Evaluation of Buccal Alveolar Bone after Orthodontic Treatment with Clear Aligner (cone beam study)

Mohamed Abdelaziz Gaafar¹, Saleh Anwar El-Sayed¹, Ibrahem Saad Abd El-Ghafar¹, Ahmed Dahy Abogabal²

ABSTRACT

Aim: To evaluate the effect of clear aligner on buccal alveolar bone after orthodontic treatment. Subjects and Methods: The present study composed of 14 patients (males, females) aged between 15-25 years who had minor to moderate malocclusion which were randomly selected and divided into two group: Aligner group and Fixed group both groups are prepared for orthodontic treatment and aligner sets and wires are changed in sequence. Patients are selected from the outpatient orthodontic clinic, Faculty of Dental medicine, Al-Azhar University, Assiut branch. The subjects presented to the orthodontic clinic were assessed for eligibility according to inclusion and exclusion criteria. All the patients were informed of the procedure and signed an informed consent form. This study was conducted on CBCT scans taken. Results: both aligner and braces have non-significant effect on bone thickness. However, bone height shows significant difference between both groups. Conclusion: bone height reduction in aligner group is lower than in fixed, while there is no significant difference representing bone thickness.

INTRODUCTION

Alveolar bone is the most liable structure in the periodontium subjected to continual remodeling because of its high sensitivity to external mechanical stimuli.¹

The alveolar process is the osseous tissue that houses and supports the tooth sockets in the maxillary and mandibular jaws. An external cortical plate, an interior socket wall known as the alveolar bone proper, which is compact bone, and a cancellous trabecular bone in between the two boney layers make up the process, when compared to the buccal portions, the palatal and lingual areas of the bone are typically thicker, the cribriform appearance of the alveolar bone provides a connection to the neurovascular systems, The crest of the osseous alveolar edge generally follows the contour of the cement enamel junction of teeth, and the structure and morphology of the alveolar process are dependent on the tooth.²
The thickness of alveolar crest vary from posterior to anterior, the mandibular posterior region had the thickest crestal bone, followed by the mandibular anterior region and maxillary anterior region, and the maxillary posterior region had the thinnest crestal bone.\(^{(3)}\)

From coronal to apical, alveolar width increased, the central incisor had a much greater alveolar surface area than the lateral incisor, and the central incisor had a

The assumption “bone traces tooth movement” is a basic orthodontic axiom that states that when orthodontic tooth movement occurs, the bone around the alveolar socket remodels to the same amount.\(^{(4)}\)

During orthodontic treatment the magnitude and duration of the force, dental vulnerability, age, type of orthodontic appliance, and direction of tooth movement have all been studied as factors that affect alveolar bone and root resorptions to the same amount.\(^{(5)}\)

Unfavorable changes may occur in the anchor teeth and their supporting tissues, including vestibular dental tipping, root resorption, reduction of buccal bone thickness, and marginal bone loss. In this respect, more severe periodontal sequelae such as fenestrations, dehiscence, and/or gingival recessions represent a relevant clinical concern.\(^{(6, 7)}\)

Clear aligners to treat malocclusion has seen a remarkable surge in the last decades and, fueled by aggressive marketing campaigns from manufacturers, a growing interest has been reported for such methods for invisible orthodontics, especially among adult patients.\(^{(8)}\)

Clear aligner patients with simple Class I malocclusions, treated with SmartForce features and attachments, require 4.8 months longer treatment times than patients with simple malocclusions treated with traditional braces. For simple Class I malocclusions, aligners produce the same excellent occlusal results as traditional braces at the end of treatment.\(^{(9)}\)

As the demand for clear aligner therapy grows, it’s more important than ever for orthodontists to understand how they work. Clear aligners and classic fixed appliances both work in the same way in which putting pressure on the teeth. Despite the fact that they are based on the same concepts, there are numerous distinctions in therapy techniques. The ability to remove orthodontic aligners is a significant improvement. This necessitates patient compliance. Another important factor is the design of the appliance makes a difference. Aligners are made of polymer trays that wrap securely over your teeth and allow you to apply force. This distinction has a lot of benefits (for example, patient confidentiality). and drawbacks (e.g., limitations in amount of movement per aligner) associated with clear aligner therapy.\(^{(10, 11)}\)

Aesthetic considerations play an important role in patients’ treatment selection. Because many patients prefer to hide their braces, orthodontics has advanced in this area. As a result, they seek the use of aesthetic orthodontics appliances (using clear brackets), lingual appliances, and Aligners made of thermoplastic.\(^{(12)}\)

The main advantages are the ability to remove during meals, improved conditions for oral hygiene, a reduction in pain levels experienced by patients, and the ability to view the end of treatment using a computer software.\(^{(13)}\)

**PATIENTS AND METHODS**

This study was carried out upon 14 patients with an age range from 15 to 25 years, selected from the outpatient orthodontic clinic, Faculty of Dental medicine, Al-Azhar University, Assiut branch.

The subjects presenting to the orthodontic clinic were assessed for eligibility according to the following inclusion and exclusion criteria.
All the patients were informed of the procedure and signed an informed consent form.

**Clinical procedure**

Patients who met the inclusion criteria were randomly assigned to the aligner and fixed groups using research randomization. After evaluation the patient was informed with steps and details of the treatment plan and applied on consent form.

**Clear aligner group**

1. **Clear aligner fabrication**

   For patients in the aligner group, a rubber base impression (heavy and light) was taken to ensure that fine details were recorded. The rubber base impression was sent to the manufacture (k line lab) with the records and the treatment plane for each patient for aligner fabrication.

2. **Preparation of the patient**

   There are some preparations for the patient before receiving the aligner as following:

   1. Acid etching for tooth which will have attachment
   2. Bond application
   3. Loading composite in the template tray for attachment building up
   4. Set the tray intraorally and curing

3. **Patient instructions:**

   Once the aligners have been fabricated, each patient receives their aligners and instructed by the wearing instructions and time wearing protocol according to each group. The patients were instructed to change the aligner every 2 weeks to give their effect on tooth movement and take a new aligner set every visit.

**Fixed braces group**

For fixed group braces are bonded and wires are changed in sequence every 3 weeks: 0.012 round NiTi, 0.014 round NiTi, 0.16 round NiTi, 0.018 round NiTi, 0.016*0.022 rectangular Ni Ti, 0.017*0.025 StSt.

As with aligner group teeth are etched, bonding, brackets are placed, curing and wire is placed.

**Measurement Procedures**

For every group, cone beam CT are taken before treatment (T0) and after leveling and alignment (T1) each CBCT scan was.

Imported into Mimics software using the DICOM file format and the following measurements were assessed:

**Table (1)**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccal bone thickness at 3 mm</td>
<td>BT-3 mm</td>
<td>Buccal bone thickness of the root at 3 mm from cementoenamel junction. (CEJ)</td>
</tr>
<tr>
<td>Buccal bone thickness at 6 mm</td>
<td>BT-6 mm</td>
<td>Buccal bone thickness of the root at 6 mm from cementoenamel junction. (CEJ)</td>
</tr>
<tr>
<td>Bone height</td>
<td>BH</td>
<td>Vertical distance between the facial (CEJ) and the buccal alveolar crest.</td>
</tr>
<tr>
<td>Arch width</td>
<td>AR 3-3</td>
<td>Distance between cusp tip of canine on one side and the contralateral tooth.</td>
</tr>
<tr>
<td>Buccolingual inclination</td>
<td>Tooth/Occ</td>
<td>Angle between the mesiodistal plane of each tooth and occlusal plane.</td>
</tr>
<tr>
<td>Molar rotation</td>
<td>MR</td>
<td>Angle between buccal surface of the molar at CEJ level and a line perpendicular to the palatal raphe, measured at 3 mm thick axial section.</td>
</tr>
</tbody>
</table>

For every group, central incisor and canine and first molar in the right side (for standardization) were used for measuring this variable between two groups.
RESULT

For comparing the variables within the same group, we used paired t-test to find significance, while for comparing the variables between the two groups, we used independent t-test.

The results showed as in table (2) no significant difference within the group except for one variable for Aligner group that was Buccolingual inclination of central incisor to the occlusal plane and two variables for fixed group that were bone height for central incisors and bone height for mesiobuccal root of first molar. We also found as in table (3) no significant difference between the two groups except for the difference between bone height of alveolar bone for central incisor and difference between bone height of alveolar bone for mesiobuccal root of first molar.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Aligner group</th>
<th>Fixed group</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inc/Occ (°)</td>
<td>52.48±7.92</td>
<td>57.25±7.95</td>
<td>.006</td>
</tr>
<tr>
<td>BH I</td>
<td>.86 ±.16</td>
<td>1.17 ±.25</td>
<td>.026</td>
</tr>
<tr>
<td>BH mb 1M</td>
<td>1.22 ±.29</td>
<td>1.89 ±.55</td>
<td>.010</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Aligner Group</th>
<th>Fixed Group</th>
<th>Test of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH I</td>
<td>.01 ±.12</td>
<td>.31 ±.20</td>
<td>.022</td>
</tr>
<tr>
<td>BH mb 1M</td>
<td>-.06 ±.20</td>
<td>.66 ±.32</td>
<td>.003</td>
</tr>
</tbody>
</table>

A bar chart comparing Bone thickness-central incisor (3mm) mean changes between groups.

A bar chart comparing Buccal bone-canine (3mm) mean changes between groups.
DISCUSSION

With the recent increase in adults seeking orthodontic treatment, there has been a corresponding increase in demand for appliances that are both more aesthetic and more comfortable than conventional fixed appliances.

Although the Invisalign methodology has been successfully improved in recent years, knowledge related to the appliance is significantly limited in terms of scientific evidence.

This study for evaluation of buccal alveolar bone after orthodontic treatment with clear aligner. Most literature was done to compare aligner and braces to detect their effect on hygiene, periodontium, arch width, and angulation of the teeth but there is little study to detect change in alveolar bone with aligner as with braces. (14)
The result of this study revealed that the buccal bone thickness for aligner group show change at 3mm and 6mm from cemento enamel junction most of cases show decrease and other increase and this is logical as pretreatment position and angulation of the teeth affect bone thickness at different level in which tooth that are retroclined after orthodontic treatment will return to normal angulation with decease in bone thickness at cervical and increase in apical if to move with uncontrol tipping and only increase at cervical if it moved with control tipping, the same for tooth with abnormal position as more buccal positioned tooth if it moved bodily there will be increase in bone thickness at all level of root and if tipped only increase at cervical and decrease at apical all this factors make the change in alveolar bone thickness nonsignificant {incisors(p=0.47) canine(p=0.08), and mb1M(p=0.22)}. In a confirmation to this result, previous study by Ting Jianga et al.2020 (How well do integrated 3D models predict alveolar defects after treatment with clear aligners?) reveals increase in fenestration but decrease in dehiscence in case of aligner as in the mandibular canines after treatment might result from lingual crown and buccal root tipping movement in the aligners, in addition to insufficient control of root movement with aligners might be another reason for the lower accuracy in predicting bone defects, this observation perhaps derives from the fact that clear aligners move the teeth mainly by tipping. So other factors such as tooth type and the direction and extent of root movement should be included in future studies. (15)

The result of this study revealed that the Inter canine width for aligner group which is the distance between cusp tip of maxillary canine also show change and nonsignificant increase between cases however most study show significant difference as by Roberta Lione et al. Angle Orthod.2021;91:433–440. (Maxillary arch development with Invisalign system: Analysis of expansion dental movements on digital dental casts: show that statistically significant differences were found for all measurements, except for ones at the upper second molars. The greatest increase in maxillary width was detected at the upper first and second premolars: +3.5 mm for the first premolar and+3.8 mm for the second premolar at T2. (16)

This difference in present value may be due to the more buccal position of canine in some cases in our study.

The result of this study revealed that the buccolingual inclination of the teeth to the occlusal plane for aligner group maxillary incisors show significant differences (p=0.06) while canine(p=0.36) and first molar(p=0.73) show nonsignificant change and this can be matched with result of study by Waseem Kassas et al. 2013 World Federation of Orthodontists, (Assessment of Invisalign treatment outcomes using the ABO Model Grading System show the results for the pre- and posttreatment comparisons that the buccolingual inclination scores improved significantly (P=0.024) and Invisalign treatment when used in mild to moderate malocclusions was effective in correcting tooth alignment and buccolingual inclination; however, it had a negative effect on posterior occlusal contacts and occlusal relationships. (17)
The result of this study revealed that the Molar rotation for aligner group which represents angel between tangent to the buccal surface of the first molar and perpendicular to median palatine raphe show non-significant increase in molar rotation (p=0.5), no previous study supports these results.

The result of this study revealed that the buccal bone thickness for fixed group at 3mm and 6mm from cementoenamel junction show decrease in some case and increase in other at both 3mm and 6mm level which result in non-significant change in bone thickness and this as we explain before in aligner group depend on pretreatment inclination of teeth and direction and type of movement. In a confirmation to this result, previous study by Paulo Roberto Barroso Picanço et al. 2013 (Comparison of the changes of alveolar bone thickness in maxillary incisor area in extraction and non-extraction cases: Computerized tomography evaluation) show non-significant change in alveolar bone thickness in anterior teeth in non-extraction group except for labial cervical third which show significant reduction due to protrusion of the teeth.

Another study confirms our result by Udom Thongudomporna et al. Angle Orthod. 2015; 85:549–554 (Changes of anterior maxillary alveolar bone thickness following incisor proclination and extrusion) show none of the labial alveolar thickness parameters changed significantly.

While other study shows significant reduction of buccal alveolar bone following orthodontic treatment in previous CT and CBCT studies by Juliana F. Moraisa et al. Angle Orthod. 2018; 88:748–756 (Evaluation of maxillary buccal alveolar bone before and after orthodontic alignment without extractions: A cone beam computed tomographic study) show that buccal alveolar bone showed significant reduction in thickness and height at the central incisors and mb1M.

The result of this study revealed that the bone height for fixed group which is the distance from cementoenamel junction to the crest of alveolar bone reduction in bone height which is significant at incisors (p=0.020 and mesiobuccally root of first molar (p=0.01) and non-significant at canine (p=0.07). Previous study confirms this result by Juliana F. Moraisa et al. Angle Orthod. 2018; 88:748–756 (Evaluation of maxillary buccal alveolar bone before and after orthodontic alignment without extractions: A cone beam computed tomographic study) show that buccal alveolar bone showed significant reduction in thickness and height at the central incisors and mb1M.

The result of this study revealed that the Inter canine width for fixed group which is the distance between cusp tip of maxillary canine also show non-significant increase, However other study by Tulin (Ugur) Taner et al. (Am J Orthod Dentofacial Orthop 2004; 126:464-76 (Evaluation of dental arch width and form changes after orthodontic treatment and retention with a new computerized method) show that The distances between all maxillary teeth increased significantly during orthodontic treatment, except for the inter central width. As we explain before in aligner that this difference is due to the more buccal and lingual position of canine in some cases which should be taken into consideration.

Another study by Juliana F. Moraisa et al. Angle Orthod. 2018; 88:748–756 (Evaluation of maxillary buccal alveolar bone before and after orthodontic alignment without extractions: A cone beam computed tomographic study) show that Maxillary arch widths increased significantly, especially between 1PMs (4.3 mm). The widening occurred mainly with significant buccal tipping. The greatest buccal tipping was seen at 1PMs, while canines and1Ms exhibited the least amount of tipping.

The result of this study revealed that the Buccolingual inclination of the teeth to the occlusal plane for fixed group shows non-significant change between before and after treatment. However several previous studies show significant change in buccolingual inclination as in study by Eric Lina et
al. Angle Orthod. 2022; 92:173–179. (Differences in finished case quality between Invisalign and traditional fixed appliances: A randomized controlled trial) show that buccolingual inclination changes were statistically significant.\(^{(9)}\)

The result of this study revealed that the molar rotation for fixed group which represents angle between tangent to the buccal surface of the first molar and perpendicular to median palatine raphe show non-significant change in molar rotation. However, study by Juliana F. Moraisa et al. Angle Orthod. 2018; 88:748– 756 (Evaluation of maxillary buccal alveolar bone before and after orthodontic alignment without extractions: A cone beam computed tomographic study) show that the molars rotated significantly mesiobuccally during treatment.\(^{(20)}\)

It should be clear that change in molar rotation depends on pretreatment rotation of molars as preplanned offset of molar tube will change it.

The result of this study revealed that the difference in buccal bone thickness between two groups shows non-significant difference between two groups (p value more than 0.05). No previous study compares between two groups for this variable.

The result of this study revealed that the difference of bone height between two groups shows significant difference at incisors (p=0.02) and mesiobuccally root of first molar (p=0.03) and non-significant difference at canine (p=0.09). No previous study compares between two groups for this variable.

The result of this study revealed that the difference of Inter canine width between two groups show non-significant difference (p=0.49). However, study by Lidia Galan-Lopez et al. Korean J Orthod 2019;49(3):140– 149(, systematic review of the accuracy and efficiency of dental movements with Invisalign) assessed the accuracy and efficiency of Invisalign and found that Invisalign just like braces, could increase inter canine, inter premolar, and intermolar dentoalveolar widths in the presence of crowding.\(^{(22)}\)

The result of this study revealed that the difference of buccolingual inclination of the teeth to the occlusal plane between two groups show nonsignificant difference. This can be matched with result by Eric Lina et al. Angle Orthod. 2022; 92:173–179. (Differences in finished case quality between Invisalign and traditional fixed appliances: A randomized controlled trial) non-significant difference in buccolingual inclination between two group.\(^{(9)}\)

The result of this study revealed that the difference of molar rotation between two shows non-significant difference between two groups (p=0.7), No previous study compares between two groups for this variable.

CONCLUSION

Bone height reduction in aligner group is lower than in fixed, while there is no significant difference representing bone thickness.

RECOMMENDATIONS

More clinical studies are required to give a strong evidence and information about the bone height, thickness and changes related to orthodontic treatment with clear aligner.

REFERENCES


Evaluation of Buccal Alveolar Bone after Orthodontic Treatment with Clear Aligner (cone beam study)

Mohamed Abdelaziz Gaafar, et al.

The aim of this study was to evaluate the effect of clear aligner orthodontic treatment on the buccal alveolar bone thickness.

The study included 30 patients with Class I malocclusion, 15 in each group. The patients were randomly divided into two groups: the clear aligner group and the fixed appliance group. Both groups underwent orthodontic treatment using computed tomography before and after treatment.

The results showed that the thickness of the alveolar bone decreased in the clear aligner group compared to the fixed appliance group. However, there was no significant difference between the two groups in terms of bone thickness.

Keywords: clear aligner orthodontic treatment, buccal alveolar bone, computed tomography, orthodontic treatment.