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Effect of maxillary molar intrusion on surrounding bone density during treatment of anterior open bite

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***Abstract*---**The aim of the current work is to estimate the impact of posterior maxillary intrusion on the surrounding bone intensity during correction of anterior open bite (AOB). The sample was 14 patients suffering from mild to moderate (3-5mm) anterior open bite with increased posterior maxillary vertical height. This study sample was allocated into two groups according to the corticotomy the approach. Buccal miniplates and palatal mini screws were used as skeletal anchorage for maxillary molars' intrusion. The density of the

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alveolar bone related to right and left maxillary first permanent molars were measured 4.5 months after intrusion commencement. The study revealed that the alveolar bone density of right and left first permanent molars had statistically significant decreases. In the right side, buccal and palatal cortical density had statistically significant decrease, however it was non significant for left both cortical bone. Absolute molar intrusion could be attained by skeletal anchorage miniplates and mini screws in patients with frontal open bite malocclusion. The variation of bone intensity between buccal and palatal sides may account for the variance bone thickness changes after intrusion from the buccal to the palatal sides.

***Keywords*---**anterior open bite, intrusion, miniplates, alveolar bone density.

Introduction

Due to the multifactorial nature, anterior open bite AOB is one of the key exciting cases in orthodontics to not only cure, but also to retain. Severe emaciated anterior open bite in adults is treated mostly by surgically relocating both , maxilla and mandible. Adults have limited development potential, and AOB is frequently paired with a propensity toward a long face [1-3]. For such circumstances, a variety of therapeutic options have been recommended, such as high pull headgear, vertical pull chin cup, and intraoral functional appliance such as Harvold activator, open bite Bionator, and posterior bite blocks. All those intrusive modalities are efficient in AOB treatment by molar intrusion. Unfortunately, however, these techniques have several other demerits [4-9]. Noteworthy, surgical treatment of AOB malocclusion by conventional Le Fort 1 surgery was considered as the typical treatment or the first option for AOB malocclusions [10]. However, patient acceptance of this treatment modality was almost negative and not accepted by most of the current research patients. Intrusion of the posterior teeth was the second treatment option for correcting the anterior open bite.

As a result, molar intrusion is regarded the best treatment option because it causes a counterclockwise autorotation of the jaw, which improves the long anterior facial height [11,12]. However, alternative, less invasive treatment methods available that do not need orthognathic surgery. If the patient's AOB could be closed by orthodontically intruding posterior teeth, the occlusal plane, mandibular plane, lower anterior face height, and anterior dental overbite would all alter. Intrusion of the posterior or anterior teeth, on the other hand,it is usually difficult to execute without causing extrusion of the anchoring teeth-17] [10. The temporary anchorage device TADs, such as dental implants, [14 ,18-20] miniplates [15 ,21-25] and mini-screws [16 ,23 ,26-28] have been developed in a trial to provide the solution of this problem, i.e. extrusion of anchorage teeth. According to a former clinical study in which an orthodontic anchor mini-plate system was used, the teeth were relocated on an outpatient base utilizing anchor plates and orthodontic elastics under local anesthetic in a block of bone that was joined to adjacent teeth and fastened via low-mass medullary bone. Even though this strategy is equally appropriate for AOB individuals who do not have antero-posterior dento-facial issues, the recommended surgical approach reduced treatment time by permitting quick displacement of a block of teeth and bone. Furthermore, it was thought that using Corticotomy before orthodontic therapy might allow for faster tooth movement, resulting in a shorter active treatment time with less danger of root resorption and more stable outcomes[29] .

In recent research, the association between molar intrusion productivity and bone density was investigated in individuals with hyperdivergent and hypodivergent vertical skeletal face morphology. Maxillary first molars were intruded using mini screw with elastic chains. The intrusion degree of the maxillary first molar and bone density were measured by spiral CT, and molar intrusion efficacy was determined as amount/duration (mm/month). Subsequentially, a decrease in bone density was recorded following molar intrusion. Furthermore, the decrease in bone density was larger in hyperdivergent individuals than in hypodivergent ($P < 005$). Therefore, molars were shown to be more simply intruded in hyperdivergent patients than in hypodivergent people. The variance in molar intrusion efficiency might be justified by variations in bone density and fluctuations in bone density during intrusion [30].

Based on the above-mentioned research, the present study intended to investigate the effect of posterior maxillary molar intrusion by using miniplates and mini screws in correction of AOB on the density of the surrounding alveolar bone. Cone beam computed tomography (CBCT) was utilized for assessment of the intrusion due to the proposed limitations of the two-dimensional radiographic assessments [31]. Correction of AOB cases was assisted with buccal side corticotomies with or without a palatal one.

Materials and Methods

Patients Selection

Based on sample size calculation, this clinical retrospective study was performed on 14 patients with age range between 14-22 years old. The selected patients had to be suffering from mild to moderate AOB (3-5mm) with increased posterior maxillary dento-alveolar height. Moreover, all permanent dentation should be present regardless the third molar with no previous history of orthodontic treatment.

Intervention Procedure

In all participants, buccal miniplates and palatal mini screws were used as TADs to provide palatal intrusive force in both right and left maxillary molars which were leveled and aligned with maxillary premolars using segmental fixed orthodontic appliance (Unitek™ Metal bands, 3M Unitek USA, Unitek™ Miniature Twin Metal Brackets, 3M, Unitek USA, Unitek™ Orthodontic Composite, 3M, Unitek USA). Sequential orthodontic arch wires were used starting from 0.012” Ni-Ti up to 0.016×0.022” St.St. arch wire (G & H wire company, USA).

Ethical Approval

Before beginning the study, the Ethical Committee of the Faculty of Dental Medicine for Girls, Al-Azhar University (P-PD-21-15), Cairo, Egypt, received well-versed inscribed consent from the patients and/or guardians, and the study was permitted by the Ethical Commission of the Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.

Records

The following routine orthodontic records were obtained for each patient before treatment: Extra-oral photographs (frontal at rest, frontal during smile, right and left profile views). Intra-oral photographs (Frontal, right, and left side views, maxillary and mandibular occlusal views). Orthodontic study cast to facilitate patient communication. In addition, pre-and post-intrusion CBCT images were obtained after an average observation period of 4.5 months which were needed to intrude the posterior molars.

Measurements

The following CBCT measurements were evaluated before intrusion (T1) and after intrusion (T2).The bone density was measured on the CBCT by using 3Dslicer software (3D Slicer as an Image Computing Platform for the Quantitative Imaging Network). The DICOM image file was imported to the software, after that image reorientation was adjusted for every patient (T1 and T2 CBCT). Then, the image was ready for segmentation procedure, by activation of area density measuring tool by adjusting it on CBCT cortical bone threshold. The bone density was measured on buccal and palatal cortex as an elliptic area starting from the mid root length of buccal and palatal root of first maxillary molar on both left and right side, which was ended 1mm apical to the root apex. The software had generated the average density of the selected areas in Hounsfield units: HU. The collected data were tabulated and statistically analyzed for each variable within each group using SPSS Ver., 20. Assessment of the changes in the previous measurements between groups, as well as within each group, were performed via student's t-test, paired t-test for parametric quantities, and Mann-Whitney U test for non-parametric quantities.

Results and Discussion

The current study included 14 patients (6 males and 8 females), the age range was (14-22) years with mean age 18.4 years. Based on the statistical analysis, it was founded that the alveolar bone density of right first permanent molars in the buccal and palatal side, respectively had statistically significant decrease (424.00±178.99 HU) and (63.43±181.78 HU) . Table (1, 3, 5) (Fig. 1, 3). Whereas the outcomes of the study indicated that the alveolar bone density of left first permanent molars had statistically significant decrease (461.02±162.29 HU) and non-significant decrease (59.43±179.72 HU) in the buccal and palatal side, respectively. Table (2, 4, 6) Fig.(2, 4)

Table 1
Descriptive statistics of bone density (HU)in both buccal and palatal sections of right first permanent molar before (T1) and after intrusion (T2)

Side	Time	Mean	SD	Median	Minimum	Maximum	95% CI	
							Lower bound	Upper bound
Buccal	T1	1157.14	93.17	1175.00	996.00	1285.00	1070.98	1243.31
	T2	733.14	137.34	690.00	511.00	898.00	606.13	860.16
	Change	-424.00	178.99	-491.00	-664.00	-184.00	-589.54	-258.46
Palatal	T1	611.86	71.19	633.00	521.00	690.00	1119.17	1674.26
	T2	548.43	127.74	510.00	409.00	722.00	796.25	974.89
	Change	-63.43	181.78	-156.00	-263.00	201.00	-753.48	-268.81

SD= Standard Deviation, CI= Confidence Intervals.

Table 2
Descriptive statistics of bone density (HU) in both buccal and palatal sections of left first permanent molar before (T1) and after intrusion (T2)

Side	Time	Mean	SD	Median	Minimum	Maximum	95% CI	
							Lower bound	Upper bound
Buccal	T1	1187.05	83.16	1195.10	888.02	1279.00	1072.29	1244.22
	T2	726.03	125.34	640.30	531.10	900.02	695.22	854.80
	Change	-461.02	162.29	-461.00	-654.03	-176.20	-582.14	-278.86
Palatal	T1	582.36	70.24	631.80	511.00	668.20	1120.27	1664.16
	T2	522.93	129.72	551.10	428.00	712.20	792.95	971.59
	Change	-59.43	179.72	-151.60	-255.00	200.30	-693.18	-258.71

SD= Standard Deviation, CI= Confidence Intervals.

Table 3
Mean, standard deviation (SD) values and findings of paired t-test for the alters in bone mass of right first permanent molar before (T1) and after intrusion (T2)

Side	T1		T2		P-value
	Mean	SD	Mean	SD	
Buccal	1157.14	93.17	733.14	137.34	0.001*
Palatal	611.86	71.19	548.43	127.74	0.392

*SD= Standard Deviation, *= Significant at P = 0.001, P= probability level.*

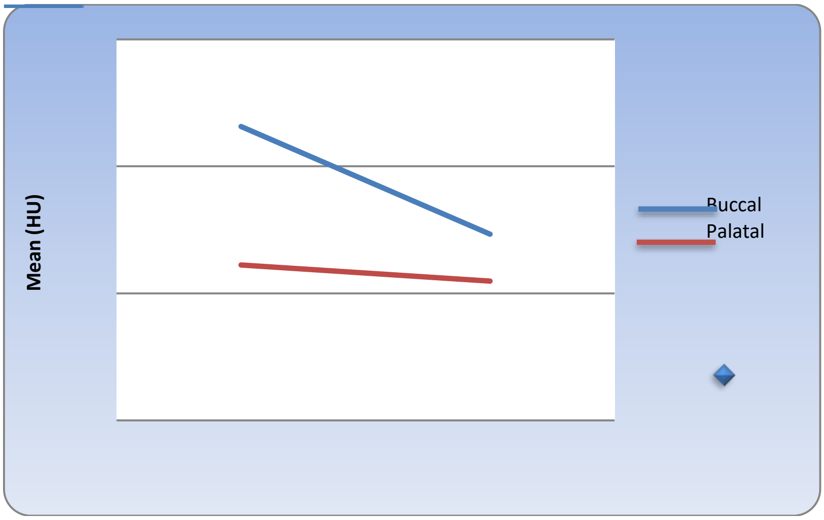

Figure 1. Line chart representing changes in mean alveolar bone density in the right side before (T1) and after intrusion (T2)

Table 4
Mean, standard deviation (SD) values and findings of paired t-test for the alters in bone density of left first permanent molar before (T1) and after intrusion (T2*)*

Side	T1		T2		P-value
	Mean	SD	Mean	SD	
Buccal	1187.05	83.16	726.03	125.34	0.001*
Palatal	582.36	70.24	522.93	129.72	0.299

*SD= Standard Deviation, *= Significant at P = 0.001, P= probability level*

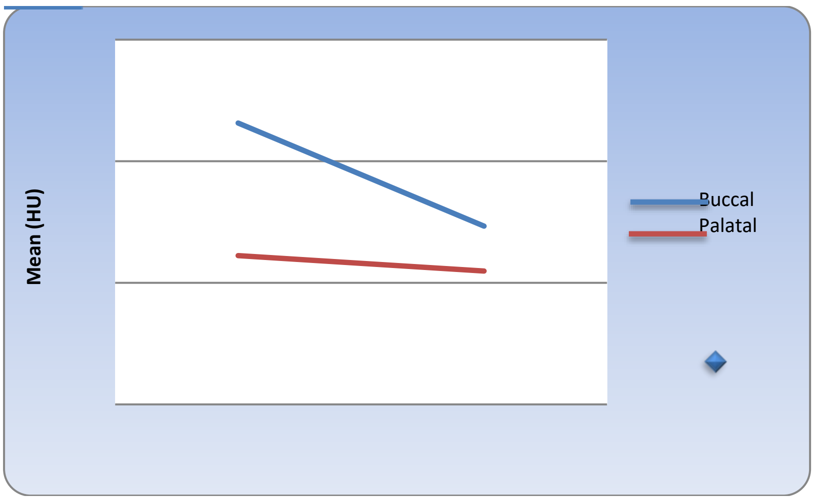

Figure 2. Line chart indicating alters in mean alveolar bone mass in the left side before (T1) and after intrusion (T2)

Table 5
Mean, standard deviation (SD) values, findings of Student's t-test and Mann-Whitney U test for the evaluation among bone density on the right side at T1 and T2

Side		Mean ± SD	95% CI for the difference		P-value
			Lower bound	Upper bound	
Buccal	T1	1157.14 ± 93.17	-498.34	19.20	0.067
	T2	733.14 ± 137.34	-290.69	-14.16	0.033*
	Change	-424.00 ± 178.99	-174.18	348.46	0.565
Palatal	T1	611.86 ± 71.19	-223.86	8.43	0.066
	T2	548.43 ± 127.74	-385.53	-103.04	0.003*
	Change	-63.43 ± 181.78	-322.22	49.08	0.142

**= Significant at P ≥ 0.001, SD= Standard Deviation, CI= Confidence interval, T1= Before intrusion, T2= After intrusion, P= Probability level.*

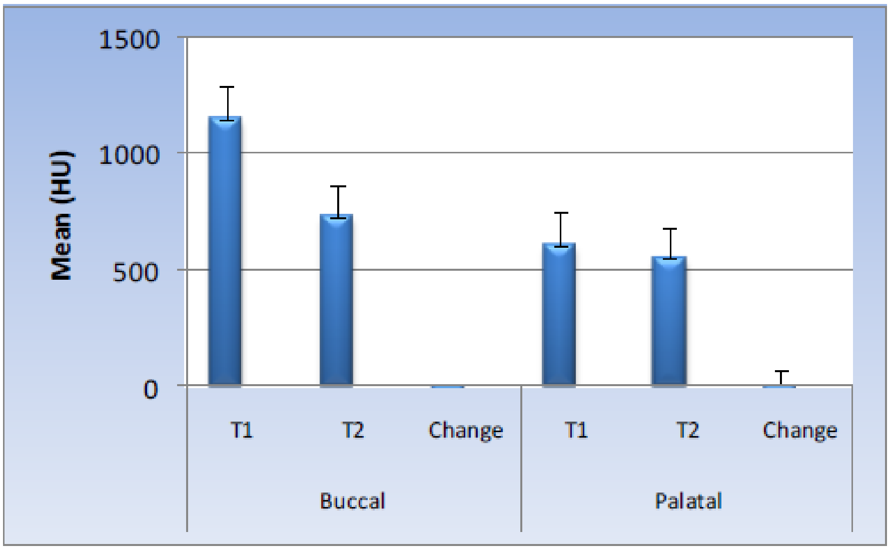

Figure 3. Bar chart representing comparison of changes in mean alveolar bone density on the right side before (T1) and after intrusion (T2)

Table 6
Mean, standard deviation (SD) rates, findings of Student's t-test and Mann-Whitney U test for the difference among bone density in the left side at T1 and T2

Side		Mean ± SD	95% CI for the difference		P-value
			Lower bound	Upper bound	
Buccal	T1	1187.05 ± 83.16	-478.31	20.01	0.066
	T2	726.03 ± 125.34	-288.62	-15.12	0.024*
	Change	-461.02 ± 162.29	-167.28	338.36	0.511
Palatal	T1	582.36 ± 70.24	-243.66	8.32	0.056
	T2	522.93 ± 129.72	-377.83	-111.00	0.004*
	Change	-59.43 ± 179.72	-312.44	50.02	0.123

*****= *Significant at P ≥ 0.001, SD= Standard Deviation, CI= Confidence interval, T1= Before intrusion, T2= After intrusion, P= Probability level.*

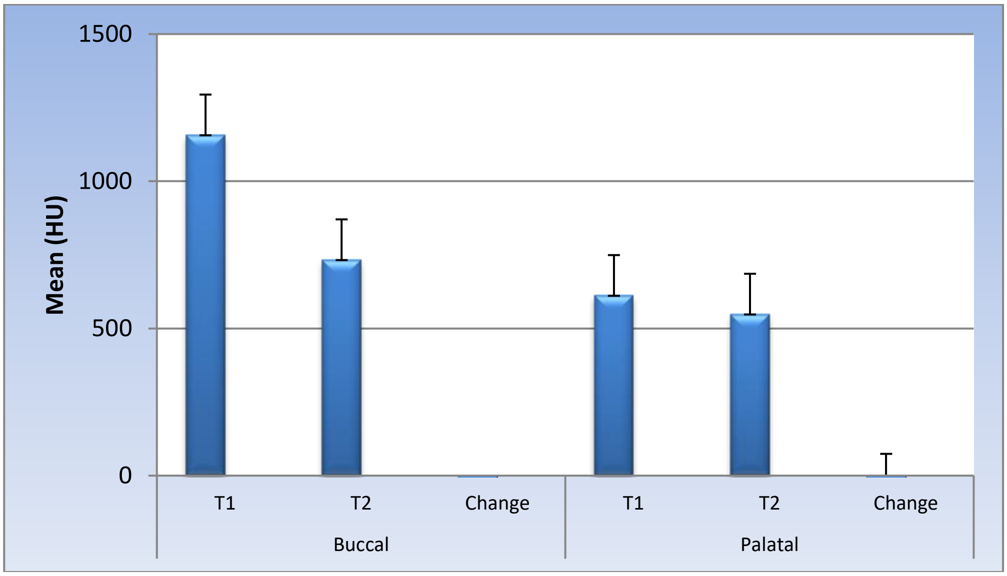

Figure 4. Bar chart representing comparison of changes in mean alveolar bone density on the left side before (T1) and after intrusion (T2)

Treatment of AOB with molar intrusion is considered one of the challenging cases due to the need of complicated mechanics and high tendency of relapse [3]. With introduction of TADs assisted orthodontic tooth movement, complicated tooth movements had been more applicable and efficient. The use of CBCT in clinical practice in the field of dento-maxillofacial imaging is growing in popularity. As a result, CBCT was utilized to assess bone density in this investigation. In the current study there was no statistical difference in bone density between male and female patients that were allocated. Moreover, there was no statistical difference regarding bone density too in the selected age range. Those findings were in accordance with previous studies [9,12,16]. Despite that a former study had correlate the amount of molar intrusion and the change in alveolar bone density, to the face type, hypodivergent or hyperdivergent types [30].

However, significant changes on bone density were detected in the current study on both buccal and palatal cortex as well medullary bone. The decrease on the bone density at both, right and left side, was considered the main facilitator to allow molars intrusion movement as a mean for treatment of AOB. This concept was demonstrated in various former studies [16,30]. Furthermore, the bone density, in the current study, was assessed at T1 and T2, T2 was determined to be on average period of 4.5 months for the range (3-6) months. This range is the time needed to achieve total molar intrusion with TADs as a treatment modality for AOB management [2,10,16].

Moreover, the bone density changes were measured for both, buccal and palatal alveolar bone cortex in right and left side. The statistical analysis has revealed a statically significant decrease in bone density in both right and left side after application of intrusion force. However, there was a statistically significant difference at every side between buccal and palatal cortical bone density. This difference could be interpreted because of difference in occlusal forces that were loaded on buccal and palatal shelf of bone. As well, the buccal shelf of bone is subjected to more occlusion forces during function than the palatal one. These forces are transmitted to the dental roots through the periodontal ligament and the supporting alveolar bone, this transmission process is allowing the presence of different cell activity which is directly proportioned to the force magnitude. This concept could be an explanation for increased cellular activity (osteoblast-osteoclast remodeling) on the buccal cortex than the palatal cortex. Former studies were aimed to analysis the force- cell activity relation on alveolar bone on both animal and human, those studies had concluded the same consensus that was approved in this current study [32-34].

Conclusions

In individuals with anterior open bite malocclusion, skeletal anchoring miniplates and implants might accomplish absolute molar intrusion. The variety in bone density changes following incursion from the buccal to the palatal sides might be explained by the differential in bone density between the buccal and palatal sides.

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