Case Report

Extreme skeletal open bite correction with vertical elastics

Marco Antonio Cruz-Escalante[a]; Aron Aliaga-Del Castillo[b]; Luciano Soldevilla[c]; Guilherme Janson[d]; Marilia Yatabe[e]; Ricardo Voss Zuazola[f]

ABSTRACT

Severe skeletal open bites may be ideally treated with a combined surgical–orthodontic approach. Alternatively, compensations may be planned to camouflage the malocclusion with orthodontics alone. This case report describes the treatment of an 18-year-old man who presented with a severe open bite involving the anterior and posterior teeth up to the first molars, increased vertical dimension, bilateral Class III molar relationship, bilateral posterior crossbite, dental midline deviation, and absence of the maxillary right canine and the mandibular left first premolar. A treatment plan including the extraction of the mandibular right first premolar and based on uprighting and vertical control of the posterior teeth, combined with extrusion of the anterior teeth using multiloop edgewise archwire mechanics and elastics was chosen. After 6 months of alignment and 2 months of multiloop edgewise archwire mechanics, the open bite was significantly reduced. After 24 months of treatment, anterior teeth extrusion, posterior teeth intrusion, and counterclockwise mandibular rotation were accomplished. Satisfactory improvement of the overbite, overjet, sagittal malocclusion, and facial appearance were achieved. The mechanics used in this clinical case demonstrated good and stable results for open-bite correction at the 2-year posttreatment follow-up. (*Angle Orthod.* 2017;87:911–923.)

KEY WORDS: Open bite; Corrective orthodontics; Elastics

INTRODUCTION

The etiology of anterior open-bite (AOB) malocclusion may be attributable to a combination of genetic and environmental factors.[1,2] Some characteristics of AOB are divergent maxillary and mandibular occlusal planes, mesial angulation of the posterior teeth, and increased skeletal vertical dimension.[1,3,4] Treatment in the permanent dentition depends on the balance between dentoalveolar and skeletal characteristics. If there is a predominance of skeletal imbalance, the greater will be the chance of a need for combined surgical–orthodontic intervention.[5,6] Sometimes patients may refuse the surgical option for various reasons, and in these cases orthodontic camouflage may be attempted.[7]

Conventional orthodontics can be performed with or without extractions, with anterior teeth extrusion[6,8] or with combined posterior teeth uprighting and anterior teeth extrusion with elastics.[3,9,10] Intrusion of the posterior teeth allows autorotation of the mandible and consequently AOB closure.[11–13] Temporary anchorage devices (TADs) are a good option when posterior teeth intrusion is planned.[11–15] The multiloop edgewise archwire (MEAW) technique could be used as an alternative to achieve proper vertical positioning of the anterior teeth, acceptable inclination of the maxillary and mandibular occlusal planes, and uprighting with vertical control of the posterior teeth.[3,10] The use of MEAW requires patient compliance with continuous use of elastics. This treatment approach

[a] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Universidad Nacional Mayor de San Marcos, Lima, Perú.

[b] Graduate Student, Department of Orthodontics, Bauru Dental School, University of São Paulo, Bauru, SP, Brazil.

[c] Associate Professor, Department of Orthodontics, Faculty of Dentistry, Universidad Nacional Mayor de San Marcos, Lima, Perú.

[d] Professor and Head, Department of Orthodontics, Bauru Dental School, University of São Paulo, Bauru, SP, Brazil.

[e] Postdoctoral Fellow, Hospital of Rehabilitation of Craniofacial Anomalies, University of São Paulo, Bauru, SP, Brazil.

[f] Associate Professor (retired), Department of Orthodontics, Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile.

Corresponding Author: Dr Marco Antonio Cruz-Escalante, Department of Orthodontics, School of Dentistry, Universidad Nacional Mayor de San Marcos, Av. Germán Amézaga N° 375, Ciudad Universitaria, Lima, 15081, Perú
(e-mail: marcocruz244@hotmail.com)

Accepted: July 2017. Submitted: April 2017.
Published Online: September 12, 2017

Figure 1. Pretreatment facial and intraoral photographs.

has been shown to be efficient, providing stable results in severe AOB correction.[10,16,17] The treatment choice would depend on the patient's chief complaint and compliance level, AOB severity, and professional skills.

This case report presents the nonsurgical treatment of a severe AOB malocclusion by means of posterior teeth uprighting and intrusion combined with anterior teeth extrusion using the MEAW technique and vertical elastics.

Diagnosis and Etiology

An 18-year-old male patient presented to the orthodontic clinic with chief complaints of "severe open bite and self-esteem and speech problems." He had a history of tooth extractions. The clinical examination showed a straight to convex profile, vertical growth pattern, mild chin deviation to the left, lack of maxillary incisor exposure upon smiling, lip incompetence at rest, and an infantile swallowing pattern. He had an open bite involving the anterior (10 mm) and posterior teeth up to the first molars, bilateral posterior crossbite, bilateral Class III molar and left Class II canine relationships, 2 mm of maxillary dental midline deviation to the right and 6mm of mandibular dental midline deviation to the left in relation to the midfacial plane, mild anterior crowding, and an absence of the maxillary right canine and mandibular left first premolar (Figures 1 and 2).

Cephalometric examination showed a skeletal Class III sagittal relationship, large mandible, steep mandibular plane, increased lower anterior face height, and maxillary and mandibular incisors with normal and lingual inclinations, respectively (Figure 3, Table 1). He was in the last maturational stage.[18] The temporomandibular joint showed no symptoms and had normal function and structure. There were no signs of active periodontal disease (Figure 4). He had no contributory medical history, and he expressed a strong desire to avoid orthognathic surgery.

The patient was diagnosed with a severe Class III skeletal open-bite malocclusion, increased lower anterior face height, steep mandibular plane, bilateral posterior crossbite, dental midline deviations, lip incompetency, and infantile swallowing pattern.

Treatment Objectives

The primary orthodontic treatment objectives were to close the AOB, correct the posterior crossbite and dental midline deviations, achieve Class I canine and functional molar relationships as well as ideal overbite and overjet, improve facial esthetics, and obtain passive lip competence.

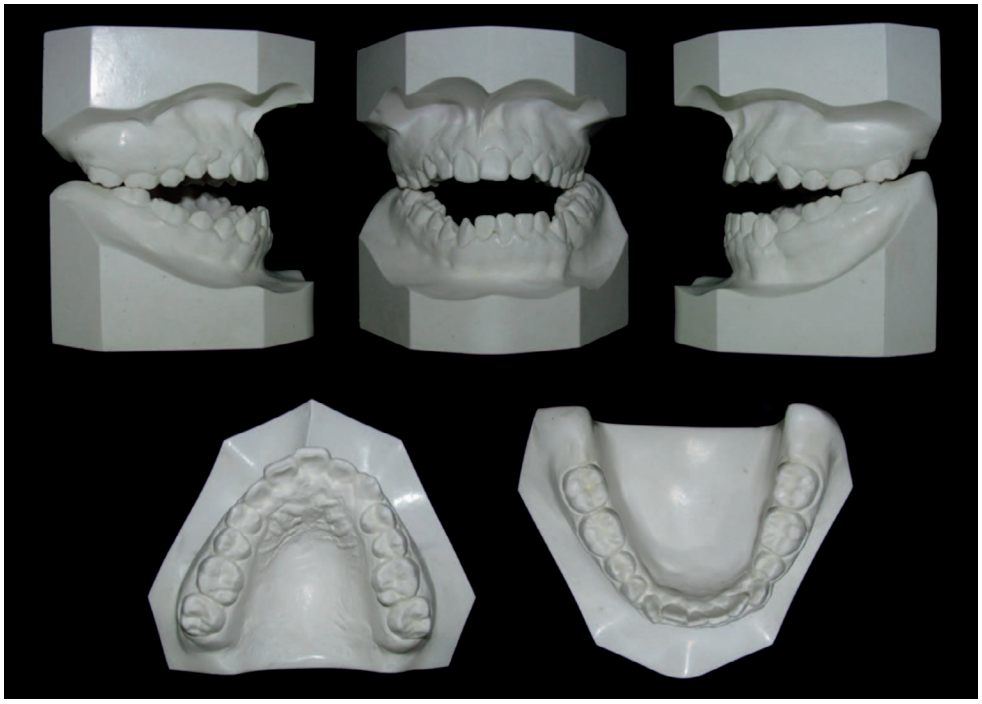

Figure 2. Pretreatment dental casts.

Treatment Alternatives

The following three treatment options were considered: (1) surgical orthodontic treatment (ideal option), which could correct the vertical, transverse and sagittal problems and improve facial appearance; (2) combined maxillary and mandibular posterior teeth intrusion with TADs[11–15] and anterior teeth extrusion with elastics[6,8]; (3) vertical control and uprighting of the posterior teeth combined with anterior teeth extrusion

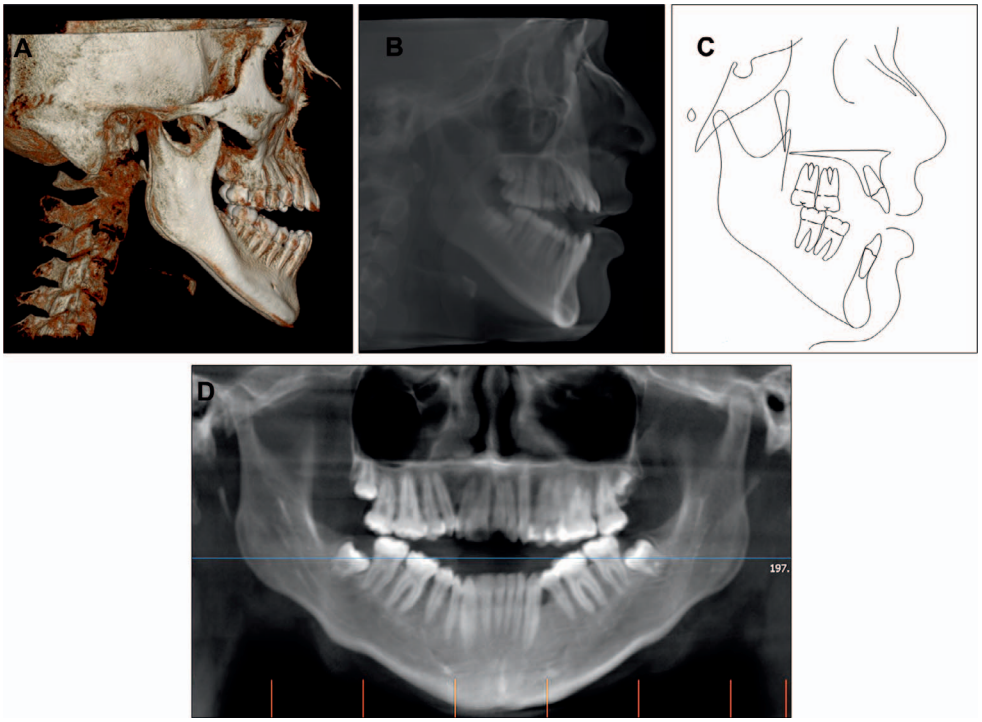

Figure 3. Pretreatment records: (A) 3D automatically reformatted image, (B) lateral ceph image generated from cone-beam computed tomography, (C) ceph tracing, (D) panoramic radiograph generated from cone-beam computed tomography.

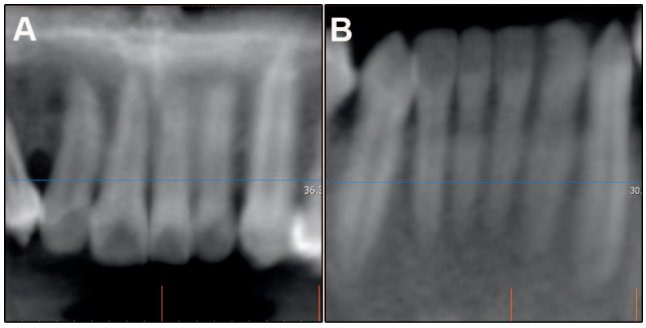

Figure 4. Cone-beam computed tomography synthesized panoramic view of maxillary (A) and mandibular (B) anterior teeth at pretreatment.

with MEAW mechanics and elastics.[3,10,16] The two nonsurgical options included dentoalveolar posterior expansion for posterior crossbite correction, maxillary right canine space creation, and mandibular right first premolar extraction to correct the maxillary and mandibular dental midline deviations, respectively, and to obtain acceptable overjet and bilateral functional Class III molar relationships.[19–21]

These treatment alternatives were discussed with the patient and the third option was chosen.

Treatment Progress

Before treatment began, the mandibular third molars were extracted to improve the prognosis for mandibular posterior uprighting mechanics. Treatment was initiated with 0.022 × 0.028-inch slot standard edgewise appliances placed in both dental arches. After the mandibular right first premolar was extracted, 0.014, 0.016, and 0.016 × 0.022-inch nickel-titanium (NiTi) archwires were used for leveling and alignment. Concomitantly, maxillary right canine space was created with an open NiTi coil spring (Figure 5A). The anterior open bite decreased by 3 mm after this first phase of treatment (6 months). Then 0.016 × 0.022-inch blue elgiloy multiloop archwires with 5° tip-back activations per loop (generating an accentuated and reverse curve of Spee of 25° in the maxillary and mandibular arches, respectively) were placed, and short Class III anterior elastics (3/16-in, 6.5 oz) were prescribed to be used full-time by the patient (Figure 5B). The activated maxillary multiloop archwire was expanded before insertion to control the transverse dimension.

After 2 months of MEAW mechanics, a significant reduction of the anterior open bite by 7 mm was achieved (Figure 5C). Posterior crossbite correction was initiated with an overlay 0.036-inch blue elgiloy expanded archwire placed in the maxillary first molar tubes in addition to intermaxillary palato-buccal cross-elastics until an acceptable posterior transverse relationship was obtained (Figure 5D). During this phase (6 months), MEAW mechanics continued until the overbite was quite satisfactory. At that time, compensation bends (progressive flattening of the posterior tip back bends) were made and a 0.018 × 0.025-inch stainless steel archwire was placed in the mandibular arch for space closure (Figure 5E). Then 0.018 × 0.025-inch blue elgiloy multiloop archwires were placed in both arches, with some individual bends, and intercuspation elastics were used during the finishing phase (Figure 5F). The patient received orofacial myofunctional therapy during the last 6 months of treatment. The total orthodontic treatment time was 24 months.

Table 1. Cephalometric Variables

Variables[a]	Initial	Final	F-I
Maxillary Component			
SNA, °	81.6	81.5	−0.1
Mandibular Component			
SNB, °	77	81.7	4.7
SND, °	75.4	80.5	5.1
Maxillomandibular Sagittal Relationship			
Facial Convexity (NAP),°	6.6	−2.8	−9.4
Wits appraisal, mm	−11.5	−6.9	4.6
Anteroposterior Dysplasia Indicator (APDI),°	82.8	92.4	9.6
ANB, °	4.6	−0.2	−4.8
Vertical Relationship			
FMA (FH-MP),°	38.7	33.2	−5.5
Occl Plane-SN, °	20.4	14.5	−5.9
SN-GoGn, °	45.8	39.8	−6
PP-MP, °	37.3	31.8	−5.5
Y-axis (NSGn), °	75.8	70.7	−5.1
Overbite Depth Indicator (ODI), °	60.6	56.5	−4.1
Anterior Face Height (NaMe), mm	132.3	127.8	−4.5
Lower Anterior Face Height, mm	83.4	77.8	−5.6
Dentoalveolar Component			
Mx1-NA, °	22	32.6	10.6
Mx1-NA, mm	2.4	6.5	4.1
Mx1-PP, mm	28.2	30.5	2.3
Mx6-PP, mm	27	26.3	−0.7
Md1-NB, °	21	11	−10
Md1-NB, mm	5.3	2.1	−3.2
IMPA (L1-MP), °	75.5	66.3	−9.2
Md1-MP, mm	41	45	4
Md6-MP, mm	35.7	34.2	−1.5
Overbite, mm	−10	2.9	12.9
Soft Tissue Component			
Holdaway Angle (NB to H-line), °	10.1	9.2	−0.9
Upper Lip − S Line, mm	−0.2	−1.8	−1.6
Lower Lip − S Line, mm	0.5	−1	−1.5

[a] F-I, Final – Initial; SND, evaluates the anteroposterior location of the anterior portion of the mandible and is obtained from the angle formed by SN to ND lines where D is a point located at the center of the cross section of the body of the symphysis;[22] APDI, evaluates the skeletal relationship and is obtained from the algebraic sum of the angles N-Pg-FH (Facial Plane) plus/minus the angle AB-Facial Plane (it is positive when point B is ahead of point A and negative when point A is ahead of point B); and plus/minus the angle FH-PP (palatal plane; it is negative when PP is tilted upward and positive when tilted down);[23] ODI, evaluates the open bite tendency and is obtained from the algebraic sum of the angles AB-MP plus/minus the angle FH-PP (palatal plane; it is negative when PP is tilted upward and positive when tilted down).[24]

Figure 5. Treatment progress: (A) leveling and alignment, (B) multiloop edgewise archwire mechanics, (C) after 2 months of multiloop edgewise archwire mechanics, (D) elastics for crossbite correction, (E) space closure, (F) finishing.

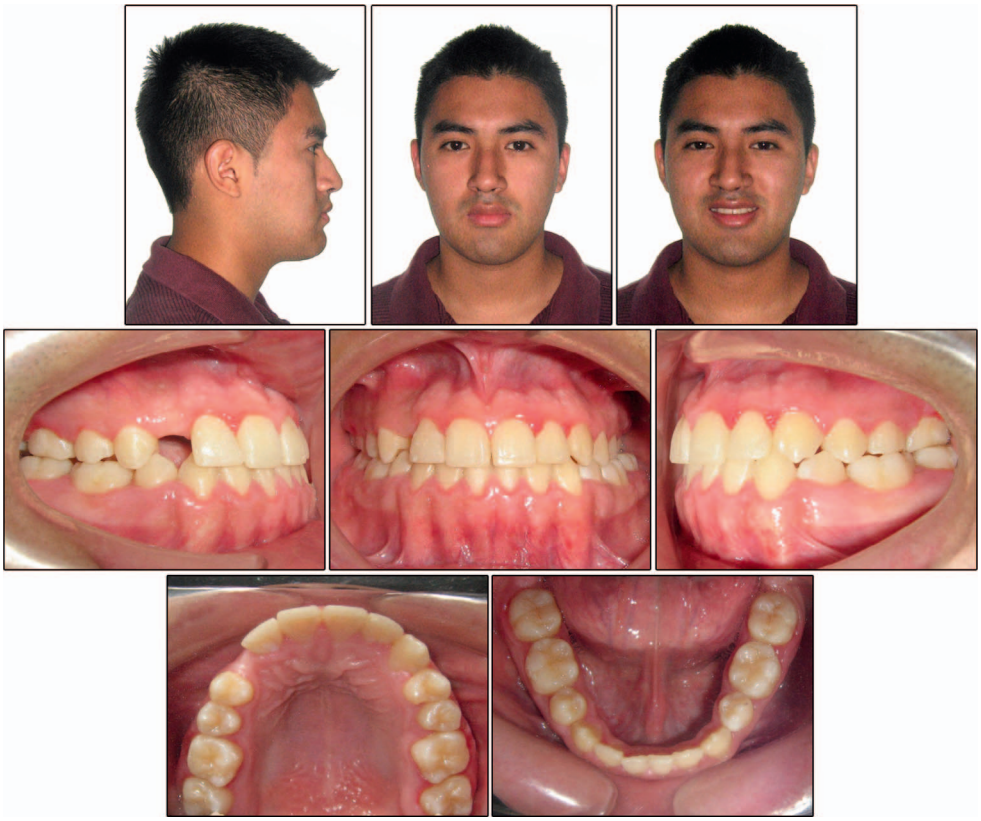

Figure 6. Posttreatment facial and intraoral photographs (after 24 months of treatment).

Treatment Results

The patient had significant facial improvements as demonstrated in the extraoral photographs. The profile was balanced with lip competence at rest and an esthetic smile with maxillary incisor exposure upon smiling (Figure 6). The intraoral and dental cast photographs showed satisfactory overbite, adequate overjet, Class III functional molar relationships, Class I canine relationship on the left side, adequate space for the maxillary right canine restoration, corrected dental midline deviations, and limited correction of the posterior crossbite (Figures 6 and 7). Periodontal heath was satisfactorily maintained. There were no signs of periodontal disease at the end of treatment (Figure 8).

The skeletal changes included an increase in mandibular projection, decreases in facial convexity, and apical base sagittal relationship and vertical relationship (Figures 9 and 10, Table 1).[22–24] Regarding the dentoalveolar changes, there was labial inclination and extrusion of the maxillary incisor; lingual inclination, retrusion, and moderate extrusion of the mandibular incisor; mild intrusion of the maxillary first and second molars; uprighting and mild intrusion of the mandibular first molars; and uprighting and moderate intrusion of the mandibular second molars (Figures 9 and 10, Table 1). There was a decrease in soft tissue convexity and concomitant protrusion of the upper and lower lips (Figure 10).

Cone-beam computed tomography (CBCT) total superimpositions at the cranial base registration[25] showed a counterclockwise pitch rotation of the mandible and mandibular residual growth (Figure 11A, Table 2). Maxillary regional superimposition[26] confirmed the cephalometric changes: small maxillary changes and posterior teeth extrusion (Figure 11B). Mandibular regional superimposition[27] also supported the results described, and residual growth of the mandible was noted. No evidence of condylar remodeling was observed (Figure 11C).

Based on the cephalometric and CBCT superimpositions, there was posterior teeth intrusion that contributed to produce a counterclockwise rotation of the mandible (Figures 10 and 11).

A modified wrap-around prosthetic retainer with an orifice in the incisive papillae region to help correct the positioning of the tongue in the rest position (learning in the orofacial myofunctional therapy) and a lingual fixed retainer including second premolars were placed in the maxillary and the mandibular arches, respectively (Figure 12). The maxillary retainer was prescribed to be used until definitive restoration of the maxillary right canine could be performed. Then a new wraparound with the same palatal orifice was used.

Figure 7. Posttreatment dental casts.

The 2-year posttreatment follow-up records showed stability of the open-bite correction and of the Class III functional molar relationship. The posterior transverse relationship did not worsen (Figures 13 and 14). Periodontal evaluation showed a healthy condition at the 2-year posttreatment follow-up as well (Figure 15).

DISCUSSION

A combined surgical–orthodontic treatment approach could have been ideal for this patient, simultaneously correcting the vertical, transverse, and sagittal relationships.[5] Nevertheless, because the patient refused the surgical option, the treatment alternatives were reduced to TADs and conventional orthodontics. However, the patient did not want to use TADs as well.

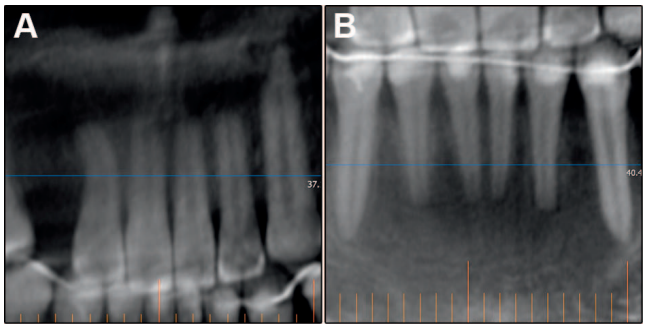

Figure 8. Cone-beam computed tomography synthesized panoramic view of maxillary (A) and mandibular (B) anterior teeth at posttreatment.

Counterclockwise mandibular rotation could have been expected when performing posterior teeth intrusion, which helps to improve the open-bite malocclusion. This is normally achieved with TADs.[11–15] However; when conventional orthodontics is planned, as in this case, posterior teeth intrusion is difficult to obtain. Treatment mechanics are based on maintaining vertical control of the posterior teeth, with different appliances, to control the vertical dimension, and the anterior open bite is generally corrected by means of extrusion of the anterior teeth.[6,8]

In the present case, anterior teeth extrusion combined with uprighting and vertical control of the posterior teeth was planned using MEAW and anterior elastics. The activated multiloop archwires generated an accentuated and reverse curve of Spee in the maxillary and mandibular aches, respectively. This activation effect alone could aggravate the open-bite malocclusion. However, short Class III anterior elastics were used to extrude the anterior teeth and correct the Class III relationship. These anterior extrusive forces counterbalanced the MEAW activations and achieved vertical control of the posterior teeth by means of uprighting and intrusion.[3,10,16] Maxillary anterior teeth extrusion was necessary to increase maxillary incisor exposure and achieve a harmonious smile (Figure 6). However, in addition to the uprighting and vertical control of the posterior teeth that the MEAW technique and anterior elastics provided to the case, different degrees of intrusion of the posterior teeth were

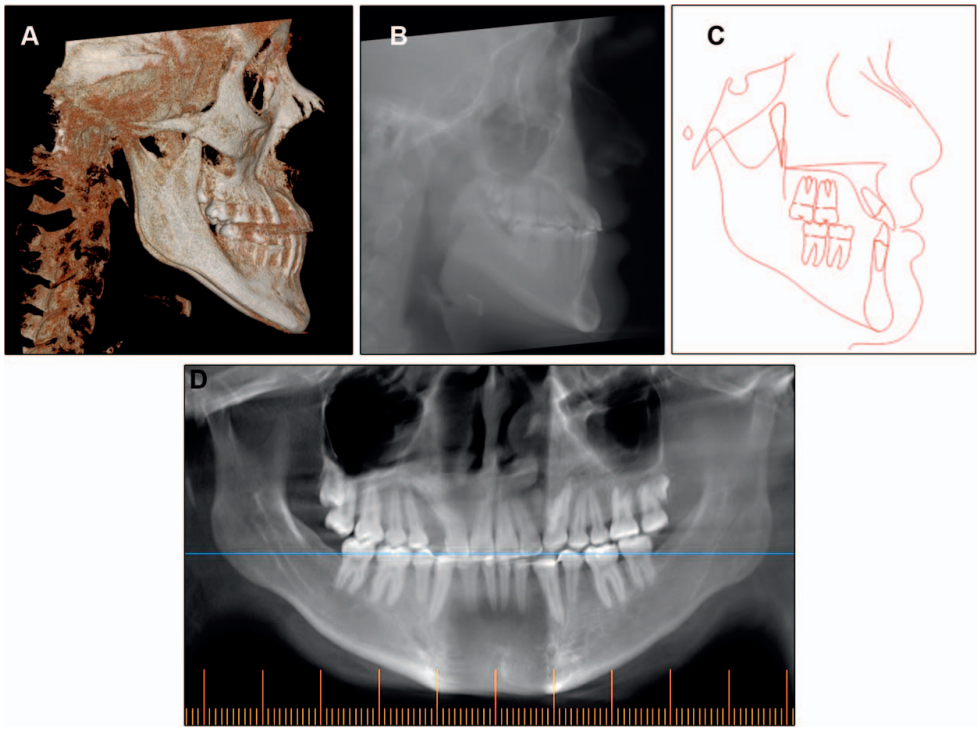

Figure 9. Posttreatment records: (A) 3D automatically reformatted image, (B) lateral ceph generated from cone-beam computed tomography, (C) ceph tracing, (D) panoramic radiograph generated from cone-beam computed tomography.

observed. Mild intrusion of the maxillary first and second molars and mandibular first molar was achieved. In addition, greater intrusion of the mandibular second molars was noted. Before treatment, the patient only had occlusal contact between the mandibular second molars and the maxillary first and second molars. Therefore, intrusion of these teeth contributed to the achievement of satisfactory results. Posterior teeth intrusion was achieved using activated MEAWs and using anterior elastics as anchorage, thus

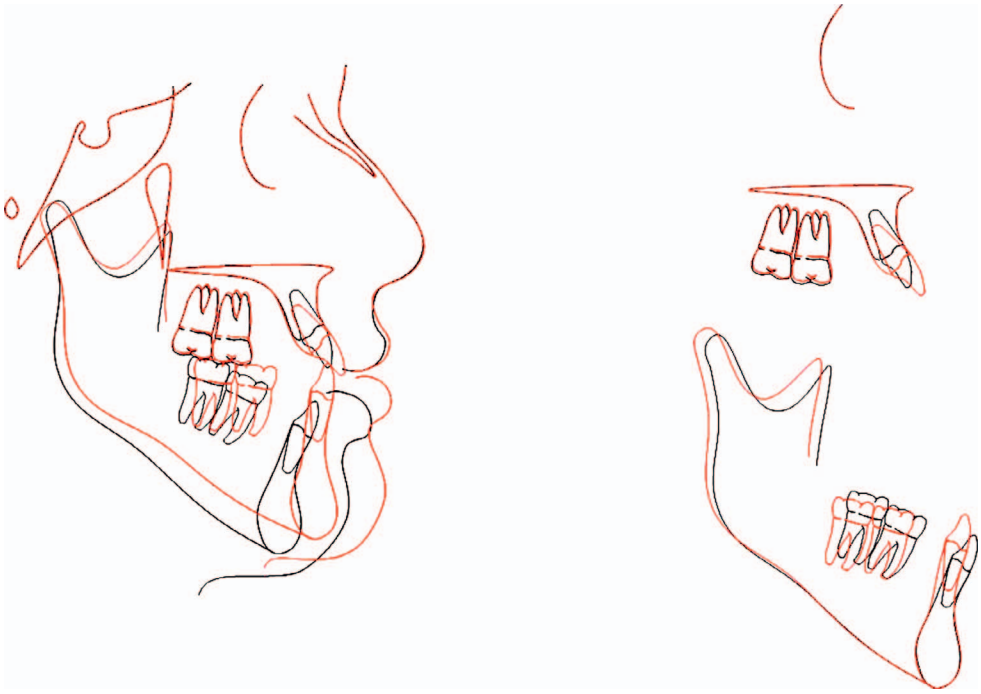

Figure 10. Cephalometric superimpositions: black line, pretreatment; red line, posttreatment.

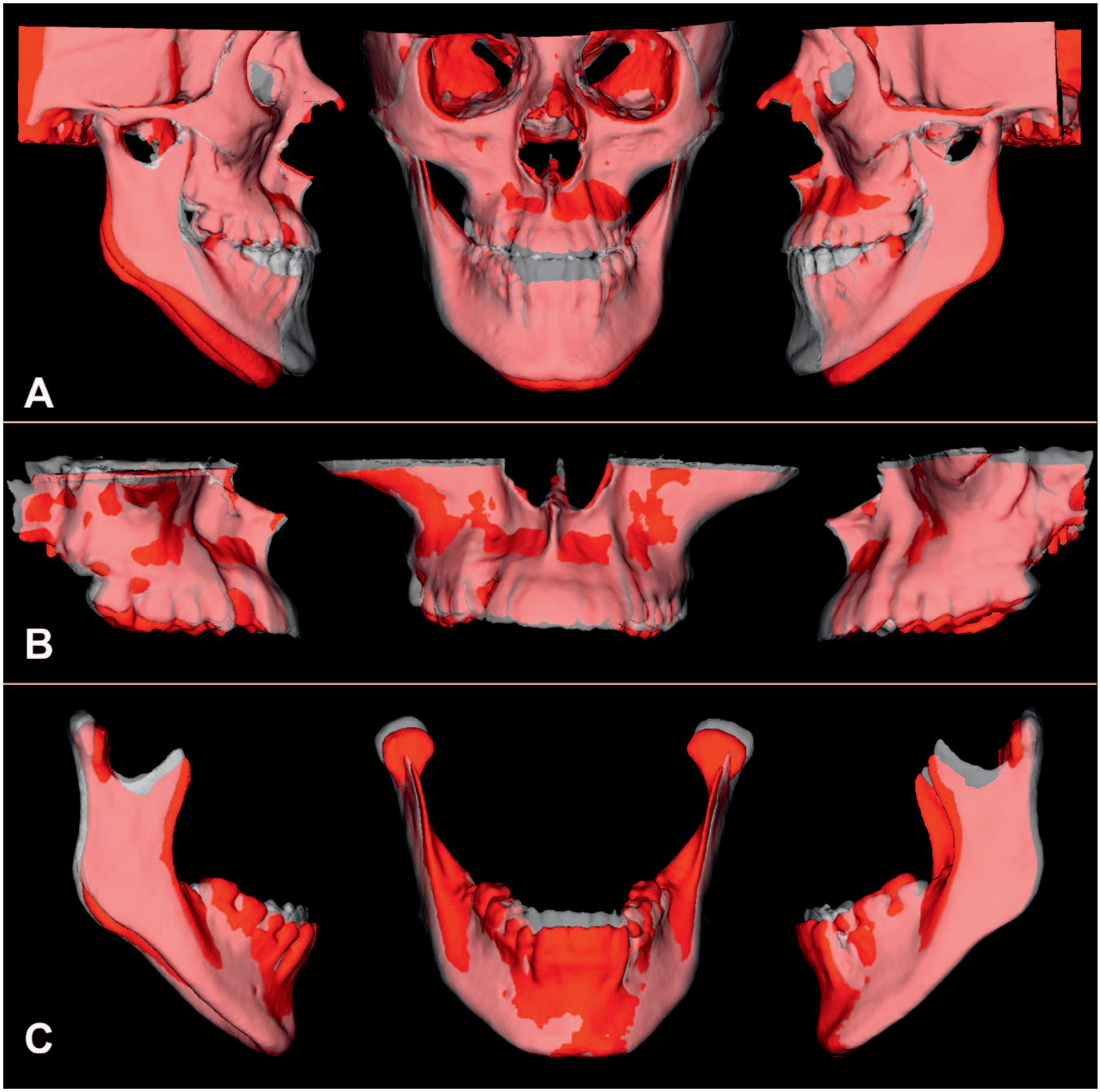

Figure 11. Cone-beam computed tomography superimpositions: red color: pretreatment; white color: posttreatment. (A) Superimposition at the cranial base, (B) maxillary regional superimposition, (C) mandibular regional superimposition.

Table 2. Mandibular Length Measurements

Mandibular Length, mm	Initial	Final	2 Years Posttreatment	F-I[a]	2 Years Posttreatment – Final
Right Condylion-Menton	122.7	125.8	127.2	3.1	1.4
Left Condylion-Menton	124.4	128.4	130.9	4.0	2.5

[a] F-I, Final – Initial.

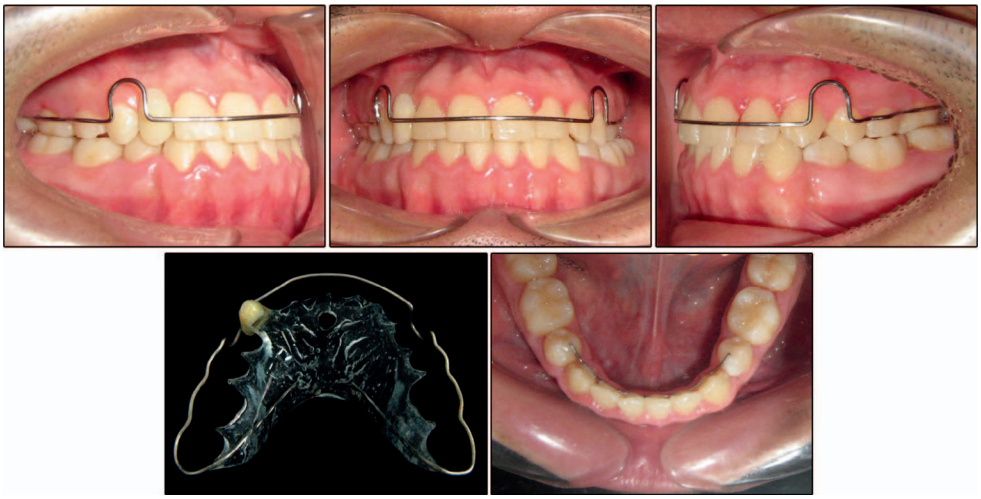

Figure 12. Wrap-around prosthetic and functional retainer with an orifice in the region of the incisive papilla in the maxillary arch and a second premolar to second premolar lingual fixed retainer in the mandibular arch.

producing occlusal plane rotation and a consequent mandibular counterclockwise rotation that contributed to open-bite correction and resulted in improvements to the patient's facial profile as a result of increased chin projection after treatment (Figures 10 and 11).

CBCT superimpositions corroborated all of the changes observed in the cephalometric tracing superimpositions (Figures 10 and 11). CBCTs were superimposed at the cranial base to visualize the skeletal displacements of the maxilla and mandible.[25] Regional superimpositions at the maxilla and mandible[26,27] were performed to observe the intrinsic changes in the apical bases. Reproducibility and reliability of the methods used to perform the three-dimensional superimpositions have been demonstrated.[25–27]

Based on the findings, it can be assumed that the mechanics described produced dentoalveolar changes and rotational modifications of the mandible in this particular case that contributed to the closing of the open bite (Figures 6 to 11). An increase of 2.13 mm in

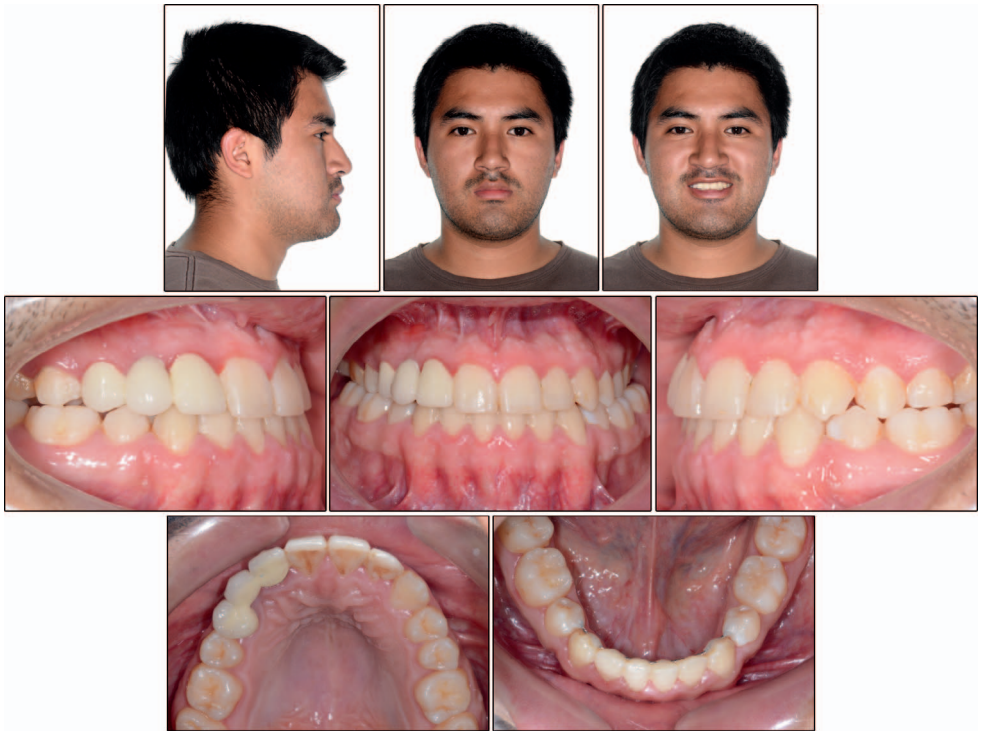

Figure 13. Facial and intraoral photographs at 2 years posttreatment.

Figure 14. Two-year posttreatment dental casts.

the overbite for each millimeter of reduction of posterior molar height (combined sum of maxillary and mandibular second molar heights) was reported previously when occlusal adjustment was performed.[28] In addition, counterclockwise rotation of the mandible between 2.3° and 3.9° consequent to maxillary and mandibular molar intrusion with TADs was reported.[29] In this particular case, open-bite correction was obtained by a combination of extrusion of the anterior teeth (greater for the mandibular incisors), intrusion of the posterior teeth (greater for the mandibular second molars), and counterclockwise rotation of the mandible, consequent to posterior teeth intrusion (Figures 10 and 11).

Similar results have been reported with other treatment approaches without the use of TADs. The use of NiTi archwires with accentuated curve of Spee in the maxillary arch and reverse curve of Spee in the mandibular arch combined with anterior elastics showed efficiency for the open-bite correction.[9] Another option could be to mesially angulate the accessories on the posterior teeth to obtain the MEAW effect.[6] Obviously, the use of anterior elastics is a critical factor for treatment success because they will deliver the required force to distally angulate and sometimes to intrude the posterior teeth.[3,6,9]

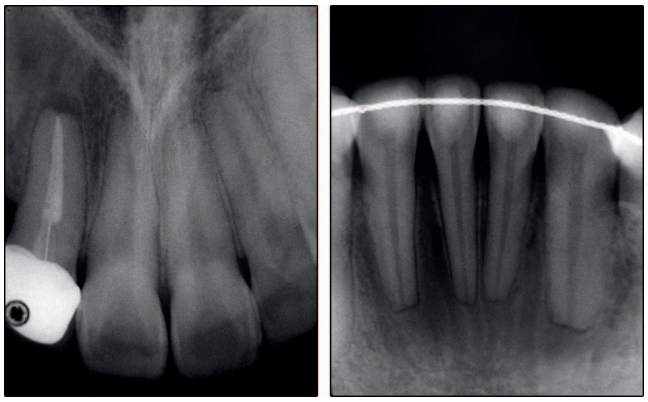

Figure 15. Two-year posttreatment periapical radiographs.

The dental midline deviations were corrected by creating adequate space for the maxillary right canine and by closing the space following the mandibular left first premolar extraction. After dental midline deviation corrections were made and when some overbite was present, the combined mesial movement of the mandibular posterior teeth and retraction of the mandibular incisors were necessary to obtain adequate overjet and Class III functional molar relationships in both sides (Figure 5).[19–21] The combination of mandibular left first premolar extraction, retrusion of the mandibular incisors, and mesial movement of the mandibular posterior teeth may have contributed to the overbite correction and counterclockwise mandibular rotation as well.

Bilateral posterior crossbite correction was initially planned. However, it was only achieved for the maxillary right second premolar and mandibular right first molar. End-to-end transverse relationships were obtained for the maxillary first molar and mandibular

second molar on the right side and for the maxillary second premolar and mandibular first molar on the left side. The crossbite between the maxillary first molar and the mandibular second molar on the left side could not be corrected. Despite these limitations, the amount of vertical and facial improvements was considerable, and the patient's chief complaints were satisfied. Premature occlusal contacts were eliminated to ensure that this posterior transverse relationship did not impair the occlusion.

Although the patient was advised to pursue implant-supported fixed prosthetic restoration for the right maxillary canine area, he decided on a conventional tooth-supported fixed prosthesis. Unfortunately, that procedure was not under our control and was performed during the follow-up period.

Anterior open-bite treatment stability of 94.4% and 90% in growing and nongrowing patients, respectively, has been reported for the treatment approach described.[16,17] Stability greater than 75% for different conventional orthodontic treatments has been reported.[6,8,17] In addition, it has been reported that posterior teeth intrusion with TADs results in a relapse of between 20% to 30% and that the greatest percentage of that relapse occurs during the first posttreatment year.[11,12,14] For this reason, the patient's records at the 2-year posttreatment follow-up were considered essential.

Satisfactory overbite correction, orofacial myofunctional therapy, and the customized retainer were considered to be important contributors to the stability observed at the 2-year posttreatment follow-up. Although there was some residual mandibular growth in the posttreatment period, it did not impair the stability of the results (Table 2). As a result of the amount of overbite observed at the 2-year posttreatment follow-up, long-term stability should be expected (Figures 13 and 14).

CONCLUSIONS

- Treatment of an adult patient with a severe skeletal open bite malocclusion was performed using MEAW mechanics and elastics (without using any TADs) by means of posterior teeth uprighting and intrusion along with anterior teeth extrusion, which produced a counterclockwise rotation of the mandible.
- This treatment approach demonstrated efficiency and good stability for open bite correction over the period observed.

REFERENCES

1. Cangialosi TJ. Skeletal morphologic features of anterior open bite. *Am J Orthod*. 1984;85:28–36.
2. Ngan P, Fields HW. Open bite: a review of etiology and management. *Pediatr Dent*. 1997;19:91–98.
3. Kim YH. Anterior openbite and its treatment with multiloop edgewise archwire. *Angle Orthod*. 1987;57:290–321.
4. Janson G, Laranjeira V, Rizzo M, Garib D. Posterior tooth angulations in patients with anterior open bite and normal occlusion. *Am J Orthod Dentofacial Orthop*. 2016;150:71–77.
5. Solano-Hernandez B, Antonarakis GS, Scolozzi P, Kiliaridis S. Combined orthodontic and orthognathic surgical treatment for the correction of skeletal anterior open-bite malocclusion: a systematic review on vertical stability. *J Oral Maxillofac Surg*. 2013;71:98–109.
6. Janson G, Valarelli F. *Open-Bite Malocclusion: Treatment and Stability*. Ames, IA: John Wiley & Sons, Inc; 2014. p. 133–312.
7. Beane RA Jr. Nonsurgical management of the anterior open bite: a review of the options. *Semin Orthod*. 1999;5:275–283.
8. Janson G, Valarelli FP, Beltrao RT, de Freitas MR, Henriques JF. Stability of anterior open-bite extraction and nonextraction treatment in the permanent dentition. *Am J Orthod Dentofacial Orthop*. 2006;129:768–774.
9. Kucukkeles N, Acar A, Demirkaya AA, Evrenol B, Enacar A. Cephalometric evaluation of open bite treatment with NiTi arch wires and anterior elastics. *Am J Orthod Dentofacial Orthop*. 1999;116:555–562.
10. Chang YI, Moon SC. Cephalometric evaluation of the anterior open bite treatment. *Am J Orthod Dentofacial Orthop*. 1999;115:29–38.
11. Baek MS, Choi YJ, Yu HS, Lee KJ, Kwak J, Park YC. Long-term stability of anterior open-bite treatment by intrusion of maxillary posterior teeth. *Am J Orthod Dentofacial Orthop*. 2010;138:396.e1–396.e9.
12. Deguchi T, Kurosaka H, Oikawa H, et al. Comparison of orthodontic treatment outcomes in adults with skeletal open bite between conventional edgewise treatment and implant-anchored orthodontics. *Am J Orthod Dentofacial Orthop*. 2011;139:S60–S68.
13. Hart TR, Cousley RR, Fishman LS, Tallents RH. Dentoskeletal changes following mini-implant molar intrusion in anterior open bite patients. *Angle Orthod*. 2015;85:941–948.
14. Sugawara J, Baik UB, Umemori M, et al. 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 Orthodon Orthognath Surg*. 2002;17:243–253.
15. Scheffler NR, Proffit WR, Phillips C. Outcomes and stability in patients with anterior open bite and long anterior face height treated with temporary anchorage devices and a maxillary intrusion splint. *Am J Orthod Dentofacial Orthop*. 2014;146:594–602.
16. Kim YH, Han UK, Lim DD, Serraon ML. Stability of anterior openbite correction with multiloop edgewise archwire therapy: a cephalometric follow-up study. *Am J Orthod Dentofacial Orthop*. 2000;118:43–54.
17. Greenlee GM, Huang GJ, Chen SS, Chen J, Koepsell T, Hujoel P. Stability of treatment for anterior open-bite malocclusion: a meta-analysis. *Am J Orthod Dentofacial Orthop*. 2011;139:154–169.
18. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Semin Orthod*. 2005;11:119–129.

19. Battagel JM, Orton HS. Class III malocclusion: a comparison of extraction and non-extraction techniques. *Eur J Orthod*. 1991;13:212–222.
20. Nangia A, Darendeliler MA. Finishing occlusion in class II or class III molar relation: therapeutic class II and III. *Aust Orthod J*. 2001;17:89–94.
21. Abu Alhaija ES, Al-Khateeb SN. Skeletal, dental and soft tissue changes in class III patients treated with fixed appliances and lower premolar extractions. *Aust Orthod J*. 2011;27:40–45.
22. Steiner CC. Cephalometrics in clinical practice. *Angle Orthod*. 1959;29:8–29.
23. Kim YH, Vietas JJ. Anteroposterior dysplasia indicator: an adjunct to cephalometric differential diagnosis. *Am J Orthod*. 1978;73:619–633.
24. Kim YH. Overbite depth indicator with particular reference to anterior open-bite. *Am J Orthod*. 1974;65:586–611.
25. Cevidanes LH, Heymann G, Cornelis MA, DeClerck HJ, Tulloch JF. Superimposition of 3-dimensional cone-beam computed tomography models of growing patients. *Am J Orthod Dentofacial Orthop*. 2009;136:94–99.
26. Ruellas AC, Huanca Ghislanzoni LT, Gomes MR, et al. Comparison and reproducibility of 2 regions of reference for maxillary regional registration with cone-beam computed tomography. *Am J Orthod Dentofacial Orthop*. 2016;149:533–542.
27. Ruellas AC, Yatabe MS, Souki BQ, et al. 3D Mandibular superimposition: comparison of regions of reference for voxel-based registration. *PLoS One*. 2016;11:e0157625.
28. Janson G, Crepaldi MV, de Freitas KM, de Freitas MR, Janson W. Evaluation of anterior open-bite treatment with occlusal adjustment. *Am J Orthod Dentofacial Orthop*. 2008;134:10.e1–10.e9.
29. Alsafadi AS, Alabdullah MM, Saltaji H, Abdo A, Youssef M. Effect of molar intrusion with temporary anchorage devices in patients with anterior open bite: a systematic review. *Prog Orthod*. 2016;17:9.