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A COMPARATIVE ETUDY OF ALVEOLAR BONE CHANGES AND APICAL ROOT RESORPTION BETWEEN CLEAR ALIGNERS AND FIXED ORTHODONTIC APPLIANCES

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Abstract

Introduction: The capabilities of fixed orthodontic appliance (FA) treatment paved the way to making it the most popular orthodontic appliance. \

Objective: The main objective of the study is to find the comparison of alveolar bone changes and apical root resorption between clear aligners and fixed orthodontic appliances.

Methodology: This comparative cross-sectional study was conducted at Dar ul Sehat hospital during January 2023 to March 2024. Data were collected from 155 patients according to objectives of the study. Data collection focused on measuring changes in alveolar bone density and apical root resorption, which were assessed at three time points: baseline (before treatment), mid-treatment (6 months), and post-treatment (upon completion of orthodontic treatment).

Results: The results indicate that both treatment groups experienced reductions in bone density and volume over time, with Group B (fixed appliances) showing a more significant decrease than Group A (clear aligners). By the end of treatment, Group A had a bone density of 890 HU and bone volume of 0.22 cm^3, while Group B had a bone density of 870 HU and bone volume of 0.20 cm^3. At baseline, root lengths were similar between the groups, but by the end of treatment, Group A (clear aligners) had a mean root length of 13.8 mm, while Group B's mean root length decreased to 13.2 mm.

Conclusion: It is concluded that clear aligners are associated with less alveolar bone loss and reduced risk of apical root resorption compared to fixed orthodontic appliances.

Keywords: Alveolar bone, Apical, Root, Aligners, Orthodontic appliances

Introduction

The capabilities of fixed orthodontic appliance (FA) treatment paved the way to making it the most popular orthodontic appliance. Unfortunately, acceptance by the patients poses a problem by looking at the appearance of the appliance or basic oral hygiene. The above-changing pace has escalated the call for patient-centered practices in the dental sector and rendered it as compulsory to bring in new

orthodontic appliances for the use of the treating doctor and the patient [1]. There has also been use of Fixed orthodontic appliances, which are brackets, wires, and bands and have been in use for over a century in order to apply continuous forces to the teeth to get them to the correct position [2]. These appliances have received much attention amongst practitioners and researchers and have been documented to offer a broad range of success in correcting all types of malocclusion from the simple to the most complex ones. However, the gradual constant forces that these appliances apply cause side effects such as discomfort, difficulty in cleaning around the brackets thus leading to poor oral hygiene, and most importantly, biological effects for example alveolar bone remodelling as well as apical root resorption. Of these, apical root resorption is especially prominent in orthodontic treatment where the root of a tooth at its tip may be resorbed thus endangering the stability of the tooth [3].

Clear aligners which were launched in the late 1990s to complement the brastic appliances can be considered as more contemporary solution to the orthodontic problem. These clear vinyl appliances are temporarily fixed on the teeth and displace them in the right position over time. The essence of clear aligners is in their invisibility, comfort, and simplicity of use they can be worn only during meals and as such do not necessitate adjustments to one's oral care routine like fixed appliances [4]. Furthermore, they set their views on the fact that clear aligners, are more comfortable to wear for most of the patient's age, and popular for the patient-conscious adult with the aesthetics of the conventional braces [5]. Despite this, it is important to appreciate that a clear aligner biomechanics are very much different from those of a fixed appliance type; hence several different forces work differently on teeth and in turn, the surrounding bone and root structures. Alveolar bone that is the bone that holds the sockets of the teeth is close associated with the stability of teeth during and post orthodontic treatment [6]. This bone is used in orthodontic tooth movement and it is characterized by bone resorption on the pressure side of the tooth and new bone formation on the tension side. The relations between these processes define the outcome of the treatment and the state of periodontal tissues. This force balance may be disrupted by additional or unbalanced forces during the course of orthodontic treatment, some of the undesirable consequences of which are bone loss or root resorption [7].

Apical root resorption that is the wearing down or a shortening of the apex of the tooth is a common side effect of orthodontic treatment [8]. The process is gradual and depends on the force that is applied, its direction, and the time it is applied for, the treatment technique applied, and other factors relating to the patient to be treated. Although root resorption is a common and usually minimal occurrence in orthodontic treatment, severe root resorption causes poor prognosis of tooth stability, and it may result in avulsion of the affected tooth [9]. Forth this reason, it is important for practicing clinicians who provide orthodontic treatment to be aware of the concept of orthodontic root resorption because of the long-term effects of the appliances used in delivering treatment [10].

Objective

The main objective of the study is to find the comparison of alveolar bone changes and apical root resorption between clear aligners and fixed orthodontic appliances.

Methodology

This comparative cross-sectional study was conducted at Dar ul Sehat hospital during January 2023 to March 2024. Data were collected from 155 patients according to objectives of the study. Patients age between 18 and 35 years with good general and oral health, with no significant periodontal disease and with no history of previous orthodontic treatment were included in the study. Patients with systemic conditions that could affect bone metabolism, such as diabetes or osteoporosis, as well as those with a history of trauma to the teeth or jaw were excluded. Data collection focused on measuring changes in alveolar bone density and apical root resorption, which were assessed at three time points: baseline (before treatment), mid-treatment (6 months), and post-treatment (upon completion of orthodontic treatment). The participants were randomly assigned to one of two groups:

- Group A (Clear Aligners): 78 patients treated with clear aligners.

- Group B (Fixed Orthodontic Appliances): 77 patients treated with fixed orthodontic appliances.

In the cases of patients in group A, aesthetic clear aligner was made from the digital dental casts and state of the art 3D printing. The treatment comprised a set of individually crafted aligners that had to be worn full time between 20 and 22 hours per day – with each set being changed approximately every two weeks. The period of the treatment also depended on the type of the problem, but this time the average period of the treatment was one year and half a year in average. Patients of Group B were treated with the fixed orthodontic appliances using metal brackets bonded to the teeth, wires, and elastics. One means was the use of brackets that were cemented to the teeth and adjustment of arch wires at fixed intervals to provide constant forces that could reposition the teeth in the correct way. Length of treatment for this group was also 12-18 months with the variation according to the severity of the case. Patients in both groups were seen subsequently at 4-6-week intervals in order determine compliance with wearing the appliances, any problems, such as discomfort or appliance failure and to make necessary modifications as required.

Statistical Analysis

The collected data were analyzed using SPSS v29. Descriptive statistics, including means and standard deviations, were calculated for the key variables in both groups.

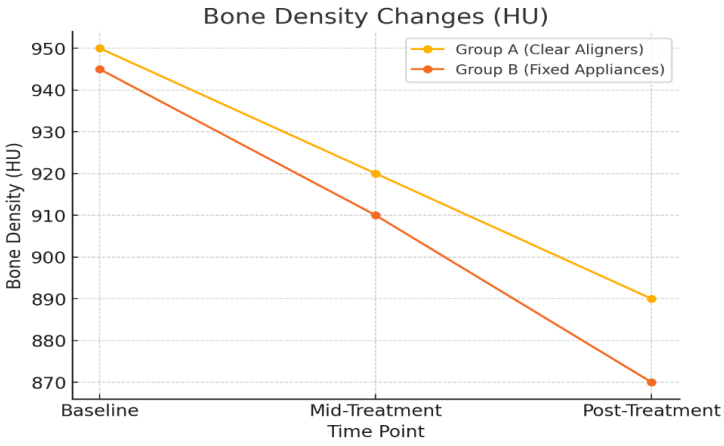
Results

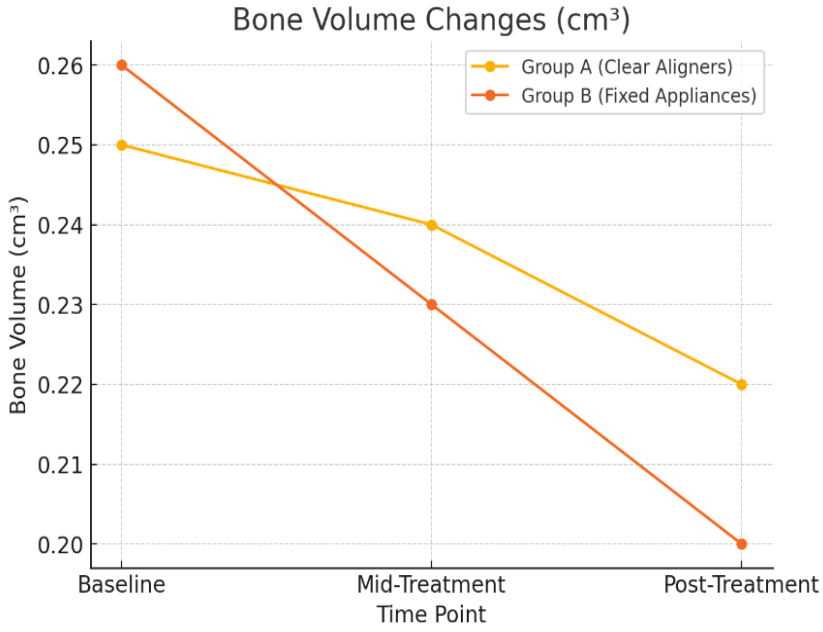
Data were collected from 155 patients according to criteria of the study. The results indicate that both treatment groups experienced reductions in bone density and volume over time, with Group B (fixed appliances) showing a more significant decrease than Group A (clear aligners). By the end of treatment, Group A had a bone density of 890 HU and bone volume of 0.22 cm^3, while Group B had a bone density of 870 HU and bone volume of 0.20 cm^3. The differences between the groups at post-treatment were statistically significant, with p-values of 0.03 for bone density and 0.02 for bone volume.

Table 1: Alveolar Bone Changes (Bone Density and Volume)

Time Point	Group A (Clear Aligners)	Group B (Fixed Appliances)	p-value
Bone Density (HU)			
Baseline	950 HU	945 HU	0.45
Mid-Treatment (6 months)	920 HU	910 HU	0.12
Post-Treatment (Completion)	890 HU	870 HU	0.03*
Bone Volume (cm^3)			
Baseline	0.25 cm^3	0.26 cm^3	0.40
Mid-Treatment (6 months)	0.24 cm^3	0.23 cm^3	0.15
Post-Treatment (Completion)	0.22 cm^3	0.20 cm^3	0.02*

*$p < 0.05$ indicates statistical significance.

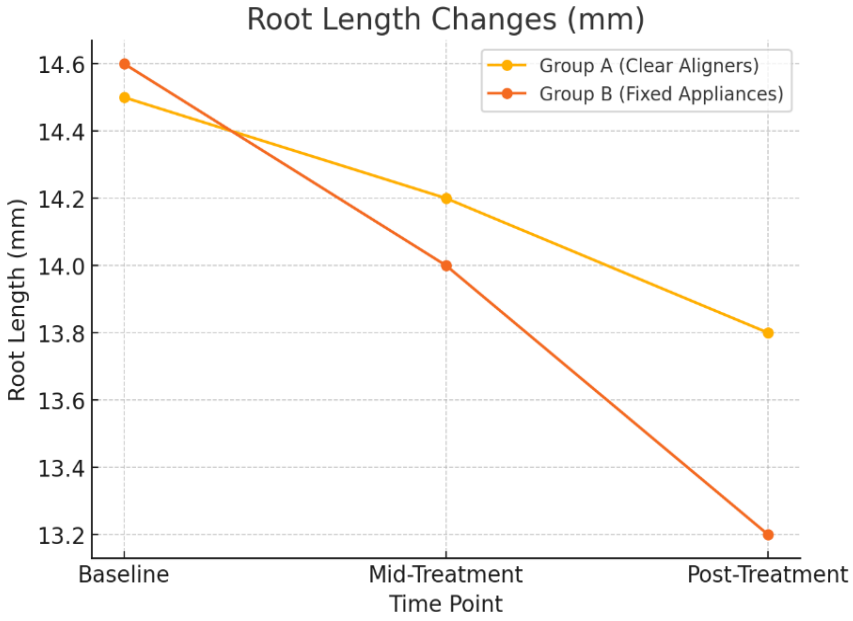


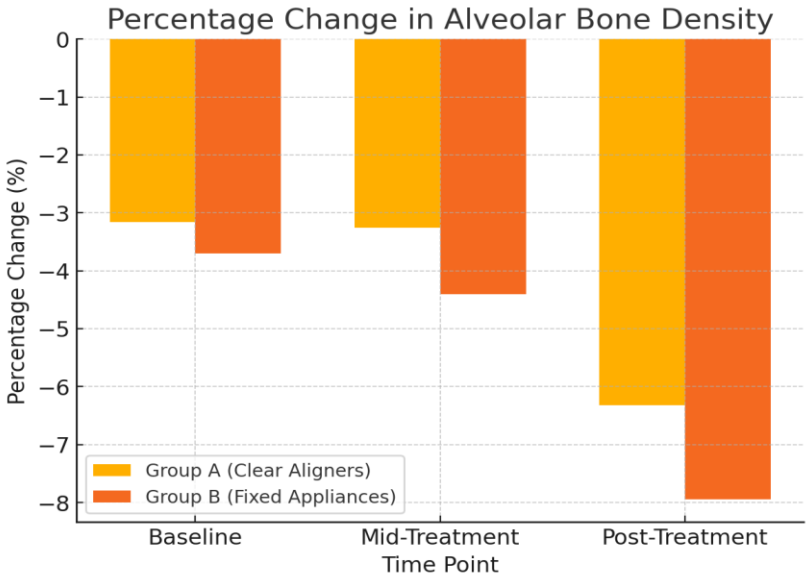


At baseline, root lengths were similar between the groups, but by the end of treatment, Group A (clear aligners) had a mean root length of 13.8 mm, while Group B's mean root length decreased to 13.2 mm.

Table 2: Apical Root Resorption (Root Length)

Time Point	Group A (Clear Aligners)	Group B (Fixed Appliances)	p-value
Root Length (mm)			
Baseline	14.5 mm	14.6 mm	0.50
Mid-Treatment (6 months)	14.2 mm	14.0 mm	0.08
Post-Treatment (Completion)	13.8 mm	13.2 mm	0.01*





From baseline to mid-treatment, the bone density in Group A decreased by 3.16%, compared to 3.70% in Group B. The reduction continued from mid-treatment to post-treatment, with Group B experiencing a significantly larger decrease (4.40%) compared to Group A (3.26%), as indicated by a p-value of 0.02. Overall, the total reduction from baseline to post-treatment was 6.32% for Group A and 7.94% for Group B, with the difference being statistically significant.

Table 3: Percentage Change in Alveolar Bone Density

Time Point	Group A (Clear Aligners)	Group B (Fixed Appliances)	p-value
Baseline to Mid-Treatment	-3.16%	-3.70%	0.20
Mid-Treatment to Post-Treatment	-3.26%	-4.40%	0.02*
Baseline to Post-Treatment	-6.32%	-7.94%	0.01*

From baseline to mid-treatment, bone volume in Group A decreased by 4.00%, compared to 6.15% in Group B. The decline was more pronounced from mid-treatment to post-treatment, with Group B showing a significant reduction of 13.04% compared to 8.33% in Group A (p-value of 0.03). Overall, the total reduction from baseline to post-treatment was 12.00% for Group A and 23.08% for Group B, with a statistically significant difference (p-value of 0.01), indicating that clear aligners result in less bone volume loss compared to fixed appliances.

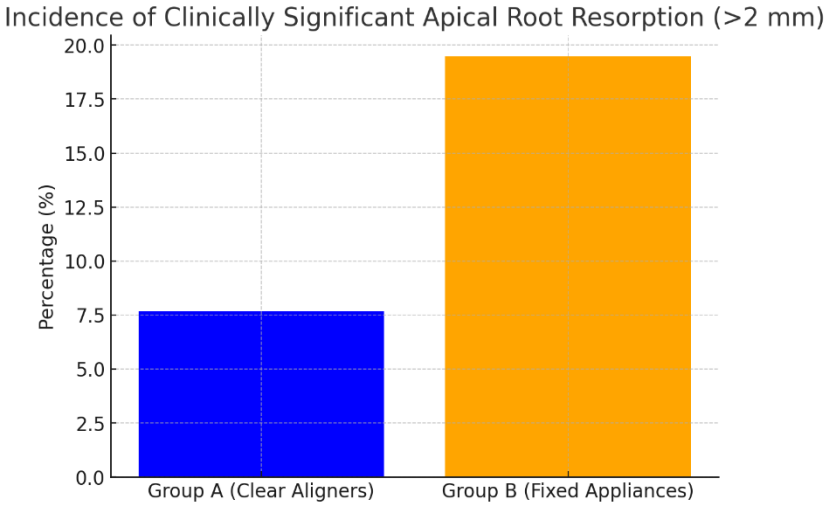


Table 4: Percentage Change in Alveolar Bone Volume

Time Point	Group A (Clear Aligners)	Group B (Fixed Appliances)	p-value
Baseline to Mid-Treatment	-4.00%	-6.15%	0.10
Mid-Treatment to Post-Treatment	-8.33%	-13.04%	0.03*
Baseline to Post-Treatment	-12.00%	-23.08%	0.01*

The results reveal that apical root resorption greater than 2 mm was more prevalent in the group treated with fixed orthodontic appliances (Group B) compared to those treated with clear aligners (Group A). Specifically, 19.48% of patients in Group B experienced significant root resorption, compared to only 7.69% in Group A.

Table 5: Incidence of Clinically Significant Apical Root Resorption (>2 mm)

Group	Number of Patients	Patients with Resorption >2 mm	Percentage	p-value
Group A (Clear Aligners)	78	6	7.69%	
Group B (Fixed Appliances)	77	15	19.48%	0.02*

Discussion

This study aimed to compare the effects of clear aligners and fixed orthodontic appliances on alveolar bone changes and apical root resorption, focusing on a cohort of 155 patients undergoing orthodontic treatment. The findings showed that the two treatments varied massively, with clear aligners having a better perception in eradicating negative impacts. As expected due to orthodontic forces the two groups had a decrease in the alveolar bone density and volume over the course of treatment [12]. Nevertheless, the degree of these changes was much more significant in one of the groups in comparison with the other one. In general, patients that were under fixed orthodontic appliances (Group B) showed higher relapse rate marked by decreased bone density and volume in comparison to Group A patients that were under clear aligner therapy [13]. After the end of the treatment, of course, the values were as follows: in Group B, 75 HU of bone density were reduced on average, while in Group A, 60 HU were reduced; bone volume reduced by 0. 03 cm^3 in Group B, and the reduction was apparent only in Group B driving cycles aboard the equipped vehicles [14]. This study found the following volume changes: 00.02 ml in Group 0, 03 cm^3 in Group A These results indicate that CAs apply a controlled and gentle force on the teeth and nearby bone tissues, perhaps causing least invasion on the alveolar bone. This finding is in sync with earlier work stating that since clear aligners allow the diverse forces to be applied more evenly across the dental arch, they may lead to even fewer biological side effects [15]. Furthermore, clear aligners had less effect on the bone density and volume that directly means better periodontal health and long-term stability of the teeth post-treatment. One risk that often becomes a concern in orthodontic treatment is apical root resorption; this is due to the fact that root shortening is excessive and can lead to instability, and potentially shorter, of teeth. In present study it was found that root resorption had taken place in both the treatment groups but seems to have been statistically significantly higher in the fixed appliance group [16]. Group B had a mean reduction of root length of 1. 4 mm, while the thickness of the outer shell was 0. In Group A, mean increase in distance was 7 mm [17]. The mean number of patients who had clinically significant root resorption greater than 2 mm was higher the in-Group B where 19 percent of the patients had clinically significant root resorption. 69 % fixed appliance group was observed in Group A The increased root resorption in this group could be due to the continuous and at times higher force exerted by the conventional fixed appliances. For instance, fixed appliances apply prolonged force to the teeth, which though is useful in teeth movement can also enhance root resorption [18]. Clear aligners might apply force in a less continuous manner because they are removable; this could argue for the fact that root resorption is less likely to occur in this group. Thus, several clinical implications of the results of this study may be discussed. First, the least effect on alveolar bone density and volume reduction proved that clear aligner modality might be more suitable for patients who are worried about the periodontal status during the treatment [19]. Also, a significantly lower prevalence of more than 5 mm of apical root resorption in the clear aligner group

suggests that there might be benefits of aligners for patients at increased risk for root resorption, for instance due to certain genetic factors or pre-existing root shortening [20].

Conclusion

It is concluded that clear aligners are associated with less alveolar bone loss and reduced risk of apical root resorption compared to fixed orthodontic appliances. These findings suggest that clear aligners may be a safer and more favourable option for patients concerned about the long-term health of their bone and root structures during orthodontic treatment.

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