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Assessment of external apical root resorption following En-masse and two steps retraction in maxillary protrusion cases: A randomized controlled clinical trial

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Assessment of external apical root resorption following En-masse and two steps retraction in maxillary protrusion cases: A randomized controlled clinical trial

Abstract

Aim: The aim of this study was to investigate the degree of external apical root resorption (EARR) following En-masse retraction (EM) and compared it to two steps retraction technique (TS) using friction mechanics.

Materials and Methods: Thirty adult female with maxillary protrusion were randomly allocated by a computer sequence generator with 1:1 allocation ratio. EM group (mean age = 17.7 ± 1.89 years) and TS group (mean age = 17.7 ± 1.77 years). Mini-screws were inserted followed by first premolars extraction then randomization was accomplished. Patients received treatment with either EM procedure or TS to close the extraction spaces after alignment and leveling with the same pre-adjusted fixed appliances. Pre- and post treatment CBCT images of both groups was used to evaluate the EARR from (T0) start of retraction till end of space closure (T1).

Results: The data of 20 patients (10 in EM group and 10 in TS group) were analyzed. EARR was detected in both groups with more root resorption in EM group by total average decrease in root length by -1.14 mm while in TS group by -0.66 mm as an average decrease in root length.

Conclusion: The difference in EARR between the study groups was statistically significant. The highest RR values were found in TS group to be -1.01 mm in upper left central (UL1), while the greatest RR in EM group to be -1.5 mm in upper left canine (UL3).

Key words: Root resorption, En-masse retraction, two step retraction, Maxillary protrusion, Mini-screw and power chain.

Introduction

The most frequent iatrogenic unpredictable adverse effect of orthodontic treatment is the external apical root resorption (EARR), which can be seen on standard radiographs(1),(2). About 90% of orthodontic patients experienced root resorption but in most cases it was insignificant (3). Root shortening is usually the most evident manifestation of EARR on routine panoramic radiographs. Maxillary and mandibular incisors, especially the maxillary incisors, are most susceptible to EARR (4). The aetiology of EARR is complex and multi-factorial (5). Patients complaining from dentoalveolar protrusion were found to have an increase in the upper and the lower incisors inclination. To treat this condition, extraction of first premolars and retraction of the anterior teeth is considered the more popular option to improve esthetics and lips competence (6). Space closure is a tough process in orthodontics, as it requires a long duration and strong basis of biomechanics in order to close a space efficiently with minimal unwanted side effects(4). It can be done with either En-masse or two steps techniques.

However, predicting the difficulties involved in the way teeth respond to the forces and moments isn't an easy challenge to many orthodontists. Moreover, sliding mechanics is widely used due to its simplicity, but it might lead to root resorption, uncontrolled tipping or rotation of the anterior teeth (5). The decrease in tooth length was claimed to occur during torque force application but it was detected during the early stages of leveling and alignment (7).

The aim of this study is to compare the effect of En-masse and two steps retraction techniques on the external root resorption using friction mechanics in adult patients. The null hypothesis assumed was that there would be no difference in root length using both space closure techniques.

Materials and Methods

Trial design, Participants, eligibility criteria, and settings

Thirty adult female patients with maxillary protrusion (a mean age of 17.7 ± 1.89 years and 17.7 ± 1.77 years for EM and TS groups respectively) were randomized in a 1:1 allocation ratio (10 patients in each group). The inclusion criteria were, no evidence of resorption on the pretreatment panoramic radiographs; no history of dental trauma; no dilacerations of incisor roots, anodontia, or impacted canines; complete root formation at the start of treatment; intact and caries-free anteriors; no endodontically treated six anteriors; extraction of first premolars; and space closure with maximum anchorage. Meanwhile, patients with badly decayed teeth (excluding the 1st premolars), poor oral hygiene, uncontrolled periodontal disease, previous orthodontic treatment, parafunctional habits, craniofacial syndromes or systemic diseases affecting the tooth movement were excluded from the current study. All selected participants had similar dental and skeletal characteristics (Table 1).

Mini-screws (8- by 1.6-mm, bracket head design; Dual Top Anchor System, Jeil Medical Corporation, Seoul, Korea) were inserted at the level of the mucogingival junction in the inter-radicular region between the maxillary second premolars and first molars bilaterally in each quadrant. Banding the first molar and bonding of conventional 0.022- inch slot, Roth prescription brackets (American Orthodontics, Sheboygan, Wis) was done to all teeth except maxillary first premolars. The second premolars brackets were ligated to the mini-screws using 0.009-inch ligature wire before extraction to ensure proper anchorage. The mini-screws were checked for stability at each visit and replaced immediately nearby area at same height if necessary. Afterwards, maxillary first premolars were extracted followed by leveling and alignment which was done by following the common sequence of wires: 0.014 NiTi, 0.016 NiTi, 0.016 × 0.022 NiTi wires and 0.017 × 0.025 stain-less steel (SS) wires.

Intervention

In En-masse group, the six anterior teeth were ligated together and retraction started by activation of an elastomeric chain (American orthodontics short power chain, USA) from the mini-screw head to an 8 mm hook (variable crimpable hook, Dentos, korea) crimped distal to lateral incisors on 0.017- by 0.025- inch stainless steel (SS) wire, by rendering a retraction force of 200g/side calibrated by Morelli orthodontic tensiometer (Morelli Orthodontics, Brazil, 50-500gr).

While in two steps group, the canines were initially retracted on 0.017- by 0.025- inch (SS) wire by using elastomeric chain delivering force of 150g/side for full canine retraction. then the four anterior teeth were retracted on the same wire by the power chain which was extended from the mini-screw head to an 8 mm hook (variable crimpable hook, Dentos, Korea) crimped distal to lateral incisors by retraction force of 160g/side calibrated by Morelli orthodontic tensiometer (Morelli Orthodontics, Brazil, 50-500gr). Patients were asked to attend for follow-up visits every 4 weeks for reactivation by replacement of the power chain and the force was calibrated using Morelli orthodontic tensiometer and evaluation of the stability of mini-screw.

Pre- and post CBCT was collected from the T0 at start of the retraction till the T1 the end of space closure and the apex and centroid point are located on the CBCT.

Measurements and analysis of this study were carried out by two blinded assessors at different time points. Consent was obtained from the patients before their recruitment. Approval of the college ethics committee (FUE.ESTHECIS (23)/11-2019) was obtained before embarking on the treatment.

Sample size calculation

Sample size calculation was done based on previous study by(Dincer *et al.* (8)) using PS software output. A continuous response variable from independent EM and TS subjects was planned. In the previous study, the response within each subject group was normally distributed with standard deviation 0.76. If the true difference in the EM and TS means is 1.0, we needed to study 10 subjects for EM and 10 subjects for TS to be able to reject the null hypothesis. The population means of the EM and TS are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05. Considering drop out a sample size of 15 per group was planned.

Randomization

Patients were randomly allocated into En-masse group and two steps group using computer-generated random sequence by Microsoft Office Excel Mac (version 16.24; Microsoft, Redmond, Wash.) with allocation ratio 1:1. The randomization was done before the start of intervention. Each number from the generated sequence (from 1 to 30) was put in an opaque sealed envelope and all envelopes were placed in a closed box. After completion of the leveling and alignment, each patient was requested to choose one envelope. According to the number in the envelope, the patient was then allocated into one of the two groups. The randomization and allocation steps were carried out by the clinic instructor who was not a part of the study.

Blinding

It was not possible to mask either patient or operator. On the other hand, it was a single blinded study; only outcome assessors were blinded to the intervention. The patients' names were removed and replaced by numbers from pre-and post-treatment records and study models. Then, two assessors carried on, blindly and independently, the measurements and analysis of the study.

Statistical analysis

Data was statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies (number of cases) and percentages when appropriate. Comparison between the study groups was done using Mann Whitney *U* test for independent samples. Within group comparison was done using Wilcoxon signedrank test for paired (matched) samples. Two-sided *p* values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22for Microsoft Windows.

Results

Participant flow

The study took place over 22 months from November 2019 to January 2021. (Figure 1) explained that initially, 50 patients were recruited, but 20 did not comply. 14 of the 20 did not follow the inclusion criteria, and six refuse to participate. These 20 patients were excluded from the study. The 30 participating patients went through the study, 15 in each group were randomly allocated to receive En-masse and two steps retraction. Of the 30 patients, there were ten patients considered dropouts since they did not attend the follow-up appointments, making a final total of 20 subjects. The Baseline characteristics were similar for both groups, with no statistically significant differences (Table 1).

The difference in EARR between the study groups was statistically significant, with high average records in En-masse group by total decrease in root length by -1.14 mm while in two steps group the total average decrease in root length by -0.66 mm (Table2), (figure2).

The most affected tooth with highest EARR values in En-masse group was the upper left canine (UL3) by 1.5 mm (figure3) while in two step group was upper left central (UL1) by 1.01 mm (figure4). The analysis of the difference in the root resorption between the two treatment groups, in millimeters by linear measurement from the centroid point to the apex on CBCT (figure5, 6& 7).

The results showed statistically insignificant decreased root length pre and post retraction in (UR2), (UR1) and (UL1) (Table2).

Discussion

In this randomized clinical trial the effect of retraction techniques either En-masse or two steps was comparatively evaluated to detect the root length shortening. Many factors were predisposing risk factors to external apical root resorption. General factors include age (9), gender(9), genetic (2) and individual variation (10). Local risk factors were related to individual variation such as previously traumatized teeth(11) , habit as bruxism, different root form such as pipette, blunt, or dilacerated roots, impacted teeth proximity to root apex (9) as well as the malocclusion classification. In order to eliminate these factors adult female patients were recruited and the patient's baseline was statistically insignificant. The degree of root resorption was affected by orthodontic treatment mechanics (12)duration (13) in addition to the force magnitude (9) applied. Accordingly all factors are standardized except the technique of retraction and the retraction force for each technique.

CBCT radiograph offered more details and better anatomical structure localization and identification, in addition to more accuracy in angular and linear measurements(14), (15). El-Beialy *et al.*(16) reported that the CBCT measurements are considered a reliable technique that can be utilized for assessment of both linear and angular measurements.

McNamara *et al* (17) concluded that CBCT craniometric measurements are accurate to a subvoxel size and potentially can be used as a quantitative orthodontic diagnostic tool. Although the choice of age group of adult patient was ethical to avoid the risk of radiation ionizationation according to the American Academy of Oral and Maxillofacial Radiology. The decrease in root length was recorded in the six anterior teeth, CBCT was the best tool to provide accurate measurements according to previous studies (18), (19),(20). In this study root resorption measurement was done by measuring linear distance from centroid point as a stable reference point to the apex of the tooth. The choice of the centroid rather than the incisal edge was to avoid the burn-out of enamel in CBCT and for better accurate results. Ren *et al*. (21) compared the diagnostic accuracy between CBCT and periapical radiograph for detecting external apical root resorption and it was concluded that CBCT is a reliable diagnostic for external root resorption, while the panoramic radiographs underestimates it(19). Centroid point, which is a midpoint between incisal edge and root apex, was chosen as a landmark for assessment of both root resorption and vertical position relative root apex and palatal plane respectively. This was proved by Sosly *et al.*(22).

Additionally, Castro *et al.*(18) concluded that minimal degrees of EARR due to orthodontic treatment can be detected by CBCT and three-dimensional evaluation of dental roots can be done. Multiple preceding studies evaluated root resorption associated with teeth retraction using CBCTs (20), while Liou et al.(23) used 2D radiographic method to evaluated root resorption.

Mini-screws were used in this study to provide maximum anchorage to full retraction of anterior segment in both groups.(24) In both groups retraction on 0.017by 0.025inch stainless steel archwire to allow stable retraction. It was reported that root resorption followed the ER was found more with increasing the friction between the working archwire and the brackets, Kalhaet al. (25) used (0.021″ × 0.025) within 0.022” slot brackets while (1) (0.018” × 0.025”) main archwire was used within the same slot size. Conclusively, more root resorption was found in the first study although different teeth were evaluated.

The force delivery system used in the current study offered intermittent manner of force application (26)in both techniques by elastomeric chain similar to Al-Sibaie *et al*. (24) Yan Huang et al(25) reported the use of NiTi coil spring. More investigation is required to analyze which force system is superior and help clinicians to choose the optimal method with less EARR. Regarding to the force magnitude, for En-masse 200 gm force(25), (27). while in Two steps 150 gm was used for canine retraction as recommended by Deguchi *et al* (28). This force of 150gm was recalibrated every 4 weeks using a force gauge(29). After full canine retraction the four incisors are retracted using power chain with force value of 160 gm. near force was applied by Dincer *et al.* (8) and Al-Sebaie *et al.*(30). On the other hand, a 100g force was used by Schneider *et al.* (27) and Gjessing P.(31) The importance of the crimpable hook in controlling the type of anterior tooth movement in sliding mechanics was confirmed by Tominaga *et al*.(32) as they reported that long power arms of 10 to 13 mm are required to achieve controlled movement of the anterior teeth in the 0.022-inch slot which is not clinically applicable. The advantages of this study include the randomized treatment allocation accounting for balanced baseline characteristics between treatment groups and thus a low risk of selection bias. In order to decrease assessor and performance bias one clinician treated all the patients with the same protocol except the technique of retraction and the retraction force was standardized using a gauge.

Previous studies reported that after fixed orthodontic treatment, the average root resorption of maxillary incisors was less than 2 mm(33),(34),(35) which is similar to this study results. Previous systematic review(36) reported significant root shortening associated with En masse technique where the least amount recorded was around 1.4 mm which approximately near to this study results as the in En masse group average root resorption was -1.14 mm while in two steps average of -0.66 mm.

Limitation

Although blinding of the operator was not feasible at the intervention stage, outcome assessment was blind; therefore, the risks of observation and detection biases can be considered low. Additionally, the prospective nature of the study allowed for better examination of the frequency and patterns of failure compared with retrospective studies for which data are likely to be less accurate because the data are often collected from patient files. 10 patients were lost to follow-up due to COVID-19 pandemic period and potential attrition biases were counteracted by analyzing data on an intention-to treat basis, which incorporated missing data imputations. The losses to follow-up highlight a problem associated with randomized controlled trials and, in general, prospective studies with long follow-up periods, and should be seriously considered at the design stage of the trial. The risk of getting infected by COVID-19 was one of the limitations as well.

Conclusion

Based on this randomized trial two steps retraction offered less root resorption in comparison to En-masse group. This may be due to difference in force magnitude used in both techniques as the force magnitude is directly proportion to EARR. Both techniques achieve space closure effectively. In En-masse group, upper left canine and upper left lateral showed the higher root resorption records while upper left central and upper left canine showed the more tooth length shortening in two steps group. The upper left quadrant was more affected by EARR in both techniques.

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Tables and figures:

Table 1: Baseline and clinical characteristics between the 2 groups.

	Two steps (n = 10)		**En-Masse (n = 10)**		**Difference**	**p value**
	Mean	**SD**	**Mean**	**SD**		
Age	17.70	1.77	17.70	1.89	0.00	1.000
ANB	3.23	0.97	2.89	1.03	0.34	0.454
SN/Mx plane	10.01	1.38	9.12	1.10	0.89	0.126
SN/Md plane	34.87	2.63	34.21	3.00	0.65	0.610
Mx/Md plane	30.13	1.67	28.98	2.20	1.15	0.205
U1/Mx	118.16	1.94	117.51	2.29	0.64	0.506
L1/Md	104.34	3.02	103.77	3.03	0.57	0.678
U1/L1	109.39	3.83	110.09	4.37	-0.70	0.709

Significance level $P \leq 0.05$. Data presented in mean (M) and standard deviation (SD)

Table 2: Mean and SD of EARR of six anterior pre and post in En-masse and two steps groups.

External apical Root Resorption	**Two steps (n = 10)**	**En Masse (n = 10)**	**Difference**	**p value**

	Pre	Post	Diff	p value	Pre	Post	Diff	p value		
UR3	23.9 (2.9)	23.5 (2.9)	-0.43	0.005*	27.6 (2.1)	26.4 (1.9)	-1.19	0.005*	0.768	0.006*
UR2	11.7 (1.6)	11.2 (1.8)	-0.57	0.047*	13.9 (1.3)	12.8 (1.9)	-1.12	0.005*	0.548	0.226
UR1	11.9 (0.8)	11.2 (1.2)	-0.67	0.005*	13 (1.3)	12 (1.2)	-1.04	0.005*	0.376	0.244
UL1	11.8 (1.3)	10.8 (1.7)	-1.01	0.005*	12.6 (1.7)	11.9 (1.6)	-0.73	0.005*	-0.274	0.326
UL2	11.5 (1.8)	10.9 (2)	-0.55	0.005*	14.1 (1.5)	12.8 (1.5)	-1.22	0.005*	0.676	0.033*
UL3	24 (2.3)	23.3 (2.5)	-0.71	0.005*	27.1 (2)	25.6 (2.1)	-1.50	0.005*	0.787	0.014*
Average	15.8 (1.3)	15.2 (1.6)	-0.66	0.005*	18 (1.5)	16.9 (1.5)	-1.14	0.005*	0.480	0.032*

Significance level $P \leq 0.05$.* Statistically significant (mm), in millimeter.
Data presented in mean (M) and standard deviation (SD)

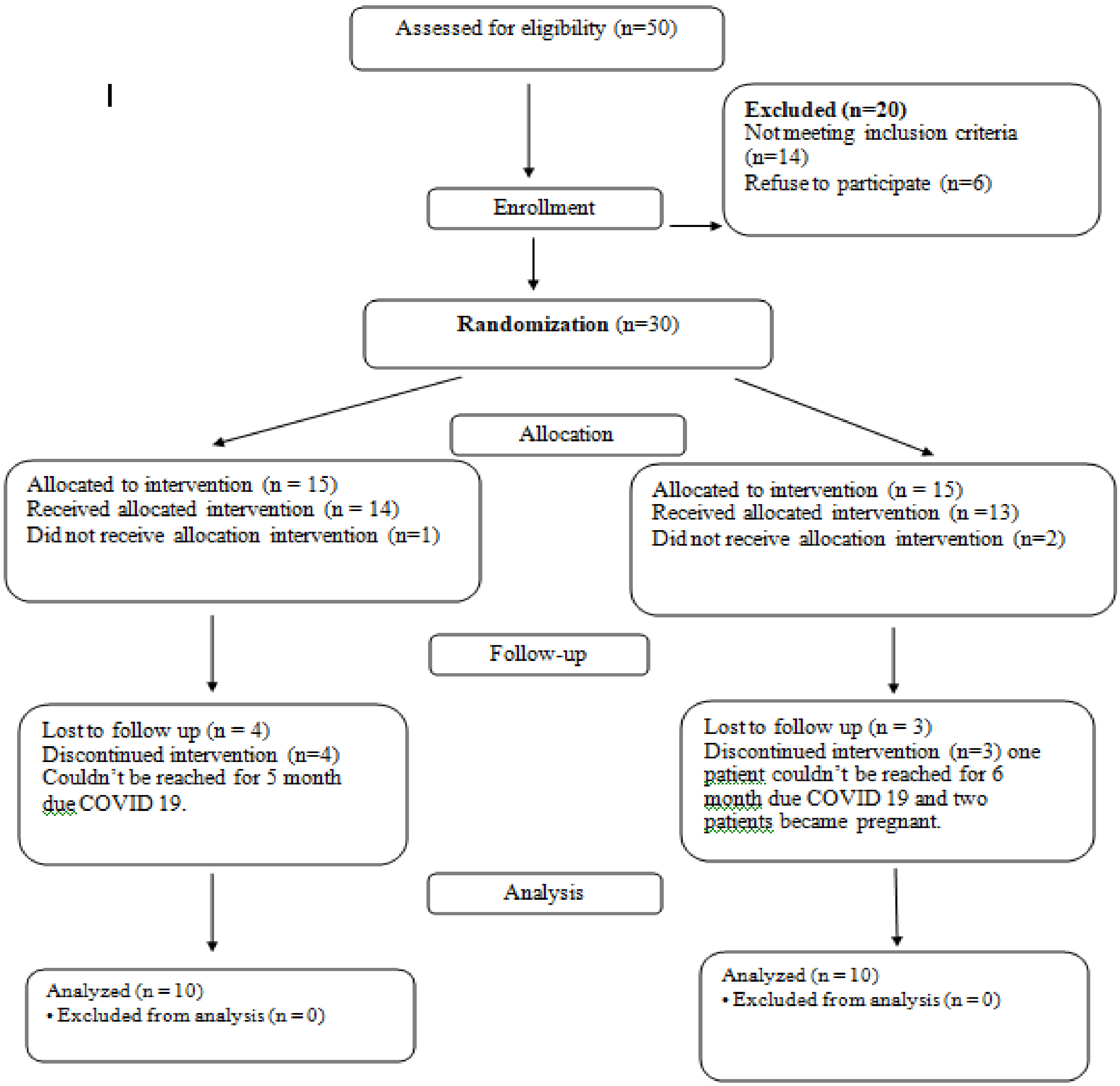


Figure1: CONSORT flow diagram showing patients' flow and drop out during the trial.

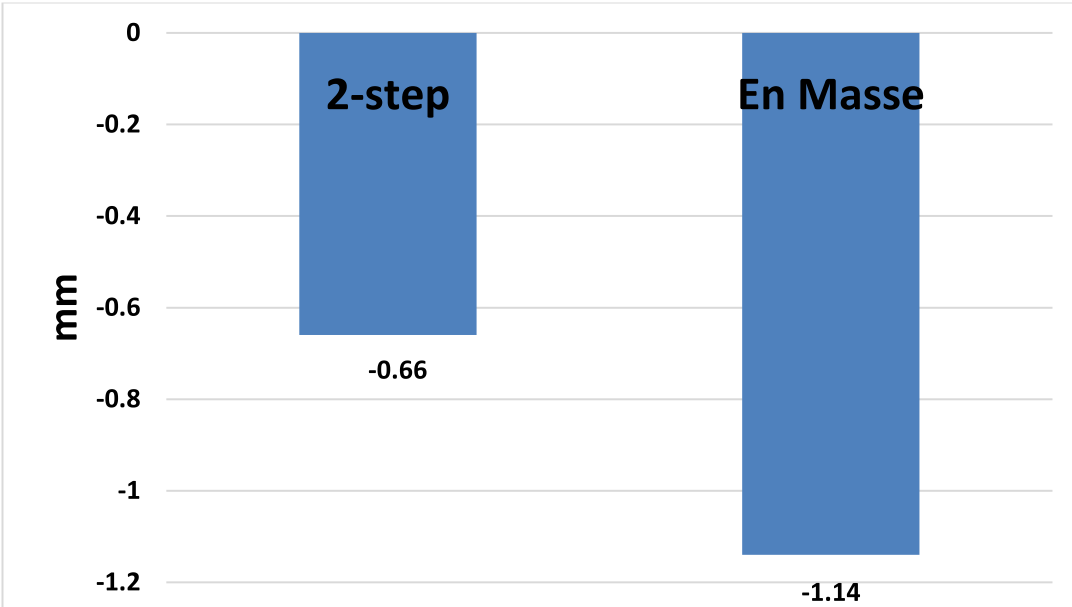


Figure 2: Bar chart showing the mean pre-post change in average root length of all teeth between the two groups (denoting amount of root resorption).

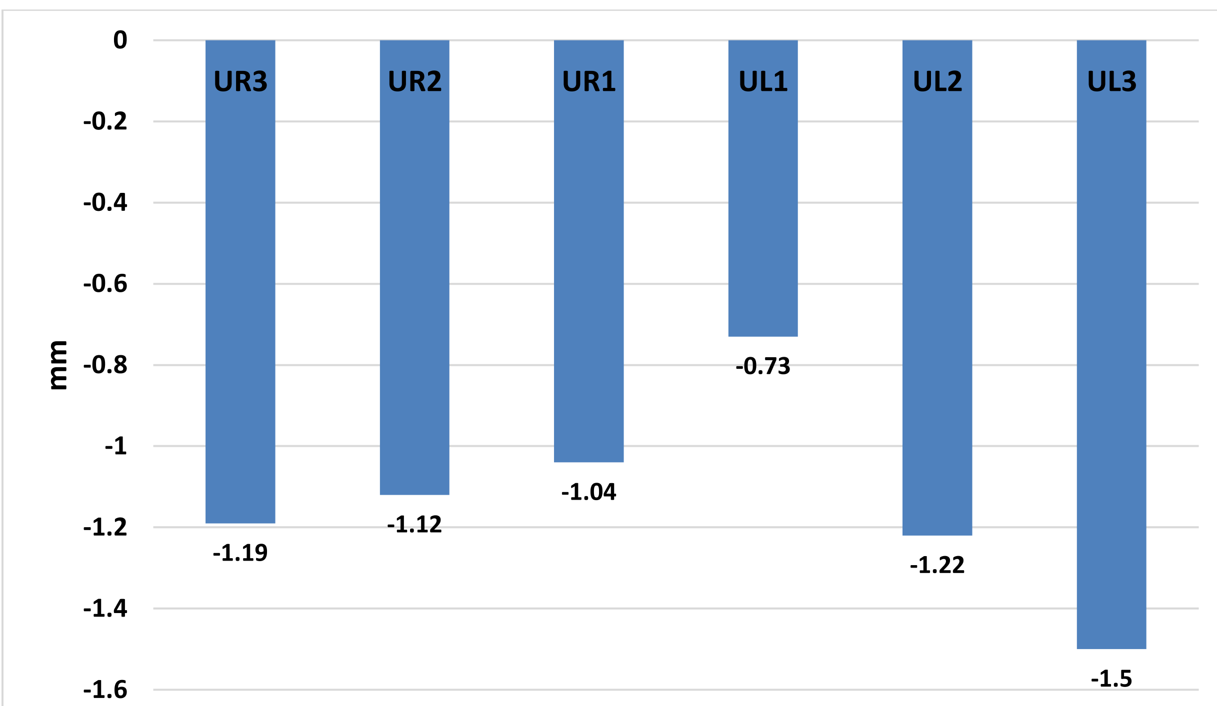


Figure 3: Bar chart showing the mean pre-post change in root length of six anterior teeth in En-masse group.

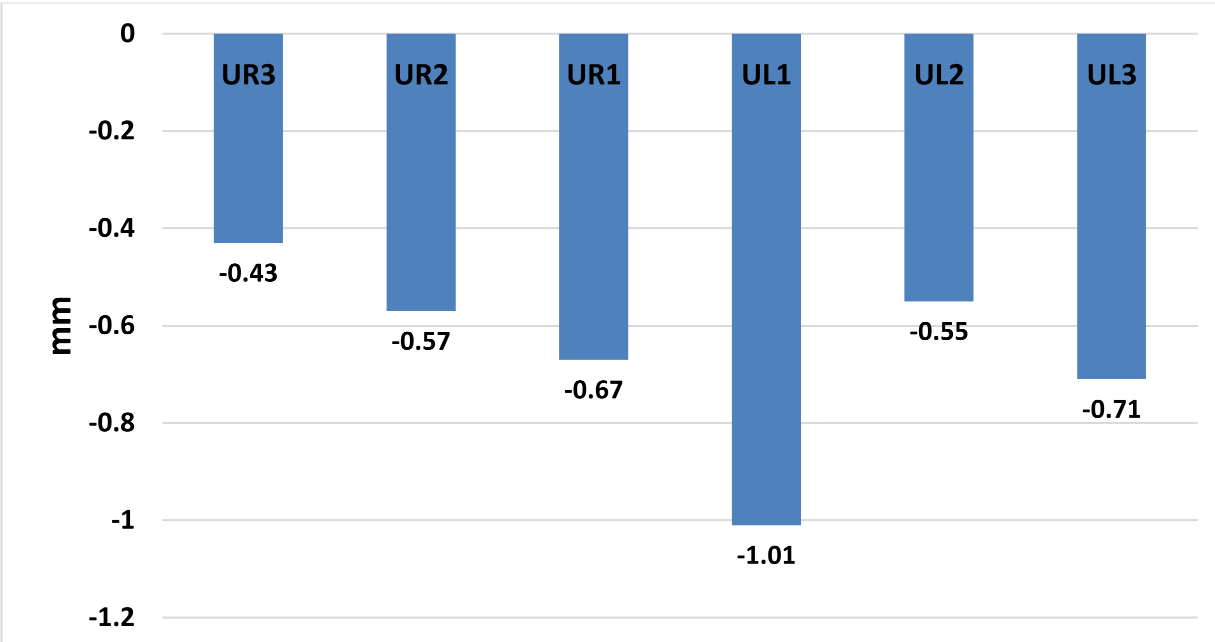


Figure 4: Bar chart showing the mean pre-post change in root length of six anterior teeth in two steps group.

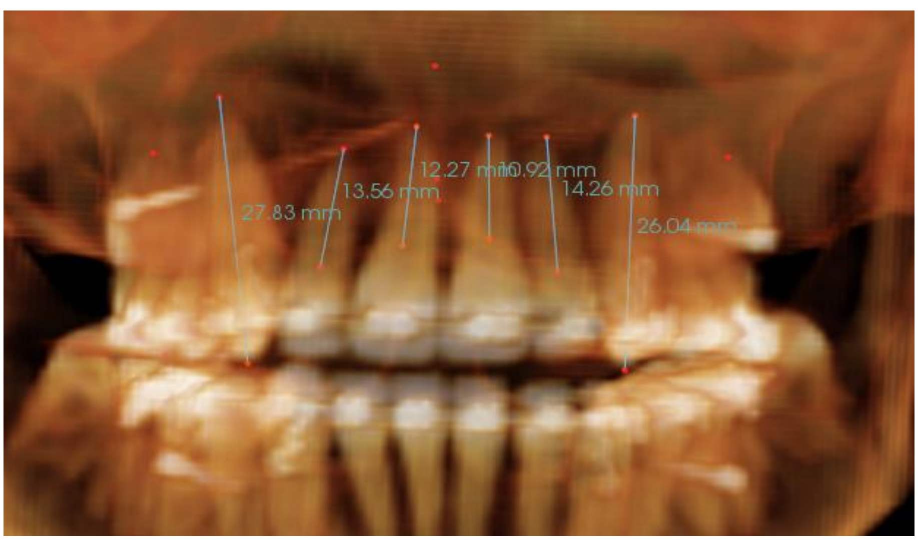
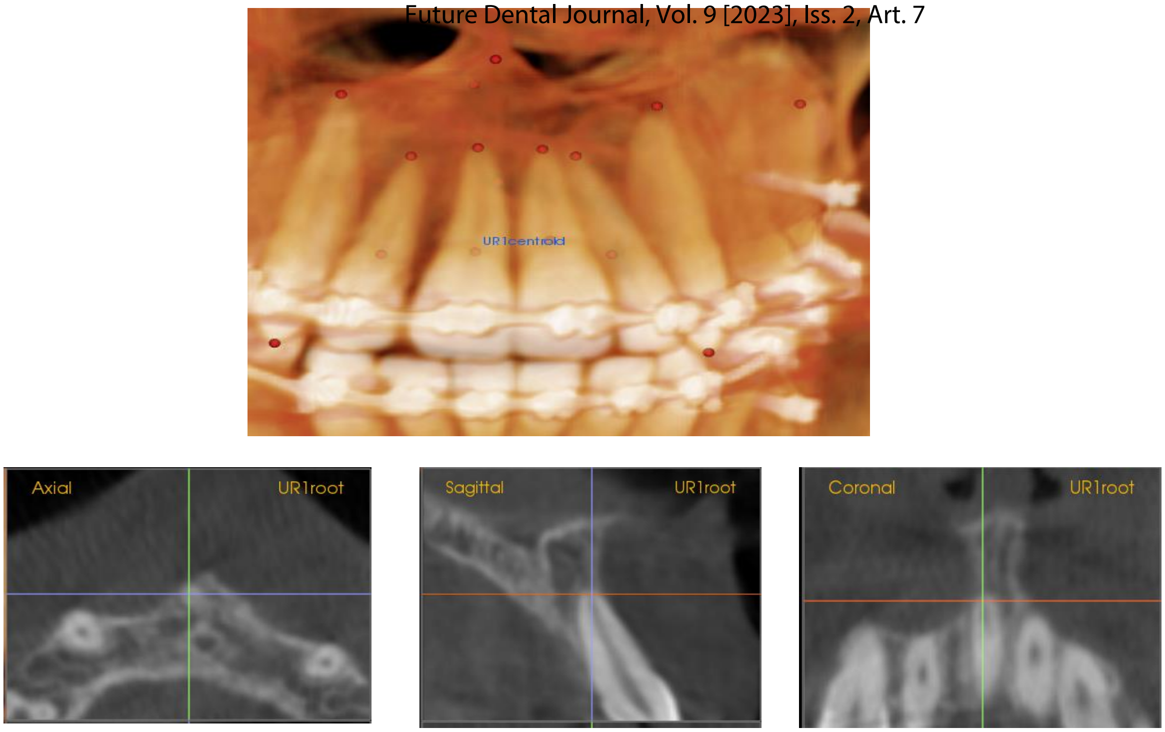
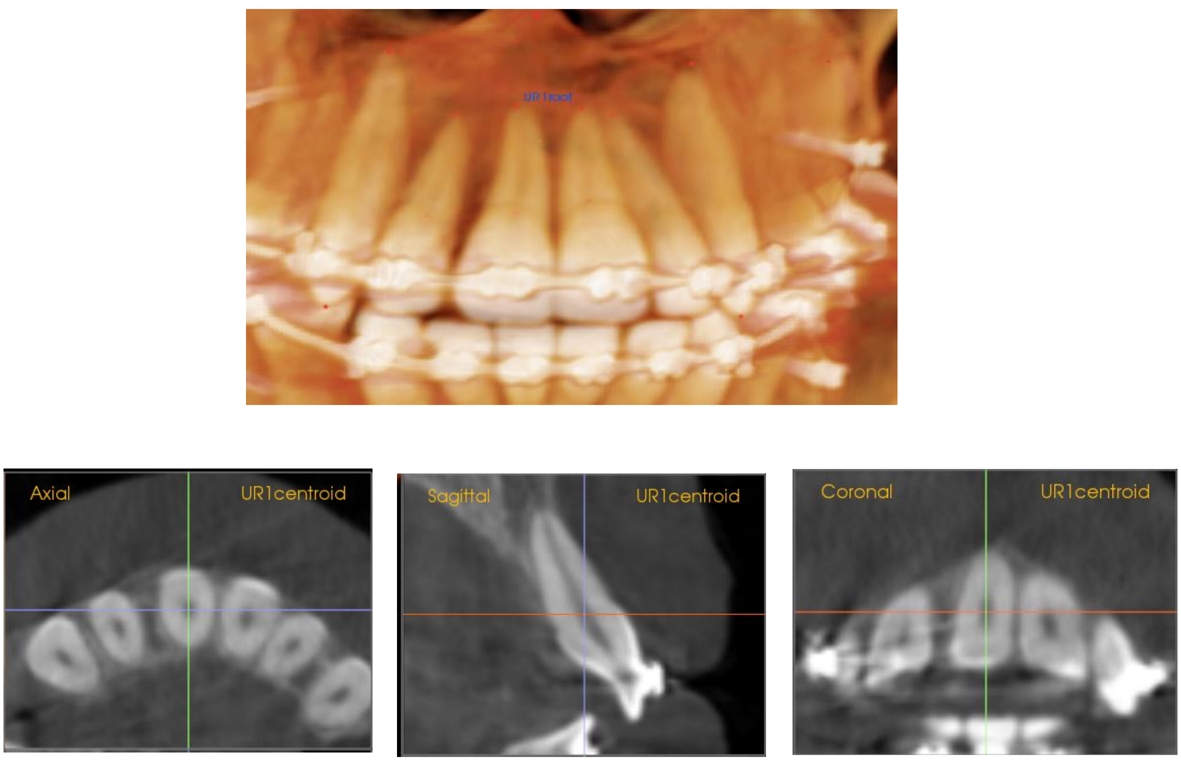


Figure 5: Root resorption measurements of anterior teeth: linear distance between upper right incisor centroid and apex points in mm.



A B C

Figure 6: Apex point on six anterior teeth in CBCT and locating the apex point in all 3 planes of space in CBCT. A, Axial view. B, Sagittal view. C, Coronal view.



A **B** **C**

Figure 7: Centroid point on six anterior teeth in CBCT and locating the centroid point in all 3 planes of space in CBCT. A, Axial view. B, Sagittal view. C, Coronal view.