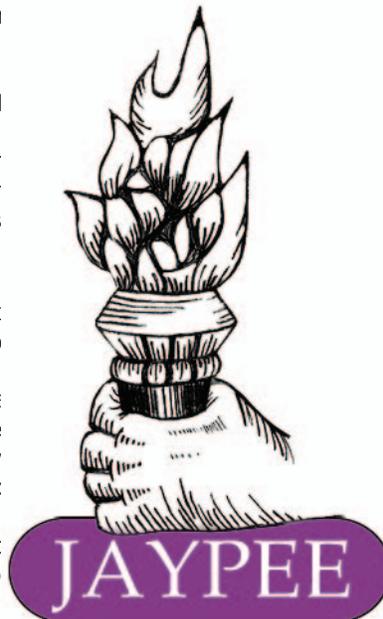
Inclusion Criteria

Long-face patients with sella-nasion mandibular plane (SN-MP) angle < 39° and sella-nasion-A point (SNA) angle between 81° and 84°, sella-nasion-B point (SNB) angle between 75° and 79°, and point-nasion-B point (ANB) angle between 2° and 6°. Patients with class I or class II skeletal relationship (class II skeletal patients were not included because of anterior superior rotation of the mandible, the class III profile was aggravated).

Patients with normal or increased overjet (in the range of 5 mm) and decreased overbite (in the range of 1–4 mm) patients with the Witt's appraisal between 1 and 4 mm patients with no oral habits patients with no degenerative pathologies of the temporomandibular joint

Exclusion Criteria

Patients with a history of previous orthodontic treatment patients with a history of nonnutritive sucking habits patients seeking to make a drastic change in their facial appearance patients with severe gumminess over 5 mm patients with neuromuscular conditions patients with extracted molar teeth patients with severe crowding over 5 mm of the mandible and over 7 mm of the maxilla patients with reduction of incisal angles by more than 5° or increase by more than 5° in the maxilla and mandible



Following parameters were evaluated in each patient: overjet, incisor mandibular plane angle (IMPA), upper incisor to sella-nasion (U1-SN), ANB, SNB, SNA, LAFH, SN-MP, the Jarabak sum of posterior angles. Table 1 summarizes these variables.

Treatment was started with the McLaughlin-Bennett-Trevisi system using standard 0.0225-inch brackets. In the alignment phase, the wires were used in the following order: 0.014-inch nickel titanium wire, 0.018-inch nickel titanium, 0.014-inch stainless steel, and stainless steel wires; 0.016-inch nickel titanium and stainless steel wires were used if required. In all patients, leveling and application of maxillary wires were performed first, and then mandibular arch treatment was commenced for the mandibular arch. After leveling and alignment of teeth in both arches, inter-arch elastics were used for correction of class II relationship (if they had class II relationship) and anterior open bite. After completion of the active phase of treatment, fixed retainers were used in both jaws. The patients were instructed to use these retainers full time in the first 3 months after completion of treatment. In case of no relapse in position of teeth in both jaws, the duration of usage of these retainers decreased to 6 months. Also, during the course of treatment and after proper positioning of the tongue was instructed to patients. During the course of treatment, the space gained by extraction of mandibular second premolars was used for mesial movement of molars (anchorage). Also, the anchorage in the maxilla was B-anchorage. During treatment, we tried our best to prevent extrusion of first molars. Since mesial movement of the molar tooth could result in its mesial rotation, an anti-rotation bend (toe-in) was made in orthodontic wires.

Cephalograms were obtained of patients at baseline prior to treatment (T1), immediately after completion of treatment (T2) and at 24 months after completion of treatment (T3), and using the Dolphin version 10 software. For each tracing, 48 points were identified. Using these points, the respective parameters required for the study (eight linear and seven angular parameters) were measured.

Raw data obtained from cephalometric analyses of patients were statistically analyzed using SPSS version 21 via the repeated measures ANOVA. Relevant tables and graphs were drawn.

Table 1: Variables evaluated in this study

Variable	De nition
Sum of posterior angles	Sum of posterior facial angles
Jarabak index	Ratio of posterior facial height to anterior facial height
SN-MP	Angle between the mandibular plane and the SN plane
LAFH	Lower anterior facial height
SNA	Angle indicating the anterior posterior position of maxilla
SNB	Angle indicating the anterior posterior position of the mandible
ANB	Skeletal relationship in the anterior posterior dimension
U1-SN	Axial inclination of maxillary teeth (angle between maxillary anterior teeth and the SN plane)
IMPA	Axial inclination of mandibular teeth (angle between the mandibular anterior teeth and the mandibular plane)
Overbite	Vertical distance between maxillary and mandibular anterior teeth
Overjet	Horizontal distance between maxillary and mandibular anterior teeth
Molar extrusion	Distance from the mandibular molar tooth to the mandibular plane
Witt s value	Distance in mm from BO (perpendicular line from B point to the functional occlusal plane) to AO (perpendicular line from A point to the functional occlusal plane)
U1-extrusion	Distance from incisal edge of upper incisors to the palatal plane
L1-extrusion	Distance from incisal edge of lower incisors to the mandibular plane

RESULTS

Cephalometric analyses and comparison of cephalograms after treatment with baseline cephalograms of patients revealed the following:

The sum of posterior angles, SN-MP, and LAFH decreased after treatment (T2) in all patients compared to baseline (T1). The Jarabak index increased after treatment in all patients compared to baseline. Also, ANB, U1-SN, and IMPA decreased after treatment in all patients. Overjet experienced a slight increase in five patients while it decreased in eight patients. Overbite increased in all patients and was positive enough to con rm open bite closure.

Cephalograms of patients taken at 24 months posttreatment (T3) were compared with those taken immediately after completion of treatment (T2) and showed no significant change in any parameter. With regard to overbite, six patients experienced a reduction and two patients experienced an increase in overbite; overbite remained unchanged in five patients. However, reduction in overbite in the mentioned six patients did not result in bite opening and all patients still had positive overbite.

Insignificant changes in cephalometric analysis of some variables such as SNA noted immediately after treatment and after 24 months (T3) were normal because cephalograms of patients had been taken by different X-ray units and at different times. Thus, insignificant changes at the two time points were inevitable and were considered normal.

Table 2 compares the mean and standard deviation of parameters measured on cephalograms of patients at baseline, immediately after treatment and at 24 months posttreatment. Also, Figures 1 to 3 show SN-MP, LAFH, and overbite at T1, T2, and T3.

According to the repeated measures ANOVA, the sum of posterior angles ($p < 0.001$), the Jarabak index ($p < 0.001$), SN-MP ($p < 0.05$), LAFH ($p < 0.05$), SNB ($p < 0.05$), ANB ($p < 0.05$), U1-SN ($p < 0.001$), IMPA ($p < 0.001$), and overbite ($p < 0.001$) showed significant changes during the period of T1 T2. Also, according to the repeated measures ANOVA, SNA, overjet, and molar extrusion did not show significant changes compared to their baseline values ($p > 0.05$).

Table 2: The mean and standard deviation (SD) of parameters measured on cephalograms of patients at baseline, immediately after treatment and at 24 months posttreatment

	T ₁		T ₂		T ₃		T ₂ T ₁			T ₃ T ₂		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p value	Mean	SD	p value
Sum of posterior angles	397.66	5.85	397.27	5.98	399.70	5.47	2.43	1.44	0.00	0.39	0.21	0.474
Jarabak index	63.59	5.17	63.75	5.13	61.47	4.96	2.34	1.77	0.001	0.22	0.17	0.840
SN-MP	37.85	6.02	37.54	6.01	39.57	5.40	1.60	2.03	0.005	0.32	0.21	0.589
LAFH	73.53	7.76	73.5	7.75	75.77	7.33	2.27	1.87	0.003	0.03	0.7	1.000
SNA	81.23	2.28	81.36	2.24	81.68	2.25	0.32	1.30	1.000	0.13	0.31	0.218
SNB	76.5	2.17	76.94	2.18	76.13	2.33	0.81	1.49	0.038	0.44	0.47	0.238
ANB	4.73	2.02	4.42	2.05	5.55	2.38	1.13	1.44	0.046	0.31	0.61	1.000
U1-SN	95.55	4.99	96.09	6.19	108.01	7.28	11.91	7.62	0.00	0.55	3.3	1.000
IMPA	86.5	4.12	86.08	4.05	97.09	4.65	11.01	4.51	0.00	0.42	0.87	0.337
Overjet	3.45	0.83	3.46	0.73	3.96	2.12	0.5	2.11	1.000	0.01	0.25	1.000
Overbite	1.12	0.6	1.18	0.63	2.71	1.85	3.89	1.59	0.00	0.06	0.13	0.510
Molar extrusion	32.73	2.84	32.76	2.80	32.40	3.22	0.36	0.42	0.813	0.03	0.04	1.000
Witt s value	0.43	1.08	0.46	1.12	2.09	1.97	1.63	0.85	0.012	0.03	0.04	1.000
U1-extrusion	30.70	2.69	30.72	2.56	28.06	2.07	2.66	0.49	0.00	0.02	0.13	0.687
L1-extrusion	42.11	3.41	42.09	3.29	40.35	3.61	1.74	0.32	0.00	0.02	0.12	1.000

Fig. 1: Comparison of SN-MP parameter at T1, T2 and T3

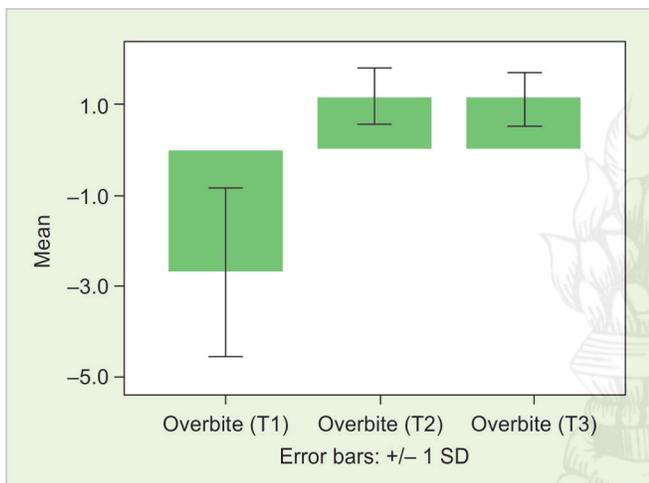


Fig. 3: Comparison of overbite at T1, T2 and T3

Statistical analysis of the data of patients at 24 months after treatment showed that none of the parameters evaluated in this study experienced any significant change compared to their value immediately after completion of treatment.

DISCUSSION

The effect of tooth extraction on vertical facial height and open bite closure has been an interesting topic of research. A challenging topic is to find out whether tooth extraction has any significant effect on open bite closure. The next question is given that tooth extraction can significantly contribute to open bite closure, extraction of which teeth would have the greatest impact on bite closure. Stability of open bite treatment over the long term is another important topic in this regard. Open bite treatment is among the most challenging orthodontic treatments due to the high risk of relapse in long term.

Some researchers believe that the results of nonextraction orthodontic treatment have optimal long-term stability. However, some others evaluated the success of extraction orthodontic treatment of open bite (in terms of relapse) and reported stability of treatment results. Some other researchers believe that extraction of second premolars compared to first premolars results in greater mesial movement of the first molar

Fig. 2: Comparison of LAFH parameter at T1, T2 and T3

This leads to the reduction of vertical facial height by the wedge effect.¹¹ In contrast, some studies showed that extraction of first or second premolars was not significantly different in terms of effect on vertical facial height; in other words, change in vertical facial height does not depend on the mesial movement of the first molar tooth.¹² Researchers have discussed that closure of space created by tooth extraction would be associated with extrusion of the first molar tooth, and the greater the mesial movement of this tooth, the greater its extrusion would be. Resultantly, vertical facial height would increase. Some clinicians prefer to extract first molar teeth in order to close the bite in open bite patients. They believe that movement of the second molar tooth to the first molar site would result in rotation of the mandible and open bite closure.¹²

In contrast, other researchers have discussed that extraction of second premolars and first molars would result in rotation of the mandible for the sake of open bite closure in skeletal open bite patients; however, extraction of first premolars does not cause significant changes in mandibular rotation. Some others have mentioned that extraction of second premolars creates a wedge effect and results in greater mesial movement of the first molar compared to patients in whom first premolars are extracted, and can result in open bite closure and reduction in vertical facial height.^{12,13}

A few researchers have shown that tooth extraction does not change the vertical facial height. Stagger¹⁵ showed that changes in vertical facial height following extraction of first premolars were similar to changes in patients who underwent nonextraction treatment. Chua et al.¹⁶ demonstrated that nonextraction treatment resulted in an increase in LAFH; whereas, tooth extraction did not cause significant changes in LAFH.

Atas¹³ evaluated the effect of extraction of first premolars, second premolars, and first molars and concluded that extraction of first premolars had no significant effect on rotation of the mandible compared with anterior open bite while extraction of second premolars and first molars affected the vertical facial height and resulted in mandibular rotation. Garlington and Logan¹⁷ showed that following extraction of mandibular second premolars, LAFH increased in patients but no significant change was noted in facial height. Kim et al.¹⁸ assessed the efficacy of the wedge-effect theory by extraction of first and second premolars for open bite closure. According to the wedge-effect concept, even small changes in mesial movement of molars would result in a pronounced effect

on the mandibular plane angle and facial vertical dimension. According to this theory, extraction of more posterior teeth results in greater mesial movement of molar teeth and better open bite closure. They concluded that extraction of first and second premolars has no significant effect on facial height of patients; thus, the wedge-effect theory for open bite closure via mesial movement of molars is inefficient.

In the current study, extraction of mandibular second premolars changed the cephalometric parameters such that the sum of posterior angles and SN-MP angle slightly decreased and the Jarabak index slightly increased. All these changes were statistically significant but not clinically perceivable. Also, the angle of maxillary and mandibular incisors relative to the palatal and mandibular planes significantly decreased. Significant increase in overbite was noted in all patients. Based on the results, it may be stated that despite reduction in facial height, open bite closure was mainly due to the retroclination of the maxillary and mandibular incisors. Thus, our study, similar to that of Kim¹² et al., showed that extraction of mandibular second premolars and mesial movement of molars had no significant effect on open bite closure. Another important issue with regard to treatment of open bite is the stability of treatment in long term. Open bite treatment at a young age and the mixed dentition period would yield the best results with minimal rate of relapse. However, opinions on the outcome of treatment of open bite in adults are controversial.

Studies on the stability of results of extraction orthodontic treatment of open bite are not many and the available ones have separately reported the outcomes of extraction and nonextraction treatments. Remmers et al¹⁸ orthodontically treated 51 open bite patients; 71% of these patients had positive overbite upon completion of treatment, out of which 10% had relapse within 5 years after treatment and developed negative overbite. The authors concluded that orthodontic treatment of open bite has a long-term stability. However, they did not mention whether they performed extraction or nonextraction orthodontic treatment for correction of open bite.

de Freitas et al¹⁰ evaluated the stability of extraction and nonextraction orthodontic treatments. The group that underwent extraction orthodontic treatment (n=31) was followed up for a minimum of 5 years with a mean of 8.35 years. The nonextraction group (n=21) was followed up for a minimum of 3 years with a mean of 5 years. The results of the aforementioned two retrospective studies showed that 38.1% of patients who underwent nonextraction orthodontic treatment and 25.8% of patients who underwent extraction orthodontic treatment relapsed during the follow-up period and developed open bite again. They concluded that stability of the results of open bite correction by extraction treatment is higher than that of nonextraction treatment. However, other studies that compared extraction and nonextraction orthodontic treatments for correction of open bite did not find a statistically significant difference between the two methods in long-term stability of treated open bite. Although a 24-month period is not sufficient to reach a definite conclusion with regard to long-term stability of treatment results, it should be noted that relapse often occurs during the first year following completion of treatment. Some researchers suggest that the stability of corrected anterior open bite malocclusion should be reported as a percentage of patients with a significant posttreatment change for the treatment. The condition is considered highly stable if significant posttreatment changes are noticed in less than 10% of the patients and stable if it is less than 20% and almost none have major

CONCLUSION

Extraction of mandibular second premolars in adult long-face patients results in slight counterclockwise rotation of the mandible but has no significant clinical effect on LAFH.

In open bite patients who underwent orthodontic treatment along with extraction of mandibular second premolars, open bite was mainly closed by retraction and relative extrusion of anterior teeth in both jaws.

Open bite closure in these patients during the first year after completion of treatment was stable and did not change significantly. Patients must be followed up for longer periods of time for more adequate assessment of the stability of treatment results.

ACKNOWLEDGMENTS

This study was approved by the Ethical Committee of our university (ethical approval code: IR.SBMU.RIDS.REC.1394.99).

REFERENCES

- Machado DB, Brizon VSC, Ambrosano GMB, et al. Factors associated with the prevalence of anterior open bite among preschool children: a population-based study in Brazil. *Dental Press J Orthod* 2014;19(5):103-109. DOI: 10.1590/2176-9451.19.5.103-109.oar.
- Antonarakis GS, Scolozzi P, et al. Combined orthodontic and orthognathic surgical treatment for the correction of skeletal anterior open-bite malocclusion: a systematic review of vertical stability. *J Oral Maxillofac Surg* 2013;71(1):98-109. DOI: 10.1016/j.joms.2012.03.016.
- Barreto GM. Angle class II malocclusion treated with extraction of permanent teeth. *Dental Press J Orthod* 2013;18(4):126-133. DOI: 10.1590/S2176-94512013000400004.
- Phillips C, Turvey T. Orthognathic surgery: a hierarchy of stability. *Int J Adult Orthodon Orthognath Surg* 1996;11(3):191-204.
- Clément C, Weissenbach M, et al. Early risk factors for posterior crossbite and anterior open bite in the primary dentition. *Angle Orthod* 2016;86(5):832-838. DOI: 10.2319/102715-723.1.
- Bahreman A. Early-age orthodontic treatment: quintessence: 2013.
- Espeland L, Dowling PA, Mobarak KA, et al. Three-year stability of open-bite correction by 1-piece maxillary osteotomy. *Am J Orthod Dentofacial Orthop* 2008;134(1):60-66. DOI: 10.1016/j.jado.2006.05.049.
- Endo T, Shimooka S. Effects of maxillary second premolar extraction on dentofacial morphology before and after anterior open-bite treatment: a cephalometric study. *Odontology* 2009;97(1):43-50. DOI: 10.1007/s10266-008-0093-0.
- Tagaka E, Iwabe T, Kawai N, et al. An adult case of skeletal open bite with a large lower anterior facial height. *Angle Orthod* 2005;75(3):465-471. DOI: 10.1043/0003-3219(2005)75[465:AACOSO]2.0.CO;2.
- de Freitas MR, Beltrão RTS, Janson G, et al. Long-term stability of anterior open bite extraction treatment in the permanent dentition. *Am J Orthod Dentofacial Orthop* 2004;125(1):78-87. DOI: 10.1016/j.jado.2003.01.006.
- Baldarriaga M, Julio R. Protocol for the treatment of anterior open bite in patients: an evaluation. *World J Orthod* 2007;8(3):285-299.
- Kim T-K, Kim J-T, Mah J, et al. First or second premolar extraction effects on facial vertical dimension. *Angle Orthod* 2005;75(2):177-182. DOI: 10.1043/0003-3219(2005)75[177:OSPE]2.0.CO;2.
- Aras A. Vertical changes following orthodontic extraction treatment of skeletal open bite subjects. *Eur J Orthod* 2002;24(4):407-416. DOI: 10.1093/ejo/24.4.407.
- W. Preventing adverse effects on the temporomandibular joint through orthodontic treatment. *Int J Orthod* 1988;26(3-4):10-12.

15. Stagers JA. Vertical changes following first premolar extraction. *Am J Orthod Dentofacial Orthop* 1990;60(4):263-267. DOI: 10.1016/S0889-5406(94)70095-8.
16. Chua A-L, Lim JY, Lubit EC. The effects of extraction versus nonextraction orthodontic treatment on the growth of the lower anterior facial height. *Am J Orthod Dentofacial Orthop* 1993;104(4):361-368. DOI: 10.1016/S0889-5406(05)81334-4.
17. Garlington M, Logan LR. Vertical changes in high mandibular plane cases following enucleation of second premolars. *Angle Orthod* 2017;30(1):21-27. DOI: 10.5152/TurkJOrthod.2017.010.
18. Remmers D, Van't Hullebaar R, Bronkhorst E, et al. Treatment results and long-term stability of anterior open bite malocclusion. *Orthodontic treatment on the growth of the lower anterior facial height.* *Am J Orthod Dentofacial Orthop* 1993;104(4):361-368. DOI: 10.1016/S0889-5406(05)81334-4.
19. Al-Thomali Y, Basha S, Mohamed RN. The factors affecting long-term stability in anterior open-bite correction-a systematic review. *Turk J Orthod* 2017;30(1):21-27. DOI: 10.5152/TurkJOrthod.2017.010.

