INNOVATION

CASE REPORT

# Non-surgical treatment of severe open bite using CTOR Plates

Teixeira CC [a], Abdullah F [b], Sangsuwon C [b], Alansari S [b], Oliveira SP [b,c], Nervina JM [b], Alikhani M [b,d]

**a** *New York University, Department of Orthodontics, New York, New York*

**b** *CTOR Academy, Hoboken, New Jersey*

**c** *Department of Mechanical Engineering, Polytechnic Institute of Viseu, Viseu, Portugal*

**d** *Harvard University, Department of Developmental Biology, Boston, Massachusetts*

## ABSTRACT

CTOR Plates are a new invention in orthodontics that can facilitate treatment of adult complex malocclusions, especially patients with severe open bites. While conventional orthodontics appliances deliver mechanics that improve the skeleto-dental relationships in these patients, the appliance designs can be very complex, which requires meticulous planning. Temporary anchorage devices (TADs) are especially valuable for treating complex cases because they widen treatment options, which can simplify the mechanics plan for these patients. However, ideal use of TADs depends on adequate cortical bone thickness and access to the desired location, which are not always possible. In this case report we describe the use of CTOR Plates in a patient with a severe skeletal open bite in which poor cortical bone quality in mechanically advantageous areas does not allow use of conventional TADs. In this patient CTOR Plates allowed us to correct a severe open bite in a reasonably short period of time, without any complications.

**Corresponding Author:**
*Mani Alikhani*
*mani.alikhani@ctor.academy*

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## Background

An open bite malocclusion is a major orthodontics problem that can negatively affect a person's quality of life. It has a negative aesthetic and psychological impact and can harm the temporomandibular joint (TMJ) and chewing function [1-3]. In addition, an open bite significantly contributes to speech disabilities [4] and, if combined with other common traumatic activity such as clenching, can significantly add to inflammatory-degenerative disorders of the TMJ [5].

Open bite is not a rare skeleto-dental abnormality. Its prevalence ranges from 0.6% to 16%, with almost 17% of orthodontics patients presenting with some degree of open bite [6]. An open bite can occur in the anterior, posterior (where it can be unilateral or bilateral) or it can extend from the anterior to the posterior dentition.

Several mechanical and biological etiologies lead to open bite malocclusion. Mechanical habits include thumb/finger sucking and pencil or pipe chewing, while biological etiologies are primarily due to airway obstruction, which can occur due to enlarged tonsils, allergies, septal deviation or apnea. These etiologies impact the open bite's severity in direct proportion to the length of time the etiology has been present.

Regardless of the specific etiological factor, conventional orthodontics treatment of anterior open bites combines etiology elimination (habit breaking, tonsillectomy, etc.) and leveling the occlusal plane through intrusion of posterior teeth with or without retroinclination of anterior teeth. Therefore, any treatment designed for correcting an open bite case should focus on controlling the vertical height of posterior teeth surgically or non-surgically. Part of the non-surgical orthodontic treatment options for these patients includes strategies to either prevent further extrusion of posterior teeth or, in more severe cases, actively intruding the posterior teeth. However, until recently, surgery was the only treatment option for severe open bite cases. However, this approach is expensive and associated with severe side effects, while failing to provide better stability after treatment than conventional orthodontics treatment [7]. These factors have made many adult patients seek more conservative non-surgical treatment options, such as the use of TADs.

TADs have simplified the application of vertical forces on the posterior teeth, with many reports of successful correction of severe open bite cases without orthognathic surgery [8]. Due to these successes, TADs are now considered a viable, non-surgical treatment option for severe open bite cases for patients who refuse to undergo, or are not good candidates for, orthognathic surgery.

While TADs are an invaluable tool in the orthodontist's armamentarium, they are not always suitable due to poor bone quality or limitations in establishing proper mechanics from anatomically disadvantageous positions. Recently a new tool – the CTOR Plate - has been introduced to the orthodontics armamentarium (psm North America Inc, CA, www.psm-na.us) that addresses these shortcomings of TADs [9]. Here we demonstrate the mechanical advantages of using CTOR Plates to treat a severe open bite case in a patient who had previously been unsuccessfully treated with TADs due to poor quality alveolar bone.

## Patient Presentation, Etiology and Diagnosis

A healthy 26.1-year old African-American female presented to our clinic at with a chief concern of poor smile esthetics, chewing problems and lack of incisal contact. The patient reported muscle tenderness and occasional pain associated with clicking on the left temporomandibular joint (TMJ). Her medical history included tonsillectomy to address difficulty in nasal breathing. At the initial exam, the patient was able to breathe through both her mouth and nose, but most of the time she reported breathing through her mouth.

Extraoral examination and frontal portrait photographs (Figure 1) showed a dolichofacial pattern and an increase in the lower facial third. However, no facial asymmetry, mentalis strain or lip incompetence at rest was noted.

The lateral portrait photograph (Figure 1) showed a bimaxillary protrusive profile with protruding upper and lower lips relative to the E-line (3.1 and 7.3, respectively). The nasolabial angle and chin-to-throat angle were acute (74.7° and 111.2°, accordingly), but the labiomental angle was acceptable (131.4°). Full smile was broad with increased buccal corridor width and a reverse smile line with 70% incisal display.

Intraoral examination (Figure 1) showed fair oral hygiene, a high maxillary labial frenum attachment and no signs of gingival recession. Spacing and a severe open bite from the anterior teeth (-10.9 mm) to the first premolars were visible. This could be related to the chronic nasal congestion and mouth breathing accompanied with forward positioning of the tongue at rest that did not improved after tonsillectomy. Constant open mouth posture could be associated with dental adaptation and extrusion of the posterior teeth. Due to this severe open bite condition the patient spoke with a lisp and sound distortion especially for /s/ and /t/ phonemes. The patient's mandibular 3rd molars were present, whereas the maxillary 3rd molars were not present. Her maxillary and mandibular midlines coincided with the facial midline.

Digital cast analysis showed a Class I molar and Class III canine relationship on both sides (Figure 2). The maxillary dental arch was constricted with an inter-canine and inter-molar width of 35.3 mm and 47 mm, respectively, whereas the mandibular dental arch was broad with an inter-canine and inter-molar width of 37 mm and 42.4 mm, respectively. The maxillary dental arch showed a severe Curve of Spee and the mandibular dental arch showed a reverse Curve of Spee. Overjet and overbite were -3.7 mm and -10.9 mm, respectively. Spacing was found in the maxillary dental arch (-6 mm) and mandibular dental arch (-10 mm). An anterior maxillary excess Bolton discrepancy of 3.1 mm was also measured.

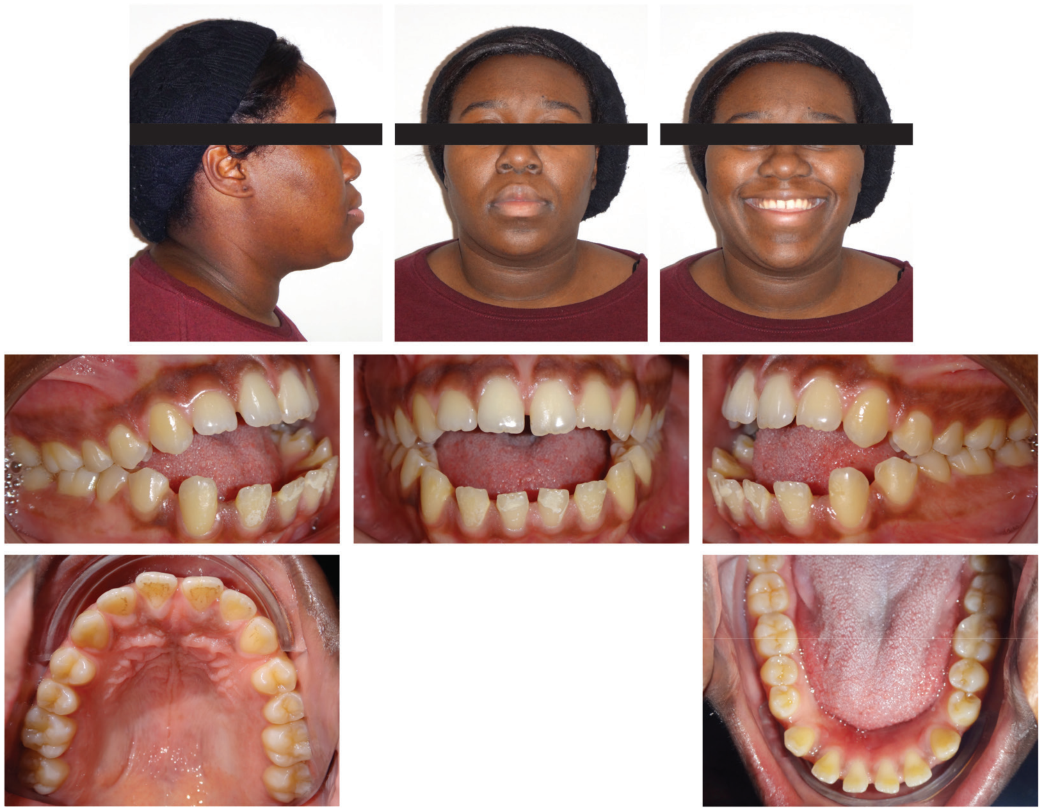

***Figure 1: Pre-treatment portrait and intra-oral photographs.*** *Lateral profile portrait showed a bimaxillary protrusion with protrusive upper and lower lips. Frontal portraits showed lip competency at rest and a reverse smile line with 70% incisal display while smiling, dark buccal corridors and coincident maxillary and mandibular midlines. Intra-oral photographs revealed a high maxillary labial frenum attachment, spacing and severe anterior and posterior open bite extending to the first premolars, proclined maxillary and mandibular incisors, a constricted maxilla, marginal ridge discrepancies, gingival margin not aligned with irregular heights of contour. The mandibular third molars were present, but the maxillary third molars were absent, and the mandibular left first premolar was severely rotated.*

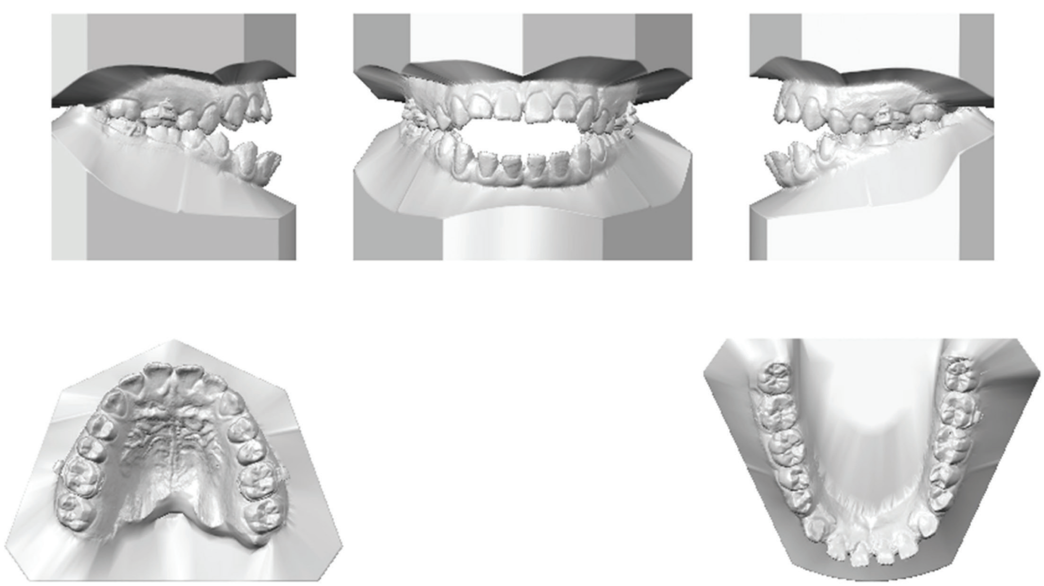

***Figure 2: Pre-treatment digital casts evaluation.*** *Pre-treatment digital casts showed a Class I molar and Class III canine relation. The maxillary dental arch width was constricted with an inter-canine and inter-molar width of 35.3 mm, 47 mm, respectively. The mandibular dental arch width was broad with the inter-canine and inter-molar width of 37 mm, 42.4 mm, respectively. The maxillary dental arch showed a severe Curve of Spee and the mandibular arch showed a reverse Curve of Spee with two distinct occlusal planes. Spacing was observed in both arches (upper = -6 mm; lower = -10 mm) and a maxillary anterior excess Bolton discrepancy of 3.1 mm. The overjet and overbite were -3.7 mm and -10.9 mm, respectively.*

The panoramic radiograph (Figure 3) revealed a complete dentition except for the missing maxillary 3rd molars. The lateral cephalometric radiograph (Figure 4) and analysis (Table 1) showed skeletal Class III (ANB= 0.9°) with a hyper-divergent profile (FMA= 29.1°, SN-MP= 44.4°). The maxillary and mandibular incisal inclinations were increased (U1°-SN= 108.2°, IMPA= 110.9°, respectively). Soft tissue analysis (Table 1) indicated that the distance of the upper and lower lips to E-line was protrusive, with measurements of 3.1 mm and 7.3 mm, respectively.

***Figure 3: Pre-treatment panoramic radiograph.*** *Panoramic radiograph showed a complete dentition except for the absence of both maxillary third molars. The bone level and density were within normal limits and the maxillary sinuses were clear. Asymmetrical short condyles revealed some degree of remodeling and asymmetrical position.*

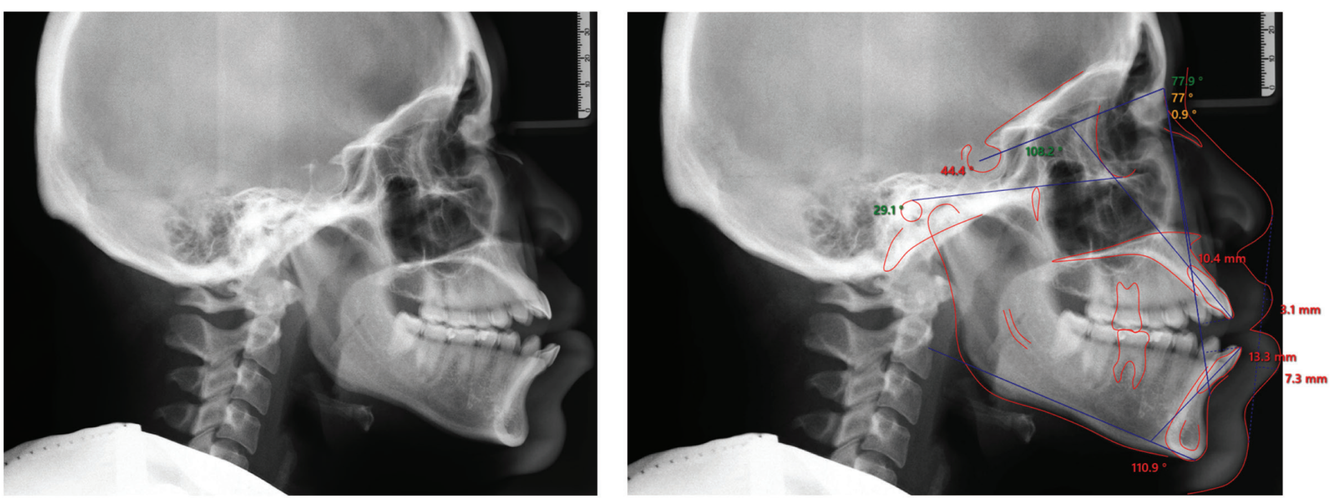


***Figure 4: Pre-treatment lateral cephalometric radiograph and analysis.*** *Cephalometric analysis showed a Class III tendency (ANB= 0.9°), hyper-divergent profile (FMA= 29.1°, SN-MP= 44.4°), proclined maxillary and mandibular incisors (U1°-SN= 108.2°, IMPA= 110.9°, respectively) and a severe skeletal open bite.*

| Measurement | Initial Value | Final Value | Norm |
|---|---|---|---|
| SNA Angle | 77.9° | 78.5° | 81.8 ± 3.7° |
| SNB Angle | 77° | 76.1° | 79.2 ± 2.3° |
| ANB Angle | 0.9° | 2.3° | 2.6 ± 2.4° |
| FMA | 29.1° | 26.2° | 25.8 ± 3° |
| SN-MP | 44.4° | 41.8° | 31.2 ± 3° |
| Upper Incisor Angle with SN | 108.2° | 96.9° | 102.4 ± 5.5° |
| IMPA | 110.9° | 80.2° | 92.1 ± 9° |
| Upper Incisor to NA mm | 10.4 mm | 6.5 mm | 3.8 ± 2.7 mm |
| Lower Incisor to NA mm | 13.3 mm | 7.3 mm | 3.4 ± 3.6 mm |
| Upper Lip to E-plane | 3.1 mm | 0.7 mm | -2 ± 2 mm |
| Lower Lip to E-plane | 7.3 mm | 3.4 mm | -2 ± 2 mm |

***Table 1: Cephalometric Analysis of Pre- and Post-treatment lateral chephalograms.*** *Angular and linear measurements were completed between craniofacial skeletal and dental landmarks identified on pre- and post- treatment lateral cephalograms (° - degrees, mm - millimeters)*

## Treatment Objectives

The treatment objectives were to establish a long-term stable functional occlusion and improve the facial and dental esthetics. The treatment objectives were as follows:

I. Facial esthetics: Improve facial profile, lip position relative to the E-line, decrease the buccal corridors, and improving the smile line and incisal display upon smiling.

II. Skeletal objectives: Correct the maxillary transverse deficiency, sagittal disharmony and achieve Class I skeletal relationship, decrease hyper-divergency and vertical excess by mandibular auto-rotation or counter-clockwise rotation following maxillary posterior dental intrusion, improve TMJ function, ease TMJ pain, and reduce jaw clicking.

III. Dental objectives: Expand the maxillary arch, consolidate maxillary and mandibular spacing, improve incisal inclination, eliminate the severe open bite and establish proper overjet and overbite, level the occlusal plane and correct the Curve of Spee, establish a Class I canine and molar relationship, improve marginal ridge discrepancies, gingival margins, gingival height of contour around the anterior teeth; and evaluate the need for frenectomy due to a high labial frenum attachment after dental and skeletal corrections are achieved.

## Treatment Options

Various treatment options were discussed with the patient. She strongly rejected orthognathic surgery due to concerns related to high treatment costs and risks associated with surgical intervention.

A second option was non-surgical orthodontic/orthopedic treatment using the CTOR I-Plate (Figure 5). This option allows us to intrude the posterior segment, allowing for autorotation of the mandible to close the open bite. Following posterior intrusion, anterior extrusion to establish ideal overbite will be performed as needed. For retention, fixed lingual retainers and special removable appliances (MA Retainers) were suggested to prevent further eruption of posterior teeth and maintenance of the treatment result. It was also suggested that after treatment the patient would benefit from speech and myofunctional therapy to improve speech and tongue posture and eliminate mouth breathing that developed due to years of nasal congestion. The patient opted for this treatment plan. Full consent was obtained before initiation of treatment.

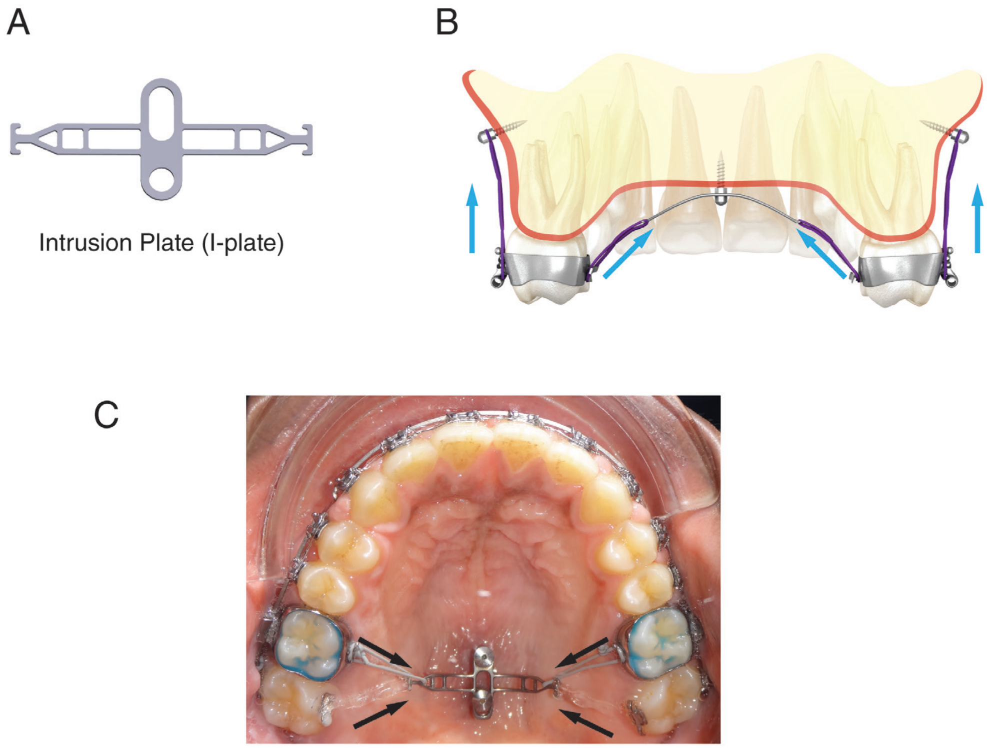


***Figure 5: CTOR Intrusion-Plates (I-Plates) can be used at different stages of treatment.*** *This CTOR Plate design is used for bilateral intrusion of posterior teeth in the upper arch. The I-Plate (A) can be easily shaped by hand or pliers to follow the patient's palatal contour. This plate can be used in combination with buccal TADs, depending on the patient's problem (B, intrusion forces shown as black arrows). Buttons on the lingual surface of the posterior teeth can be connected to the I-Plate using power thread or power chain (C). The design allows intrusion of several posterior teeth simultaneously. After intrusion this plate can be used for posterior anchorages during retraction of anterior teeth.*

## Treatment Outcome

Total treatment time was 15 months and 27 days and the patient demonstrated significant improvement in facial esthetics, skeletal jaw relation and occlusion.

**I. Facial Changes** (Figure 6):
A) Overall facial balance was improved and lower facial height was decreased. Profile analysis showed improved upper and lower lip position relative to the E-line (0.7 mm and 3.4 mm, respectively).
B) Smile analysis showed a wider maxilla and a significant decrease in buccal corridor width. Smile esthetics were also significantly improved with full maxillary incisor exposure upon smiling.

**II. Skeletal corrections and lateral cephalometric analysis** (Figure 7 and 8):
A) The post-treatment lateral cephalometric analysis (Table 1; Figure 7) showed that Class I skeletal jaw relationship was achieved (ANB= 2.3°).
B) The mandibular plane angle improved (FMA= 26.2°, SN-MP= 41.8°).
C) Superimposition of pre- and post- treatment radiographs (Figure 8) showed a counter-clockwise rotation of the mandible resulting from maxillary molar intrusion.
D) Maxillary superimposition showed molar intrusion and incisor uprighting, extrusion and retroclination.
E) Mandibular superimposition revealed molar uprighting without extrusion and significant incisor retroclination.
F) Soft tissue analysis indicated that the distance of the upper and lower lips to the E-line was improved (0.7 mm, 3.4 mm, respectively).
G) The post-treatment mandibular movement path was smooth without deviations, and neither clicking nor pain was present in the joints at the end of treatment.

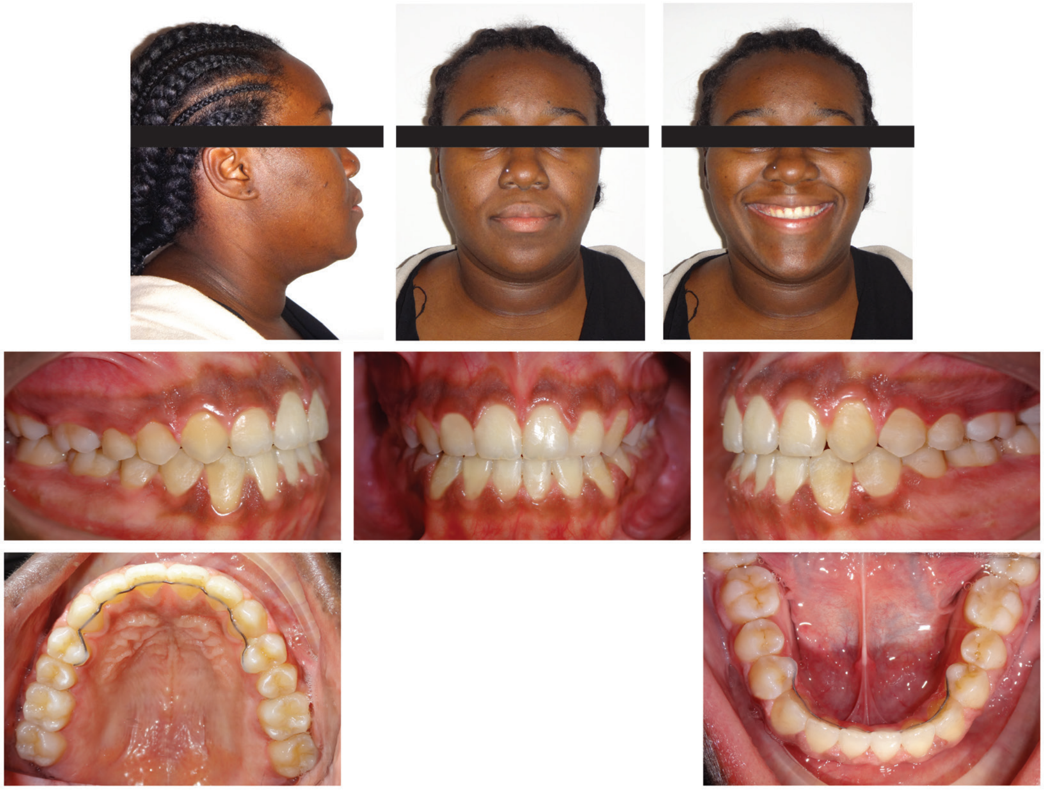

***Figure 6: Post-treatment portrait and intra-oral photographs.*** *Post-treatment photographs revealed a well-balanced straight facial profile, improved smile esthetics and maxillary and mandibular lip positions. Intra-oral photographs showed maxillary arch expansion, space consolidation in the maxillary and mandibular dental arches, a Class I molar and canine occlusal relationship, correction of the anterior open bite and retroclination of incisors into an ideal overjet and overbite relation. Both maxillary and mandibular dental midlines are aligned with the facial midline. Gingival margins and heights of contour improved around the anterior teeth. The labial frenum attachment remodeled into its normal position without surgical intervention. Lingual fixed retainers are shown extending from first premolar to first premolar in both arches.*

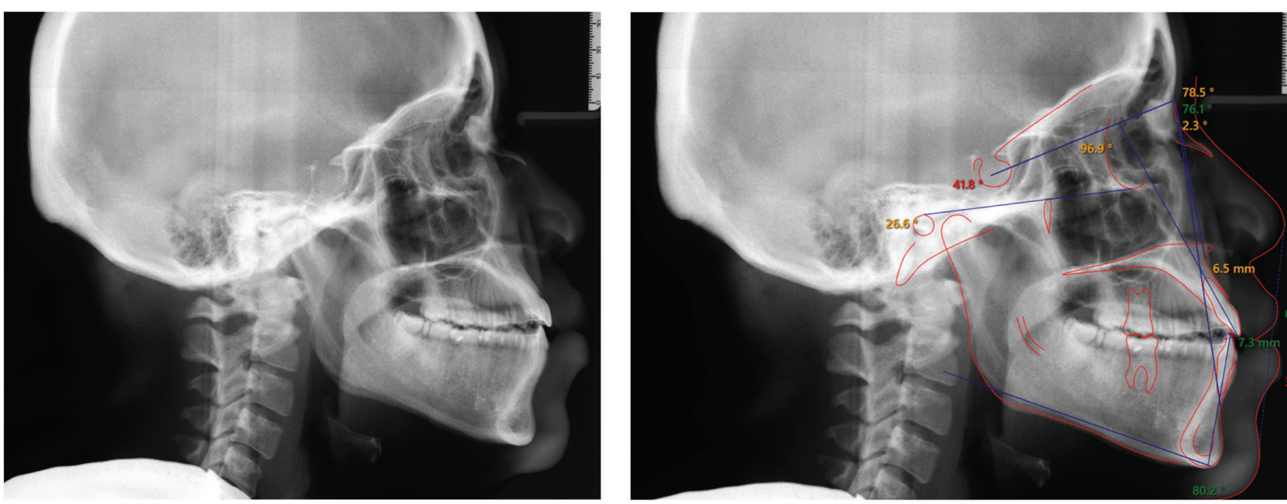


***Figure 7: Post-treatment lateral cephalometric radiograph and analysis.*** *Post-treatment cephalometric analysis showed overall improvement in maxillary and mandibular relationship (ANB= 2.3°), improved mandibular plane angle (FMA= 26.2°, SN-MP= 41.8°), correction of anterior open bite into ideal overjet, ideal overbite, improvement in the maxillary and mandibular incisor inclination (U1°-SN= 96.9°, IMPA= 80.2°, respectively) and enhanced soft tissue profile and lip position (Upper Lip to E-plane= 0.7 mm, Lower Lip to E-plane= 3,4 mm).*

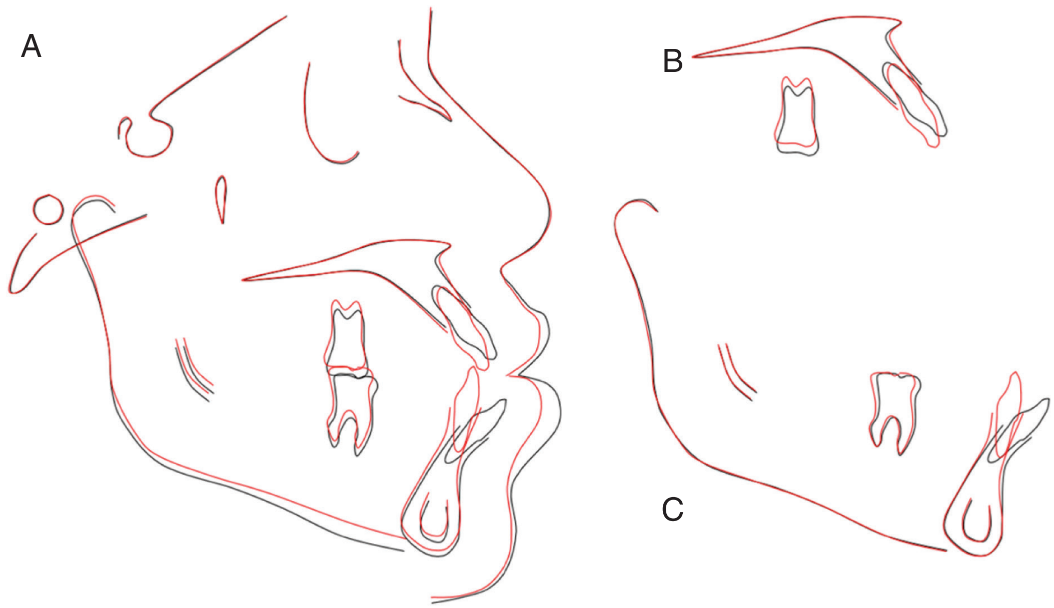


***Figure 8: Superimposition of pre- and post- treatment cephalometric tracings.*** *Cephalometric superimposition of pre-treatment (black tracing) and post-treatment (red tracing) on the anterior cranial-base demonstrated counter-clockwise rotation of the mandible by intrusion of the maxillary molars, Class I jaw relation, improvement of maxillary and mandibular incisor inclination, extrusion of the mandibular anterior teeth and flattening of the occlusal plane (A). Superimposition on the body of the maxilla showed molar intrusion and uprighting and incisor extrusion with retroclination (B). Superimposition on the inferior-alveolar nerve and inner profile of the mandibular symphysis revealed molar uprighting without extrusion and significant extrusion and retroinclination of the lower incisors (C).*

**III. Dental corrections** (Figures 9 and 10):

A) The maxillary dentition was expanded transversely (inter-molar width increased by 1.3 mm, inter-canine width increased by 2.2 mm).

B) Spaces in the maxillary and mandibular dental arches were closed.

C) The severe open bite was resolved, proper overjet (1.8 mm) and overbite (1.5 mm) were established, and the severe Curve of Spee on the maxillary dental arch and the reverse Curve of Spee on the mandibular dental arch were corrected.

D) Class I canine and molar relationships were achieved (Figure 9).

E) Maxillary and mandibular incisor inclinations were improved (U1°-SN= 96.9°, IMPA= 80.2°, respectively).

F) Gingival esthetic analysis showed that the gingival margins and height of contour were leveled around the anterior teeth. The labial frenum attachment remodeled into its normal position and the periodontal health was maintained at the end of treatment. Frenectomy was not required.

G) Post-treatment panoramic radiograph (Figure 10) showed good root alignment with no root resorption.

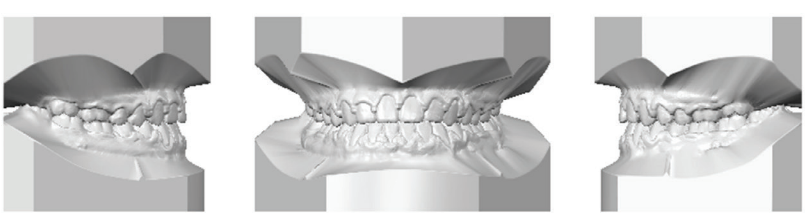

***Figure 9: Post-treatment digital casts.*** *Post-treatment digital cast analysis showed increased maxillary arch dimensions (intermolar width increased by 1.3 mm, while inter-canine width increased by 2.2 mm), coincident dental midlines, Class I molar and canine occlusal relation, ideal overjet (1.8 mm) and overbite (0.8 mm).*

***Figure 10: Post-treatment panoramic radiograph.*** *Panoramic radiograph at the end of treatment showed flatten condyles, good root parallelism and no root resorption or other pathological problems.*

## Discussion

Here we present an adult severe open bite case involving both dental and skeletal components. The open bite was accompanied by maxillary posterior dental extrusion and severe proclination of maxillary and mandibular anterior teeth. In addition, the patient had a constricted maxillary arch and a Class III skeletal pattern. Expanding the maxilla and uprighting the maxillary posterior teeth to address the Class III dental relation could worsen the open bite. In addition, the open bite extended to the first premolar, requiring intrusion of the maxillary posterior segment from second molar to second premolar for correction. Under these conditions treatment with conventional fixed appliance mechanics (without TADs) would require a significant amount of time, complex mechanics and significant compliance with elastics that the patient could not achieve. Therefore, TAD-anchored CTOR Plates were considered a better choice in this case, as this allowed us to efficiently address the constricted upper arch, control the vertical position of the mandibular posterior teeth, retract both maxillary and mandibular anterior teeth and upright the mandibular posterior teeth to correct the Class III dental relationship.

For a TAD to be successful (regardless of whether the mechanics plan ties the TAD directly to the Target Unit being moved or whether the TAD is anchoring a CTOR Plate) two factors are necessary: First, the TAD position should allow application of proper intrusion forces, and second, the TAD needs to be stable during treatment.

TAD position must be based on the ideal mechanics plan for the Target Unit, which was the posterior segment in the case presented here. We considered two TAD-based mechanics designs for the posterior segments (Target Units): 1) Free-Object design, where the posterior teeth would be treated as one Free-Object on each side of the arch. An intrusion force from a CTOR Plate would be used to correct the Target Unit's vertical discrepancy; 2) Semi-Restricted design, where the posterior segments would be connected to the anterior segment and the force from the CTOR Plate would not be applied to the segment but, rather, to the whole arch. In this case, a Semi-Restricted design would not be the treatment of choice to intrude the posterior segments, since it would limit the magnitude of movement of the posterior teeth and slow down treatment progress. In addition, connecting the posterior segment to the anterior segment would transfer the side effect forces and moments placed on the posterior segment to the anterior segment, thereby adding to the complexity of treatment. Therefore, we opted to intrude the posterior segment as one individual segment using a CTOR Plate in a Free-Object design and, after completing intrusion, connect the posterior and anterior segments and maintain the intrusion result by connecting the CTOR Plate to the main arch wire using a Semi-Restricted design.

How the posterior segment moves in a Free-Object design is determined by the relationship between the applied force's line of action and the segment's center of resistance [10]. The distance between these two elements defines the magnitude of the moment appearing in the system. The applied force's line of action, in turn, is determined by the relationship between the attachments on the posterior teeth and the TAD. These attachments are usually connected to the TAD by power chain or power tread, and since the attachments on the segment (for example, buttons or brackets) are almost fixed in their position, the applied force's line of action depends on the position of the TAD. If a TAD is placed close to the segment's center of resistance, the magnitude of the moment in the system would be small, whereas if the TAD is placed far from the center of resistance, the magnitude of the moment in the system would be large and could produce unwanted tilting of the posterior segment. Since, after expansion in the case presented here, the posterior segments were slightly tilted buccally, we determined that the best position for the TADs to anchor the CTOR Plates and to generate uprighting moments was the palatal side of the alveolar bone. In most cases, placing the TAD about 6-8 mm from the alveolar crest on the palatal side provides enough stability for the TAD, while allowing the applied force's line of action to be closer to the posterior segment's center of resistance.

Implant stability is subdivided based on the interaction between the implant and the bone it is placed in. Primary or mechanical stability is seen when a TAD is placed in cortical bone. Secondary stability or osteointegration is observed in dental implants [11-16]. If we placed the TAD 6-8 mm from the palatal alveolar crest in the patient presented here, TAD stability would be classified as Primary (mechanical) because it would depend on the cortical bone properties at that site. Unfortunately, in this case, the palatal cortical plate 6-8 mm from the alveolar crest was thin and was not able to support the TAD. Therefore, four options were considered. First, we could position the TAD more occlusal, which would bring it closer to the roots of adjacent teeth. This was not a good option since TAD proximity to the root of an adjacent tooth may result in TAD failure [17-19]. The second option was to place the TAD on the horizontal portion of the palate, farther away from the alveolar bone, where soft tissues are thicker. This would require a longer TAD to compensate for the thickness of the soft tissue, and would be accompanied by two risk factors: 1) more soft tissue irritation, and 2) increase in the tip-moment on the TAD. Tip-moment appears when head of the TAD is far from the bone. High tip-moment can cause significant stress on the bone and activate the remodeling machinery, and therefore, increase in chance of TAD failure [20, 21]. The third option was to increase the length of the TAD or increase the thickness of the TAD. Increasing the length of the TAD used at the palatal alveolar bone site only puts the TAD deeper in trabecular bone, which does not increase TAD stability [22]. Dramatically increasing the TAD length to reach from the palatal cortical plate to the buccal cortical plate was another possibility (bicortical penetration) [13]; however, this significantly increases TAD proximity to the roots and this procedure is done almost blindly. Increasing TAD thickness to enhance the contact surface between the TAD and bone is not a viable option as increasing the TAD diameter increases insertion torque, which stresses and damages the bone and activates bone remodeling, and thereby reduces TAD stability [23-25]. In addition, increasing a TAD diameter also increases its proximity of the adjacent roots. Therefore, this option was also rejected. The last option was to place the TAD into high quality bone in the mid-palatal area, distant from the palatal avelolar bone. However, placement of the TAD further into this bone and directly attaching it to the posterior segment would put the applied force's line of action far from the posterior segment's center of resistance and would produce large moments that would be very difficult to control. To bypass this problem we decided to use TAD-anchored CTOR Plates, which allowed us to optimize TAD stability by taking advantage of high quality bone, while controlling moments in the system by keeping the point of force application close to the center of resistance.

CTOR I-Plates in this case were beneficial from many aspects. First, application of two short TADs far from the teeth close to the mid-palate decreased root proximity. Second, placing the TADs in attached keratinized tissue allowed us to keep the head of the TAD close to the bone, and therefore, decrease the tip-moment. Third, having two TADs instead of one, allowed us to maximize the contact point between the TADs and cortical bone without increasing insertion torque. In addition, by taking advantage of the thick cortical bone in the mid palatal area, and the application of two TADs reinforced through a strong plate, we could simultaneously apply a higher magnitude of force on both sides of the arch to a different number of teeth, which can shorten the treatment time. Fourth, applying forces to the plate would not create any unwinding effect on any of the TADs. This problem is observed only if we use an extension that is connected only to one TAD. This extension could act as one-couple system and can decrease the TAD's stability by producing a counterclockwise moment. The CTOR Plate structure protects the anchoring TADs by preventing the moments from being directly applied to the TADs.

The most advantageous aspect of using CTOR Plates was the fact that we were able to adjust the point of force application as the posterior segment intruded, since CTOR Plates could be removed quickly, adjusted and screwed back to the same TADs without any pain or discomfort for the patient. Finally, after we achieved the proper intrusion, we were able to stabilize the posterior segment and use the same CTOR I- Plate to correct the anterior segment position, without the need for a separate transpalatal arch (TPA).

It should be emphasized that correcting any open bite case is prone to relapse if the etiological factors are ignored. In this patient one possible etiological factor could be the long-term blocked airway, since the patient reported that during her childhood and teenage years she had adopted a mouth breathing habit. That could explain the anterior position of the tongue that the patient adopted and maintained even after her tonsillectomy and the airway problem was corrected. The majority of open bite patients demonstrate these adaptions and maintain deleterious habits long after the etiological factors have been resolved. In these patients, muscle habits should be corrected by myofunctional therapy after etiological factors have been eliminated (tonsillectomy in this case). However, myofunctional therapy alone cannot correct the existing deformity and should be used as adjunct treatment to dental-orthopedic corrections . These patients require customized retainers to control extrusion of posterior teeth long term and especially during sleep.

In the majority of open bite patients, speech therapy is required to establish the proper speech pattern. As we mentioned before this patient had a speech impediment and a lisp, which are very common due to lack of proper anterior teeth contact during pronunciation of some sounds. In this case, the patient had difficulty in pronouncing s/ and /t/ phonemes. After establishing a proper contact of the anterior teeth, a few speech therapy sessions can help these patients relearn proper pronunciation.

Another complication in this case was the occasional pain and discomfort in the TMJ and masticatory muscle tenderness, all of which disappeared after treatment. This confirms previous studies showing that open bite may contribute to TMJ symptoms (26). In cases when the open bite is the source of a TMJ problem, correcting the malocclusion may be essential to prevent further damage to TMJ tissues. However, further research in this area is required.

## Applied Innovation

We reported here an innovative approach to treat severe open bite cases. CTOR I- Plates provide the flexibility to control the type of tooth movement of the posterior segments during intrusion by taking advantage of better bone and soft tissue in the mid-palatal area and, at the same time, allowing the clinician to adjust the point of force application in relation to the center of resistance of the Target Unit. CTOR Plates can be used not only in combination with a Free-Object design to achieve intrusion, but due to their adjustability they can be used as anchorage during retraction of anterior teeth when using a Semi-Restricted design. Replacing the plates requires only unscrewing the old plate and screwing on a new or modified plate without the need to change the position of the TADs. This can be done without any surgery or the need for anesthetic or another specialist intervention and is, therefore, very cost effective. This versatility and maneuverability allows the clinician to treat a wide variety of open bite cases non-surgically and in a shorter period of time.

## References


1. Nordahl S, Alstergren P, Appelgren A, Appelgren B, Eliasson S, Kopp S. Pain, tenderness, mandibular mobility, and anterior open bite in relation to radiographic erosions in temporomandibular joint disease. Acta Odontol Scand. 1997;55(1):18-22.

2. Bakke M, Michler L. Temporalis and masseter muscle activity in patients with anterior open bite and craniomandibular disorders. Scand J Dent Res. 1991;99(3):219-28.

3. Piancino MG, Isola G, Merlo A, Dalessandri D, Debernardi C, Bracco P. Chewing pattern and muscular activation in open bite patients. J Electromyogr Kinesiol. 2012;22(2):273-9.

4. Leavy KM, Cisneros GJ, LeBlanc EM. Malocclusion and its relationship to speech sound production: Redefining the effect of malocclusal traits on sound production. Am J Orthod Dentofacial Orthop. 2016;150(1):116-23.

5. Manfredini D, Vano M, Peretta R, Guarda-Nardini L. Jaw clenching effects in relation to two extreme occlusal features: patterns of diagnoses in a TMD patient population. Cranio. 2014;32(1):45-50.

6. Proffit WR, Fields HW, Jr., Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey. Int J Adult Orthodon Orthognath Surg. 1998;13(2):97-106.

7. 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(2):154-69.

8. Bailey LJ, Haltiwanger LH, Blakey GH, Proffit WR. Who seeks surgical-orthodontic treatment: a current review. Int J Adult Orthodon Orthognath Surg. 2001;16(4):280-92.

9. Alikhani M, Sangsuwon C, Alansari S, Nervina JM, Oliveira SP, Teixeira CC. CTOR Plates:A new invention for non-surgical treatment of complex malocclusions. Innovation. 2021.1(1)e2. doi:10.30771/2021.2.

10. Alikhani M. Mechanotherapy in Orthodonitcs Volume I: CTOR Press, Hoboken NJ 2018 [Available from: https://www.ctor.academy/book.

11. Motoyoshi M, Inaba M, Ono A, Ueno S, Shimizu N. The effect of cortical bone thickness on the stability of orthodontic mini-implants and on the stress distribution in surrounding bone. Int J Oral Maxillofac Surg. 2009;38(1):13-8.

12. Melsen B, Lang NP. Biological reactions of alveolar bone to orthodontic loading of oral implants. Clin Oral Implants Res. 2001;12(2):144-52.

13. Brettin BT, Grosland NM, Qian F, Southard KA, Stuntz TD, Morgan TA, et al. Bicortical vs monocortical orthodontic skeletal anchorage. Am J Orthod Dentofacial Orthop. 2008;134(5):625-35.

14. Lin JC, Liou EJ. A new bone screw for orthodontic anchorage. J Clin Orthod. 2003;37(12):676-81.

15. Costa A, Pasta G, Bergamaschi G. Intraoral hard and soft tissue depths for temporary anchorage devices. Seminars in Orthodontics. 2005;11(1):10-5.

16. Misch CE, Qu Z, Bidez MW. Mechanical properties of trabecular bone in the human mandible: implications for dental implant treatment planning and surgical placement. J Oral Maxillofac Surg. 1999;57(6):700-6; discussion 6-8.

17. Asscherickx K, Vande Vannet B, Wehrbein H, Sabzevar MM. Success rate of miniscrews relative to their position to adjacent roots. Eur J Orthod. 2008;30(4):330-5.

18. Kang YG, Kim JY, Lee YJ, Chung KR, Park YG. Stability of mini-screws invading the dental roots and their impact on the paradental tissues in beagles. Angle Orthod. 2009;79(2):248-55.

19. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung HM, Takano-Yamamoto T. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop. 2007;131(4 Suppl):S68-73.

20. Gapski R, Wang HL, Mascarenhas P, Lang NP. Critical review of immediate implant loading. Clin Oral Implants Res. 2003;14(5):515-27.

21. Buchter A, Wiechmann D, Koerdt S, Wiesmann HP, Piffko J, Meyer U. Load-related implant reaction of mini-implants used for orthodontic anchorage. Clin Oral Implants Res. 2005;16(4):473-9.

22. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop. 2003;124(4):373-8.

23. Lim SA, Cha JY, Hwang CJ. Insertion torque of orthodontic miniscrews according to changes in shape, diameter and length. Angle Orthod. 2008;78(2):234-40.

24. Chen Y, Kyung HM, Zhao WT, Yu WJ. Critical factors for the success of orthodontic mini-implants: a systematic review. Am J Orthod Dentofacial Orthop. 2009;135(3):284-91.

25. Leo M, Cerroni L, Pasquantonio G, Condo SG, Condo R. Temporary anchorage devices (TADs) in orthodontics: review of the factors that influence the clinical success rate of the mini-implants. Clin Ter. 2016;167(3):e70-7.