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Original article

Non-surgical treatment of anterior open bite using miniscrew implants with posterior bite plate

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ABSTRACT

Purpose: This study describes the quantitative relations between the intrusion of posterior teeth and changes in overbite and lower anterior facial height after treatment of open bite patients with miniscrew implants and posterior bite plates. The study also assessed changes in masticatory muscular activity that may result from the use of bite plate.

Materials and methods: Fifteen patients (mean age ± SD = 20.6 ± 4) with anterior open bite were treated with two miniscrew implants in each side of posterior maxillary dentoalveolar bone and fixed posterior bite plate. Changes in upper posterior dental height (UPDH), overbite (OB) and lower anterior facial height (LAFH) were measured using cephalographs. Activities of masseter and anterior temporalis muscles during clenching and swallowing were assessed before treatment, after placement of bite plate and after removal of the plate. Linear regressions were used to investigate the relationships between morphologic parameters, and paired t-test was used to test changes in muscular activity.

Results: Linear relationships were found between posterior teeth intrusion and the increase of overbite and reduction in LAFH. Each 1 mm intrusion improves the open bite by 1 mm and the LAFH by 0.7 mm. The muscular activity decreased after placement of the plate but recovered immediately after its removal.

Conclusion: Outcomes after treatment with miniscrew implants and bite plate can be predicted by the amount of intrusion in posterior teeth. The bite plate seems not to affect the muscular activity after removal of the plate.

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1. Introduction

Temporary anchorage devices (TADs) like miniscrew implants (MSIs) and miniplates are commonly used in modern orthodontic treatment. They present reasonable stability along the treatment and facilitate treatment plans that were difficult or impossible before [1–3]. Skeletal anterior open bite (AOB) malocclusion in adults is one of the most difficult types of malocclusion that may face an orthodontist. In severe cases

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it is usually required to either have a combined orthodontic and surgical treatment or to use extraoral appliances [4]. Recently this type of malocclusion has been efficiently treated with TADs eliminating the need for surgery or the use of extraoral appliances [5]. The treatment core concept depends on intrusion of maxillary posterior teeth allowing forward autorotation of the mandible. Autorotation of the mandible will contribute to the closure of the AOB and decrease the lower anterior facial height which is usually increased in this type of malocclusion. Autorotation will also advance the chin, which is a favorable effect if the open bite is accompanied with class II component.

Some authors delivered the intrusion force to posterior teeth through brackets attached to teeth, while others used posterior bite plates bonded on posterior teeth (Table 1). The later method seems to provide more control on the buccolingual inclination of the posterior teeth during intrusion and is preferable in the cases where considerable amount of intrusion is required.

The currently available studies that used TADs for correction of AOB reported inconsistent results in regard to the necessary amount of intrusion of posterior teeth. The inconsistency may be partially related to the variation among studies and among the subjects of each study in age of subjects and the severity of open bite before treatment. Scheffler et al. [6], for example, studied a group of patients whose age ranged between 13 and 48. The initial average open bite ranged −1.2 to −4.0 mm (Table 1). It would be useful from the clinical perspective to know how much correction of open bite correction we may obtain for a certain amount of intrusion. Availability of such information may help choose the appropriate treatment approach for each patient according to the severity of open bite, expect the necessary treatment time, and determine the feasibility of complete correction of open bite. In the current study, we described the relations between the amount of intrusion achieved using MSIs and posterior bite plate and the changes in over bite and lower anterior facial height. We also assessed the muscular activity before and after treatment to investigate the effect of bite plate on masticatory muscles.

2. Materials and methods

2.1. *Sample and treatment procedures*

Fifteen consecutive non-growing subjects with anterior open bite were recruited for the study. The inclusion criteria were that overbite <-1 mm and mandibular plane angle (MPA) ≤ 40 degrees. Patients who had systemic diseases or syndromes were excluded. The power of study was more than 80% for detecting a standardized change in overbite of 0.8, whereas SD = 1.7 mm for overbite in AOB malocclusion in adults [10]. Treatment plan and the nature of the study were explained for each patient, and informed consent was obtained. The study was approved by the Academic Committee for Research Ethics in Damascus University. The sample consisted of seven males and eight females, and average age (SD) was 20.6 (4) years. They had average overbite (SD) equal to −3.7 (1.9) mm, and average MPA (SD) equal to 46.9 (5) degrees.

Each patient received four miniscrew implants (Dewimed Medizintechnik GmbH, Tuttlingen, Germany), two in each side of the maxilla. In each side, one implant is placed between second premolar and first molar, and a second implant is placed between the first and second molars. All miniscrew implants had 1.8 mm-diameter and 8 mm-length, and were placed by the same author (Y.A.) using self-drilling technique. A 3 mm-thick bite plate was constructed for each patient with two transpalatal bars to control the buccolingual inclination of posterior teeth during intrusion, as illustrated in Fig. 1A. The plate was fixed with glass ionomer cement all the time of treatment. Two coil springs (G&H Orthodontics, Franklin, IN)

Table 1 – Summary of studies that used TADs with biting plate to intrude posterior teeth in patients with AOB malocclusion.

	N Age (yrs) Initial OB	Mean and range of period of treatment (months)	TAD type and position	Δ UPDH Δ OB Δ LAFH Mean (SD)
(Scheffler et al., 2014) [6]	30 12.7∼48.1 −1.2 (SD 1.7)	6 (3.6-9.6)	One MSI 5-6 or 6-7	−2.3 (1.4) 2.2 (1.6) −1.6 (2.2)
(Foot et al., 2014) [7]	16 12.2∼14.3 −2.2 (SD 1.7)	4.9 (2.5-7.7)	Two MSIs 4-5-6	−2.2 (1.7) 3.0 (1.5) −0.9 (1.1)
(Akan et al., 2013) [8]	19 17.7 −3.2 (SD 1.4)	6.8 (SD 1.6)	Zygomatic miniplate	−3.4 (1.2) 4.8 (1.4) −4.2 (1.7)
(Erverdi et al., 2007) [9]	11 19.5 −4.0	9.6 (SD 1.8)	Zygomatic miniplate	−3.6 5.1 −2.9

UPDH; upper posterior dental height, OB; overbite, LAFH, lower anterior facial height.

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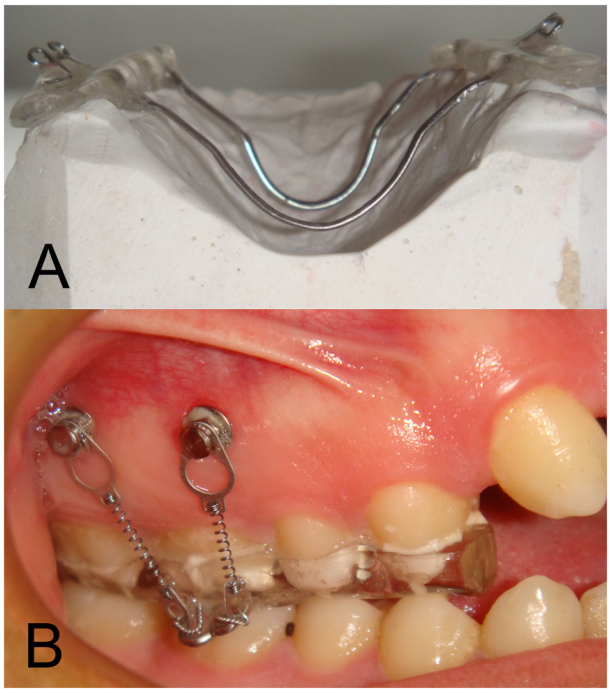


Fig. 1 – A, a bite plate was constructed with two parallel transpalatal arches. (B) the bite plate was cemented to the posterior teeth and coil springs were attached between MSIs and the bite plate.

were applied on each side from the heads of the MSIs to buccal wire loop on the bite plates (Fig. 1B). The total intrusion force on each side was 250g. Overbite was measured intraorally every 4 weeks to monitor open bite closure. When positive overbite is achieved the active treatment with coil springs was stopped. None of the patients underwent teeth extraction during the treatment with bite plate. For retention, patients were instructed to wear removable bite plate similar to the old plate with light elastics connecting the plate to MSIs.

2.2. *Morphological changes*

Cephalometric radiograph taken before and after intrusion of posterior teeth were used to measure the upper posterior dental height (UPDH), overbite (OB) and lower anterior facial height (LAFH) as illustrated in Fig. 2. Twenty radiographs were retraced to assess tracing error using the formula [11]: $ME=\sqrt{\Sigma d^2/2n}$, (ME; method error, d; difference between two measurements, n; the number of retraced radiographs). Tracing error was less than 0.4mm. Linear regression of UPDH on each of OB and LAFH was conducted in JMP Pro 11.0.0 (SAS Institute Inc., Cary, NC, USA). All changes in cephalometric parameters showed normal distribution using Shapiro-Wilk tests.

2.3. *sEMG recoding*

EMG recordings for Masseter and Anterior Temporalis muscles were obtained during clenching and swallowing activities. The EMG recordings were obtained using MYOHANDY matrix line

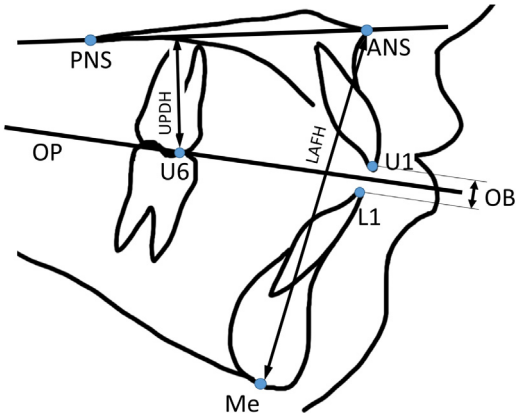


Fig. 2 – The cephalometric measurements. Overbite (OB) is the distance between U1 and L1 perpendicular to the occlusal plane (OP). Upper posterior dental height (UPDH) is the distance between U6 and ANS-PNS plane. Lower anterior facial height (LAFH) is the distance between ANS and Me landmarks.

system (Micromed S.p.A., Mogliano Veneto, TV, Italy). The EMG signals were processed in SystemPlus Evolution (Micromed S.p.A., Mogliano Veneto, TV, Italy) and expressed in μV. Muscular activity was recorded three times; these were before treatment (T1), immediately after placement of the biting plate (T2), and after removal of the plate (T3). For technical reasons, recordings in 3 patients were not obtained at T2 or T3, so they were excluded from the statistical analysis. All measurements had normal distribution (Shapiro-Wilk test), and paired t-test was used to compare means of muscular signals between T1, T2 and T3 ($P<0.05$).

3. Results

3.1. *Morphological changes*

Intrusion time ranged from 3 to 8.2 months (average 6.3, SD 1.4). At the end of intrusion time, all patients had some amount of anterior overlapping. Overbite after treatment ranged between 0.5 and 3mm. Change in OB for each patient is presented in Fig. 3. Average (SD) of posterior teeth intrusion was 2.9mm (1.2). This resulted in average closure of open bite by 5.2 (1.6)mm and average decrease in LAFH of 3.1 (1.4)mm, Table 2.

The amount of posterior teeth intrusion (Δ UPDH) had meaningful relations to changes in LAFH and OB (Fig. 4), $P<0.05$. The linear regression formulae (Fig. 4) predict that for each 1mm intrusion of upper posterior teeth, there will be 1mm increase in OB and 0.7mm decrease in LAFH. As much as 5.5mm intrusion of upper posterior teeth was achieved in the current study, closing the bite by 7.5mm (Cases 14 and 15 in Fig. 3).

3.2. *Changes in muscular activity*

Insertion of the bite block significantly reduced the activities of masseter and anterior temporalis during clenching, and

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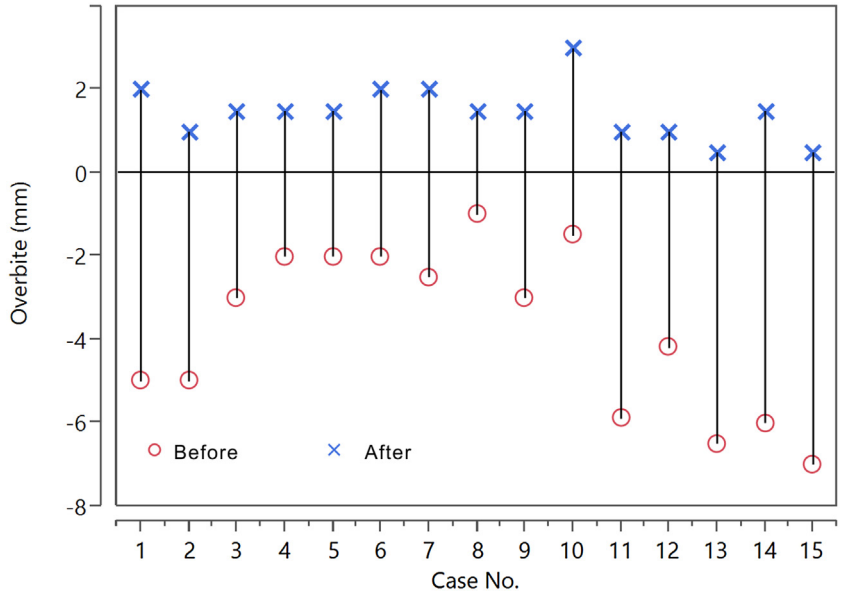


Fig. 3 – The overbite values for each patient before and after treatment. Positive overbite was achieved in all patients.

Table 2 – Changes in morphological parameters of interest after intrusion with MSIs and posterior bite plate.

Analysis columns	Mean	Std dev	Min	Max
Δ UPDH	−2.9	1.2	−5.5	−1
Δ OB	5.2	1.6	2.5	7.5
Δ LAFH	−3.1	1.4	−6	−1

activity of anterior temporalis during swallowing ($P<0.05$, Fig. 5). Immediately after removal of bite block the activity of masseter muscle recovered while the anterior temporalis still had significantly reduced activity during clenching ($P<0.05$, Fig. 5).

4. Discussion

Overeruption of posterior teeth in patients with skeletal open bite is a common component [12], and it is believed to be a part of the mechanism with which the dentoalveolar heights compensate for the dominant vertical growth [13]. For this reason, intrusion of posterior teeth demonstrated good efficacy in correction of anterior open bite. However, the previous studies varied in the efficacy that they reported for correction of open bite after the use of TADs with posterior bite plate. Means and standard deviations reported in previous studies for the morphological changes of interest were plotted in Fig. 4. The linear fits in the current study seem to have the same overall trends in previous studies. Specifically, our

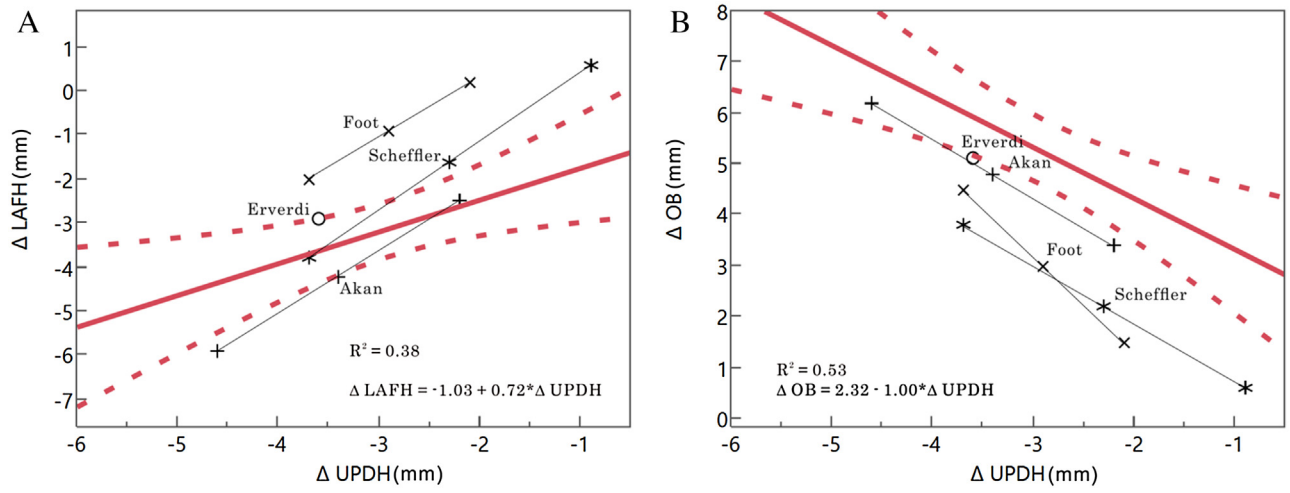


Fig. 4 – The linear fits and confidence curves for relations between intrusion of posterior teeth and changes in overbite (A) and lower anterior facial height (B). The previous studies were plotted here using means and standard deviations reported by each study.

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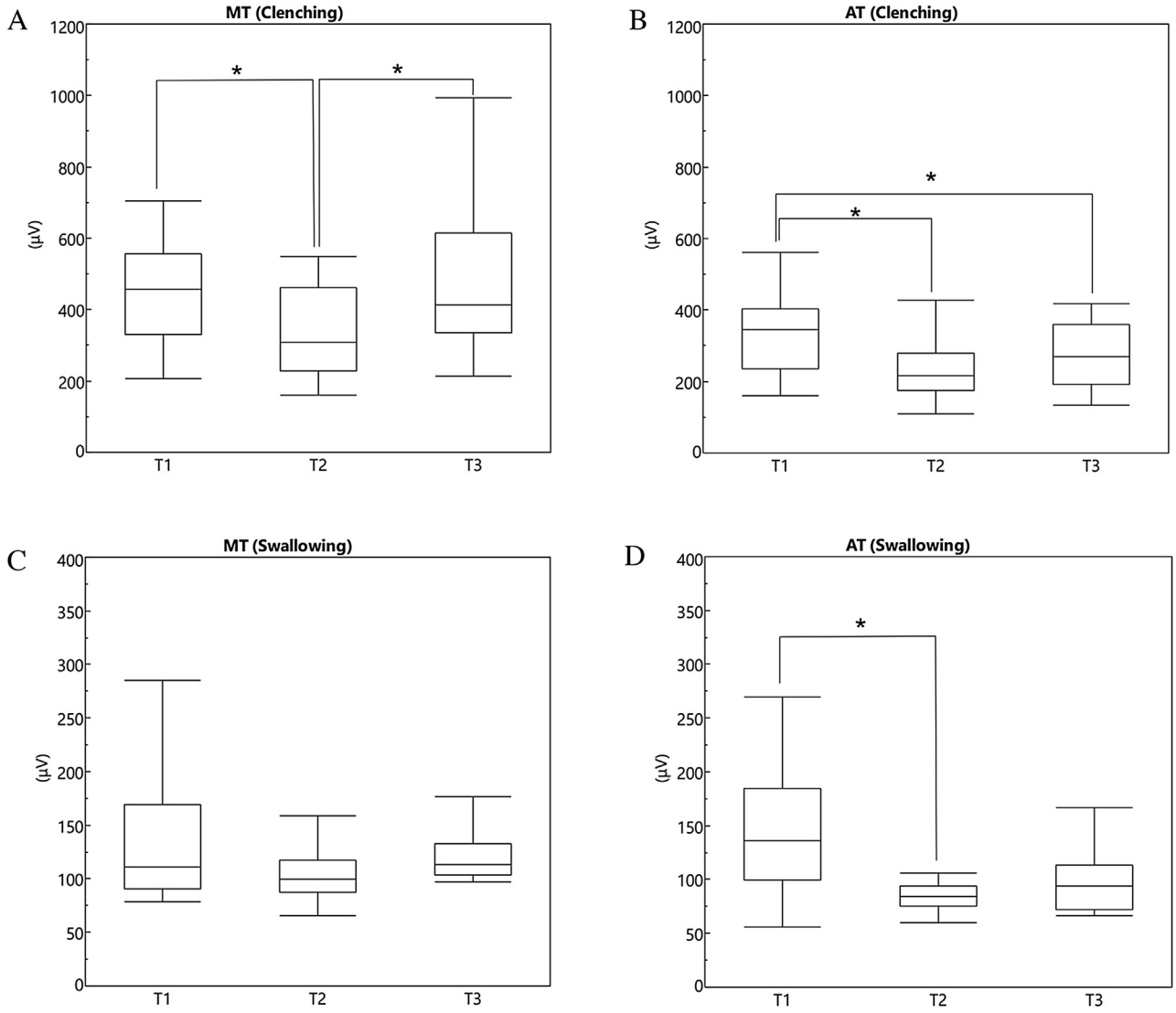


Fig. 5 – Muscular activities during clenching and swallowing for masseter muscle (A and C) and anterior temporalis (B and D) at T1; before treatment, T2; after placement of the bite plate, and T3; after removal of the plate. *P < 0.05.

results are close to those of Akan et al. [8] who studied only adult patients. On the other hand, the results of Scheffler et al. [6] and Foot et al. [7] reported smaller treatment effects compared to the current study. They needed a greater amount of intrusion to achieve smaller improvements in OB and LAFH. The less efficacy in these two studies could be attributed to the fact that they studied samples with wide range of age that included both growing and adult patients. Erverdi et al. [14] reported mean treatment effects that are close to those of Akan et al. and falls within the confidence curves of our linear regression fit (Fig. 4). On the other hand, some studies reported greater closure of open bite for smaller amount of intrusion than the current study. These studies either involved extraction of teeth during treatment [15] or intruded the lower molars as well as upper molars [16]. Therefore, the effect of upper molars intrusion on anterior open bite cannot be isolated in these studies.

There is no information available on how much intrusion in upper posterior teeth can be achieved without complications. Factor that may be considered when planning to intrude upper posterior teeth is the thickness of bone available between the root tips of posterior teeth and the floor of maxillary sinus. If the available bone thickness may not allow enough intrusion to completely close a severe anterior open bite, combination of extraction with TAD treatment could be inevitable.

The effect of bite block on the masticatory muscular activity seems to be temporary and it is unlikely that muscular forces had contributed to the intrusion of the posterior teeth during treatment. Similar findings were reported by Akan et al. [8]. Although, in their study, the muscular activities decreased after intrusion with bite blocks, the changes were not statistically significant.

It is well known that open bite patients have weak masticatory muscular activity [17]. It is still not clear, however, whether certain treatment approach, surgical or nonsurgical, improves this functional deficit. Several aspects of masticatory function need to be assessed to confirm the improvement of function after treatment in patients with open bite malocclusion. Such aspects include biting force, muscular activity and muscular strength. Only one aspect was assessed in the

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current study, which consists a limitation for the conclusion that treatment with bite block has not affected the function in these patients. Even orthognathic surgery seems not to change the muscular activity. However, biting force do increase during the first two years after surgery approaching the normal values [18]. The muscles seem to adapt and get trained to produce more force by time while maintaining the same level of activity. Further research is needed to confirm such functional changes after non-surgical treatment modalities.

5. Conclusions

Severe open bite cases in adults can be closed with TADs, and may eliminate the need for surgery. The amount of posterior teeth intrusion is linearly related to resulting increase of overbite and reduction of lower anterior facial heights. Almost every 1 mm of intrusion can produce 1 mm closure of open bite and 0.7 mm reduction in LAFH. Muscular activity may not be affected by the posterior bite block after removal of the appliance.

Conflict of interest

None of the authors have any conflict of interest to disclose.

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