Original Article

Apical Root Resorption Accompanied Orthodontic Treatment Using Clear Aligners Versus Fixed Appliances: A Cbct Comparative Study

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Abstract

Objectives the objective of this study is to compare the root resorption accompanied orthodontic treatment using fixed orthodontic appliance versus removable clear aligner. **Material and methods** This prospective randomized clinical study was conducted on a sample of 30 patients with mild to moderate crowding. The patient ages ranged from (12-18) years. Patients were randomly divided into three groups; Group I: ten patients treated with fixed orthodontic appliance using Roth brackets 0.022-inch slot. Group II: ten patients treated with removable clear aligner. Group III: ten patients treated with removable clear aligner with application of low-level LASER. Each patient in the study had a pre and post treatment CBCT. **Results** root resorption was measured by importing pre and post treatment CBCT on Mimics software (version 18, Materialise, Leuven, Belgium) to reconstruct the roots in 3D. **conclusion** Root resorption accompanied with aligners is considered less than fixed appliances however the difference is not significant. The use of laser has no effect on reducing or minimizing the incidence of root resorption.

Keywords: Root resorption, CBCT, Aligners, Volumetric, Laser

INTRODUCTION

In the orthodontic office, external apical root resorption (EARR) is a prevalent idiopathic and unpredictable occurrence. it is described as an irreversible root structure loss including cementum and dentin surrounding pressures zones caused by orthodontic forces.[1] EARR most commonly affects the roots of the upper anterior teeth, but it can affect any tooth.[2] Because of diversity of the study designs and measuring and assessment methodologies, prevalence estimates for EARR vary substantially.[3] The percentage of teeth that resorb as a result of orthodontic stresses varies from one to 100%.[4] on the other hand, the estimations of sever root resorption are more conservative ranging from 4 to 14%.[5] EARR's clinical effects are frequently insignificant in terms of the health and durability of the affected teeth.[6] Severe resorption, on the other hand, if left undiagnosed and untreated, can result in issues such as increased mobility, early discontinuation of therapy, and possibly may jeopardize the longevity of the severely resorbed teeth if accompanied with periodontal bone loss.[7]

The aetiology of EARR is complex, and it is frequently divided into two groups: Factors of the patient and treatment-related factors. Age, gender, dental anomalies, genetics, and past trauma have all been postulated in the literature as potential patient-related risk factors for EARR.[8-12] EARR has been linked to a variety of treatment-related factors. Such as mechanical variables including continuous vs. dissipating forces, intrusion and extrusion, overjet reduction, apical displacement, torque changes, force level, and time of treatment.[13-18]

Aside from the mechanical and time-related factors, different appliances have varying impacts on EARR. Since the early days of EARR observation, its prevalence has been linked to the type of appliance and technique used.[19] Since then, several researches have been conducted to study the impact of various fixed and removable appliances on the prevalence of EARR. Despite the fact that numerous studies have revealed that no difference in the amount of EARR between various appliances and techniques, there are some exceptions.[20-23] There is also some contradictory evidence about the influence of clear aligners on the amount of EARR. Some studies have found minimal or no EARR with aligners[24,25]. on the other hand, other studies found no difference in the amount of EARR between conventional treatment and clear aligner therapy.[26]

Because root resorption is a complicated, three-dimensional phenomenon, many traditional imaging techniques are prone to errors, which may explain for some of the contradictory results in the literature. Resorption has been discovered in studies on extracted teeth where it was previously undetectable on two-dimensional radiography.[27-29] While in vitro procedures like histology, scanning electron microscopy, and micro-CT are extremely precise, they are not applicable clinically.[30]

Modern imaging methods, such as cone beam computed tomography (CBCT), have improved practitioners' ability to visualize the amount and morphology of EARR from any angle and without the requirement for superimposition. Due to the greater radiation dosage, practitioners were previously hesitant to use CBCT for regular imaging. While the radiation dosage for CBCT is greater than that of a panoramic or cephalometric radiograph, CBCT dose is being reduced due to technological advancements.[31] In fact, when supplementary images, such as a full mouth series for a patient with periodontal disease, are included, a CBCT image may minimise the overall dosage.[31] Furthermore, periapical, panoramic, and cephalometric radiography are all prone to magnification error and unreliable reproducibility.[32] It has been demonstrated that panoramic radiography overestimates the amount of EARR by up to 20%[33]. while minor changes in the angulation of periapical images might affect perceived EARR[34,35]. CBCT, on the other hand, gives more accurate three-dimensional information on EARR, as previously mentioned.

Upon the previous literature several articles compared between root resorption incidence using clear aligner appliances versus fixed appliances, by measuring root length most of them revealed that aligner therapy showed less root resorption, on the other hand some articles showed no difference between both appliances.

However, no one measured the root volume in comparison between the two systems; aligner versus fixed, so the present study conducted to compare root volume using the two system and inspect the amount of root resorption volumetrically.

SUBJECTS AND METHODS

Study design: A prospective clinical study.

Study setting and population:

The current study was conducted on 30 adult orthodontic patients All patients were received treatment at the outpatient clinic at Orthodontic Department, Faculty of dental medicine, Boys, Al-Azhar University, Cairo, Egypt. The study was approved from the ethics committee for dental research in Al-Azhar university, faculty of dental medicine (Boys, Cairo). And clinical trial protocol No. 357/1150 Date: 19-02-2020, clinical trial gov ID number: NCT05232318.

Inclusion criteria

1. Age ranges from 12 to 18 years old.
2. Healthy systemic condition/no systemic illness, as reported by patients.
3. No use any form of anti – inflammatory drugs the at beginning of study.
4. Good oral hygiene.
5. Cooperative and motivated.
6. In the permanent dentition with all teeth present (except third molars).
7. Minimum to moderate anterior crowding.
8. No previous orthodontic treatment.

Exclusion criteria

1. Previous orthodontic treatment.
2. Patients who required surgery to correct skeletal discrepancies.

3. Patients with hyperdontia, hypodontia, or syndromic diseases (e.g. cleft lip and palate).
4. Uncooperative patients.
5. Patients with poor oral hygiene.

Patient division

The current study was conducted on 30 adult orthodontic patients which was divided into three groups:

group A (Fixed orthodontic appliance group): 10 patients treated by conventional fixed orthodontic appliance.
group B (Clear aligner group): 10 patients treated with removable clear aligner.

C (Clear aligner with laser group): 10 patients treated with removable clear aligner with application of low-level laser.

Pretreatment and posttreatment records were taken for each patient in the study including extra-oral and intra-oral photographs, diagnostic study casts, Lateral cephalometric radiograph and cone beam computed tomography CBCT.

Root resorption measurement

Data from CBCT scans were obtained, just before treatment (T1) and 6 months later (T2). Mimics software (version 18, Materialise, Leuven, Belgium) was used to reconstruct the roots in 3D. After CBCT being imported, the nearest threshold to root segmentation of the lower incisors was chosen taking in consideration that the same threshold values are typically used in the in the post operative CBCT (Fig. 1). Further manual segmentation was done to ensure complete isolation of the lower incisors from the surrounding bone and teeth (Fig. 2). After isolation, the lower incisors are converted to 3D model where each tooth was separated from its adjacent one from one hand and each tooth was decapitated at it cementoenamel junction from the other hand leading to isolated root model of each tooth (Fig. 3). Then volume measured in mm^3.[36]

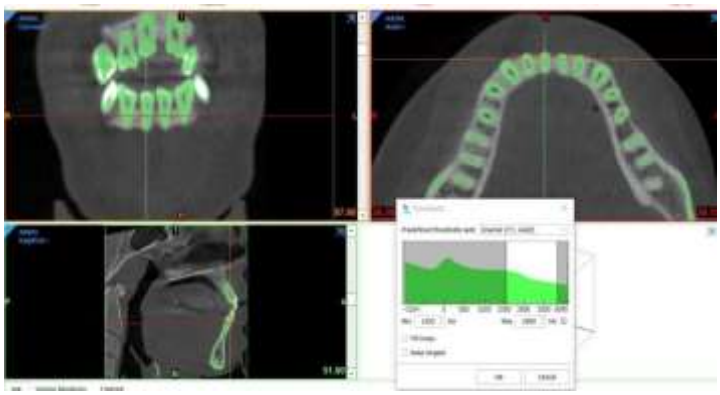

Figure (1) choosing the nearest threshold of the lower incisors.

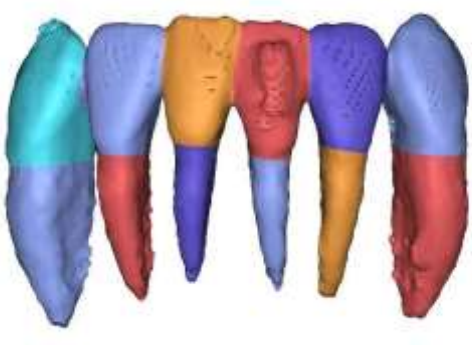

Figure (2) manual segmentation for isolation of the lower incisors from the surrounding bone and teeth

Figure (3) measuring the volume of the isolated roots of the lower incisors separately.

Statistical analysis

Data management and statistical analysis were performed using the Statistical Package for Social Sciences (SPSS) version 20. Numerical data were summarized using mean, standard deviation, median and range. Data were explored for normality by checking the data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests.

Comparisons between groups with respect to normally distributed numeric variables was performed using one way analysis of variance (ANOVA) test followed by Bonferroni's post hoc test, while Kruskal Wallis was used for comparing g the difference (root resorption) between groups. Paired t test was used to compare the pre and post values.

All p-values are two-sided. P-values ≤0.05 were considered significant.

Results

Normality test for LR1 and LL1

Tests of Normality

	Groups	**Kolmogorov-Smirnov[a]**				**Shapiro -Wilk**	
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
LR1.pre	Group 1 "Fixed appliance"	.193	9	.200*	.945	9	.639
	Group 2 "Aligner without laser"	.159	10	.200*	.949	10	.655
	Group 3 "Aligner with laser"	.178	10	.200*	.936	10	.508
LR1.post		.192	9		.930	9	.483

	Group 1 "Fixed appliance"	.145	10	.200*	.959	10	.778
	Group 2 "Aligner without laser"	.171	10	.200*	.932	10	.471
	Group 3 "Aligner with laser"			.200*			
LR1.difference	Group 1 "Fixed appliance"	.283	9	.036	.790	9	.016
	Group 2 "Aligner without laser"	.193	10	.200*	.933	10	.480
	Group 3 "Aligner with laser"	.163	10	.200*	.919	10	.353
LL1.pre	Group 1 "Fixed appliance"	.201	9	.200*	.959	9	.786
	Group 2 "Aligner without laser"	.233	10	.133	.868	10	.096
	Group 3 "Aligner with laser"	.148	10	.200*	.913	10	.299
LL1.post	Group 1 "Fixed appliance"	.156	9	.200*	.939	9	.568
	Group 2 "Aligner without laser"	.164	10	.200*	.937	10	.518
	Group 3 "Aligner with laser"	.185	10	.200*	.939	10	.543
LL1.difference	Group 1 "Fixed appliance"	.310	9	.013	.695	9	.001
	Group 2 "Aligner without laser"	.260	10	.055	.839	10	.043
	Group 3 "Aligner with laser"	.174	10	.200*	.952	10	.691

Normality test for LR2 and LL2

Tests of Normality

	Groups	**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
LR2.pre	Group 1 "Fixed appliance"	.169	9	.200*	.927	9	.451
	Group 2 "Aligner without laser"	.205	10	.200*	.907	10	.263
		.173	10	.200*	.923	10	.382

	Group 3 "Aligner with laser"						
LR2.post	Group 1 "Fixed appliance"	.133	9	.200*	.935	9	.529
	Group 2 "Aligner without laser"	.214	10	.200* .161	.904	10	.245
	Group 3 "Aligner with laser"	.226	10		.903	10	.236
LR2.difference	Group 1 "Fixed appliance"	.176	9	.200*	.910	9	.314
	Group 2 "Aligner without laser"	.265	10	.046	.841	10	.045
	Group 3 "Aligner with laser"	.185	10	.200*	.905	10	.249
LL2.Pre	Group 1 "Fixed appliance"	.185	9	.200*	.926	9	.442
	Group 2 "Aligner without laser"	.288	10	.019	.818	10	.024
	Group 3 "Aligner with laser"	.282	10	.023	.862	10	.081
LL2.post	Group 1 "Fixed appliance"	.218	9	.200*	.866	9	.111
	Group 2 "Aligner without laser"	.252	10	.073	.883	10	.141
	Group 3 "Aligner with laser"	.262	10	.051	.840	10	.044
LL2.difference	Group 1 "Fixed appliance"	.290	9	.028	.685	9	.001
	Group 2 "Aligner without laser"	.311	10	.007	.846	10	.051
	Group 3 "Aligner with laser"	.204	10	.200*	.919	10	.351

*significant difference means non-parametric (non-normal distribution).

Normality test for LR3V and LL3V

Tests of Normality

	Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
LR3V.pre	Group 1 "Fixed appliance"	.204	9	.200*	.910	9	.315
	Group 2 "Aligner without laser"	.129	10	.200*	.988	10	.993
	Group 3 "Aligner with laser"	.140	10	.200*	.979	10	.962
LR3V.post	Group 1 "Fixed appliance"	.168	9	.200*	.935	9	.528
	Group 2 "Aligner without laser"	.140	10	.200*	.968	10	.868
	Group 3 "Aligner with laser"	.169	10	.200*	.968	10	.868
LR3V.difference	Group 1 "Fixed appliance"	.232	9	.175	.811	9	.027
	Group 2 "Aligner without laser"	.225	10	.164	.897	10	.204
	Group 3 "Aligner with laser"	.278	10	.027	.843	10	.048
LL3V.pre	Group 1 "Fixed appliance"	.148	9	.200*	.949	9	.683
	Group 2 "Aligner without laser"	.159	10	.200* .187	.944	10	.604
	Group 3 "Aligner with laser"	.220	10		.945	10	.607
LL3V.post	Group 1 "Fixed appliance"	.212	9	.200*	.901	9	.256
	Group 2 "Aligner without laser"	.204	10	.200* .127	.911	10	.286
	Group 3 "Aligner with laser"	.234	10		.923	10	.383
LL3V.difference	Group 1 "Fixed appliance"	.184	9	.200*	.938	9	.557
	Group 2 "Aligner without laser"	.179	10	.200* .000	.915	10	.319
	Group 3 "Aligner with laser"	.412	10		.647	10	.000

*significant difference means non-parametric (non-normal distribution).

LR1

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 2 (Aligner without laser) (-6.2±2.94; median -6.5) value, followed by group 1(Fixed appliance) (-5.5±4.97; median -3.5), then Group 3 (Aligner with laser) (-5.3±2; median -5). The difference between groups was not statistically significant (p=0.530).

LL1

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 2 (Aligner without laser) (-4.3±1.95; median -6.5) value, followed by Group 3 (Aligner with laser) (-3.9±1.2; median -4) and group 1(Fixed appliance) (-3.9±3.87; median -1.5). The difference between groups was not statistically significant (p=0.413).

LR2

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 1(Fixed appliance) (-4.4±3.24; median -3.5) value, followed by group 3 (Aligner with laser) (-3.3±1.42; median -3), then Group 2 (Aligner without laser) (-3.3±1.23; median -3). The difference between groups was not statistically significant (p=0.90).

LL2

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 1(Fixed appliance) (-9.3±10.59; median -4.5); followed by Group 2 (Aligner without laser) (-4.3±1.06; median -4) value, then group 3 (Aligner with laser) (-3.4±1.65; median -3). The difference between groups was not statistically significant (p=0.312).

LR3

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 1(Fixed appliance) (-6±2.31; median 5) value, followed by group 2 (Aligner without laser) (-4.4±1.71; median -4), then Group 3 (Aligner with laser) (-4.1±2.38; median -3). The difference between groups was not statistically significant (p=0.106).

LL3

Comparing the groups regarding the difference (resorption) value revealed that the highest value was recorded in the Group 1(Fixed appliance) (-5.2±2.49; median -5.5); followed by Group 3(Aligner with laser) (-4.6±1.07; median -4) value, then group 2 (Aligner without laser) (-3.7±2.21; median -3.5). The difference between groups was not statistically significant (p=0.296).

Discussion

The current study was conducted on 30 adult orthodontic patients which was divided into three groups, group A (Fixed orthodontic appliance group), group B (Clear aligner group) and group C (Clear aligner with laser group). All patients were selected according to the following criteria and received treatment at the outpatient clinic at Orthodontic Department, Faculty of dental medicine, Boys, Al-Azhar University, Cairo, Egypt.

Upon the previous literature several articles compared between root resorption incidence using clear aligner appliances versus fixed appliances, by measuring root length most of them revealed that aligner therapy showed less root resorption[37-44], on the other hand some articles showed no difference between both appliances.

However, no one measured the root volume in comparison between the two systems; aligner versus fixed, so the present study conducted to compare root volume using the two system and inspect the amount of root resorption volumetrically.

The laser group's patients received LLLT from a semiconductor galliumaluminum-arsenide diode laser (Fig. 12), operated in a continuous mode, 635 nm wavelength, 6.5J/cm^2 energy density, for 10 sec per point, at total 10 points. A total dose of 2J (2 × 50 sec × 20 mw) was applied to each tooth of the lower four incisors teeth. as described in several studies[45-48]

The laser beam was applied immediately after clear aligner delivery then at days 7, 14. This protocol was repeated every 2 weeks after clear aligner replacement.

The LLLT was applied to a previously dried mucosa overlying labial and lingual aspects of the roots. For each exposure, the tip was held perpendicular to the mucosa and in contact with it for 10 seconds during laser application. The standard procedure of sterilization and disinfection was followed. Cold sterilization was used to sanitize the hand piece body and optic tips in particular.[48]

The result showed that only the lower central incisors in clear aligner group without laser revealed more root than that fixed appliance group and aligner with laser group, this is the only teeth that showed these results, which is might be related to the presence of attachment on those teeth. However, the difference between group were not statistically significant

In accordance to the lower laterals and canine, the amount of root resorptions were more in fixed appliance group than the aligner groups whether they are with laser or not.

After comparing the aligner groups whether with laser or not, the results showed no significant difference between the groups.

Conclusion

1. Aligners therapy is very effective in treating orthodontic patients in cases of mild to moderate crowding.
2. Root resorption accompanied with aligners is considered less than fixed appliances however the difference is not significant.
3. The use of laser has no effect on reducing or minimizing the incidence of root resorption.

Recommendation

Further study must be applied for more sample size and comparison of upper teeth both anteriorly and posteriorly.

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