

Comparative Assessment of External Apical Root Resorption of the Maxillary Anteriors in En Masse Retraction Cases Between Friction and Frictionless Mechanics Using 3-Dimensional CBCT: An *in vivo* Study

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Abstract

Background: To compare the external apical root resorption (EARR) of maxillary anterior teeth during the retraction phase in fixed orthodontic treatment using friction mechanics and frictionless mechanics with en masse retraction. **Materials and Methods:** The sample consists of 14 patients who underwent fixed orthodontic treatment with maxillary first premolar extraction and were categorized into two groups. Group-1 (n = 7) was treated with friction mechanics using a Ni-Ti closed coil spring, and Group-2 (n = 7) was treated with loop mechanics using a Teardrop loop. Cone-beam computed tomography was taken to evaluate root resorption in both groups. A paired t-test and analysis of variance single factor test were performed for overall teeth to know the significance within and between the friction and frictionless mechanic groups. **Results:** Study subjects (n = 14) were evaluated for linear tooth length measurements for root resorption, where a statistically significant difference ($P \leq 0.05$) in mean root resorption was observed in both groups, in Group-1 (1.37 ± 0.48 mm), and Group-2 (1.66 ± 0.50 mm). **Conclusion:** There was a higher EARR seen in frictionless mechanics compared to friction mechanics.

Keywords: Cone-beam computed tomography, Friction mechanics, Frictionless mechanics, Retraction, Root resorption.

INTRODUCTION

External apical root resorption (EARR) is a common side effect in orthodontic treatment. We must know about the causes, effects, and prevention of EARR. Naturally, roots do not reduce unless excessive force compresses the periodontal ligament. The appositional process of root repair normally repairs the resorptive defects of the root. The excessive force causes irreversible root resorption, which results in the shortening of root length.^[1]

Root resorption of the permanent teeth is a complex biologic process among which a lot of statements remain obscure. Recently, due to medico-legal factors, once again, a lot of interest has been generated about apical root resorption (ARR). ARR arises most commonly in the maxillary anterior teeth; increased overjet was also associated with greater root resorption and there was no gender predilection for root resorption of any teeth.^[2]

The two-step retraction is claimed to place less stress on the anchorage but is seen as more complex and time-consuming than en masse retraction. Maxillary anterior teeth are the most displaced teeth during retraction (space closure), making them vulnerable to root resorption. Classically, it has been considered that segmental canine retraction would save posterior anchorage. Canine retraction can be carried out little enough to create space for incisors without flaring them. There is no reason

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to retract the anterior segment in two phases unless crowding is present. In addition, two phases can be unesthetic due to a more anterior spacing, in addition to increasing treatment time.^[3]

Loop mechanics is preferred over sliding mechanics due to the absence of friction. The teardrop loop was the preferred choice among the other loops because of the advantages it has over the other loop designs concerning the anchorage control, intrusive or extrusive movement of the roots, and minimum forward movement of posteriors compared to anterior teeth.^[4,5]

However, it is now a known fact that either of the methods can cause some amount of EARR. Conventional radiographs may have several limitations, such as overestimation or underestimation of root resorption.^[2] However, ARR after orthodontic tooth movement is underestimated when evaluated on an orthopantomogram, and it has been shown to overestimate the amount of tooth loss by 20% or more compared with periapical radiography.^[6]

Recent studies have evaluated the diagnostic values of 3-dimensional imaging methods such as cone-beam computed tomography (CBCT).^[7,8] When compared to periapical radiography, the CBCT approach provides images in all three planes, demonstrating resorption on surfaces that are not observable with traditional radiography. The main advantage of multiplanar reconstructions over traditional radiography is the high degree of accuracy they provide, as they allow for optimum resolution of each tooth irrespective of changes in tooth position that arise during orthodontic treatment. With the advent of CBCT, more detailed and accurate measurements of root resorption in three planes of space are now possible.^[7,8]

To date, there are several arguments for finding the best mechanics with minimum root resorption. This study was planned to compare EARR between friction and frictionless mechanics.

MATERIALS AND METHODS

The present study was done on patients ($n = 14$) who were undergoing orthodontic treatment in a dental institution selected using the convenience sampling method. An informed consent was obtained from the participants before the study. Ethical approval was also obtained from the institutional ethical committee. Participants were selected based on the criteria given below:

Inclusion criteria

- Both male and female patients aged between 18 and 25 years
- Those undergoing fixed orthodontic treatment with maxillary first premolar extraction
- Minimum of 4 mm space remaining after leveling and alignment
- Maximum anchorage preparation cases.

Exclusion criteria

- Endodontically treated maxillary anterior teeth

- No prior history of orthodontic treatment.
- Deep carious lesions
- Those suffering from uncontrolled systemic diseases
- Periodontally compromised patients
- Missing any anterior teeth
- Malformed root.

Participants who fall in the above-mentioned criteria were selected and divided into two groups (Groups 1 and 2).

Group-1 ($n = 7$):

En masse retraction by friction mechanics, using Ni-Ti closed coil spring with maximum anchorage in 0.022×0.028" MBT metal bracket slot using 0.019×0.025" SS working archwire (Figure 1), with a force level of 150 g on each side.

Group-2 ($n = 7$):

En masse retraction by loop mechanics, using a Teardrop loop with maximum anchorage in 0.022×0.028" MBT metal bracket slot using 0.019×0.025" SS working archwire (Figure 2), with biologically acceptable force levels, by activation of loops 1 mm on each side.

En masse retraction with consecutive activations scheduled for every 4–6 weeks till space closure. CBCT for the maxillary anterior segment was taken before the start of space closure (T1) and at the end (T2). A comparison was made between T1 and T2 to evaluate the amount of root resorption. CBCT images were obtained using CS9600 imaging software with a field of view of 5×5 cm; slice thickness of 1 mm; tube voltage of 120 KV; current measured 6.3 Ma; and the exposure time was 10 s.

Parameters for measuring root resorption:

To analyze EARR, the linear length between the incisal edges/



Figure 1: NiTi closed coil spring supported retraction in friction mechanics group

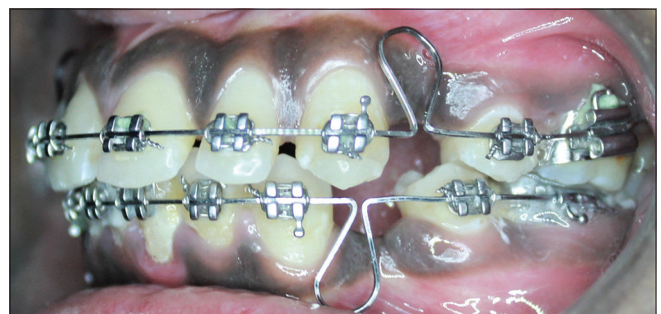


Figure 2: Teardrop loop supported retraction in the frictionless group

cusps tips and root apex was measured in the sagittal section using axially guided navigation.

Statistical analysis

Statistical analyses were performed using a statistical package for the social sciences version 21.0. Descriptive statistics for means and standard deviations were obtained and tabulated. A paired t-test, analysis of variance, and Pearson correlation coefficient were used to determine the amount of EARR within groups, between the groups, and treatment duration. Intraobserver agreement was obtained using Cohen's kappa coefficient (0.935).

RESULTS

The mean difference in ARR between Group-1 (1.37 ± 0.48 mm) and Group-2 (1.66 ± 0.50 mm) after retraction was statistically significant ($P < 0.037$) (Table 1), where it was observed that root resorption was more in frictionless mechanics using teardrop loop when compared to friction mechanics with coil spring. Within-group comparisons were also found significant

($P < 0.001$) (Table 2). A positive correlation between the duration of retraction and the amount of ARR was observed ($r = 0.039$, $r^2 = 19\%$).

DISCUSSION

EARR is the process in which the destruction of root structures such as cementum and dentine is due to osteoclastic cell activity. Resorption is commonly seen in the apical region of the root as apical one-third is covered with more amount of cellular cementum, containing active cells along with microvasculature with 4% of vasculature in the apical region compared to 47% of vasculature in the periodontal ligament.^[9]

Castro *et al.*^[10] used multiplanar reconstruction in CBCT to measure the root resorption in millimeters by reference points, which were marked at the intersection of the sagittal or coronal cursor guided by the axial cursor. In the present study, we used the equivalent method for the measurement of root resorption from incisal/cusp tips to root apex from maxillary canine to canine.

In the present study, mean root resorption in Group-1 (friction mechanics) using NiTi closed coil springs was 1.37 ± 0.48 mm, and there was a statistically significant difference ($P < 0.05$) within the group before and after en masse retraction, which is in accordance with the study conducted by Luni *et al.*,^[11] in which friction mechanics along with mini-screws in en masse retraction were used and ARR significantly increased after treatment with 2.48 ± 0.82 mm mean change. Similarly, Liou and Chang^[12] reported mean root resorption of 2.6 ± 1.25 mm in patients treated with mini-screws for anterior maxillary en masse retraction. The mean root resorption was much lesser in the present study, which might be due to a mini-screw anchorage that has made maxillary anteriors more vulnerable to ARR.

Table 1: Mean root resorption for anterior teeth between the friction and frictionless mechanics groups

Tooth	Group 1 Root resorption in mm±SD	Group 2 Root resorption in mm±SD	P-value
Maxillary right canine	1.33±0.37	1.90±0.32	0.3762
Maxillary right lateral incisor	1.21±0.44	1.50±0.69	0.3800
Maxillary right central incisor	1.37±0.46	1.48±0.36	0.6603
Maxillary left central incisor	1.39±0.34	1.97±0.65	0.0587
Maxillary left lateral incisor	1.38±0.26	1.37±0.55	0.9519
Maxillary left canine	1.54±1.05	1.59±0.48	0.9238
Total mean±SD	1.37±0.48	1.66±0.50	0.0371*

* $P < 0.05$ —significant. Analysis of variance test applied. SD: Standard deviation

Table 2: Root resorption before and after retraction in group 1 and group 2

Tooth (mean±standard deviation)	Linear measurements T1 in mm	Linear measurements T2 in mm	Apical root resorption	P-value
Friction mechanics (group 1)				
Maxillary right canine	24.37±2.34	23.04±2.46	1.33±0.37	0.00008*
Maxillary right lateral incisor	21.64±1.57	20.43±1.40	1.21±0.44	0.00038*
Maxillary right central incisor	23.51±2.29	22.14±2.27	1.37±0.46	0.00022*
Maxillary left central incisor	23.39±2.46	22.00±2.48	1.39±0.34	0.00004*
Maxillary left lateral incisor	21.57±1.54	20.19±1.53	1.38±0.26	0.00001*
Maxillary left canine	24.30±2.29	22.76±2.87	1.54±1.05	0.00833*
Total	23.13±2.29	21.76±2.36	1.37±0.48	<0.001*
Frictionless mechanics (group 2)				
Maxillary right canine	24.79±1.04	22.89±1.18	1.90±0.32	0.000005*
Maxillary right lateral incisor	21.06±1.40	19.56±1.69	1.50±0.69	0.001273*
Maxillary right central incisor	22.59±0.82	21.11±0.80	1.48±0.36	0.000039*
Maxillary left central incisor	22.56±0.85	20.59±0.92	1.97±0.65	0.000213*
Maxillary left lateral incisor	21.17±1.42	19.80±1.39	1.37±0.55	0.000600*
Maxillary left canine	24.89±2.02	23.30±2.06	1.59±0.48	0.000126*
Total	24.09±1.71	22.43±1.58	1.66±0.50	<0.001*

* $P < 0.05$ —significant. A paired t-test was applied

Barros *et al.*^[13] had conducted a study on EAAR of maxillary central incisors in anterior retraction with and without skeletal anchorage in Group 1, and Group 2, with a force of 250 g applied on each side by friction mechanics. The mean ARR in Group 1 and Group 2 was 1.81 ± 0.73 mm and 2.33 ± 0.77 mm, which is higher compared to mean root resorption (1.38 ± 0.40 mm) in Group 1 in this study, which might be due to skeletal anchorage and higher forces compared to 150 g of orthodontic forces.

In the present study, mean ARR values after retraction of maxillary anteriors in Group 2 using a teardrop loop were maxillary centrals (1.72 ± 0.50 mm), lateral incisors (1.43 ± 0.62 mm), and canines (1.74 ± 0.4 mm). A similar study was conducted by Gupta *et al.*^[14] using T-loop showed similar values, with mean ARR of maxillary central (1.57 ± 0.88 mm), lateral incisors (1.79 ± 0.71 mm), and canines (0.60 ± 0.55 mm). There is less amount of resorption in canines compared to incisors which might be due to the proximity of cortical bone near the roots of maxillary incisors along with increased torque values of incisors.

ARR of maxillary anteriors between the friction and frictionless mechanic groups, by en masse retraction in Group 1 and Group 2, showed that there was a significant difference between the groups. Contradicting results were obtained by Balakrishna *et al.*^[15] where he had executed segmental canine retraction instead of en masse retraction, and ARR was measured between friction and frictionless mechanics, and it was concluded that there was no difference between the two groups.

In the present study, the mean root resorption of the left maxillary canine in Group-1 using NiTi closed coil springs is 1.54 mm, and the right maxillary canine in Group-2 using teardrop loop is 1.90 mm, which showed a significant difference before and after en masse retraction. In contrast to the present study, Makhlof *et al.*^[16] conducted a study to evaluate ARR in a two-step retraction with a split-mouth trial in which the mean ARR of the left maxillary canine (0.2 mm) and maxillary right canine (1.1 mm), using NiTi coil springs and segmental T-loops supported retraction with 0.017×0.025 inch TMA wires in which there was no significant difference in mean root resorption values, which might be due to differences in 4 months follow up with the use of 0.017×0.025 inch TMA wires in their study compared to full retraction in this study with 0.019×0.025 inch SS wire, as TMA wires are less stiffer than SS wires and lighter forces could be used at each stage in two-step retraction compared to en masse retraction.^[17,18]

Mean root resorption values for Group 1 is 1.37 ± 0.48 mm and for Group 2 is 1.66 ± 0.50 mm and showed a significant difference ($P < 0.05$) between the groups, in which frictionless group showed more amount of ARR compared to the friction group, which might be attributed to the fact that difference in the stress distribution at the apex in bodily movement is less in friction group compared to the tipping movement in

frictionless mechanics. Therefore the risk of root resorption that is due to bodily movement should be less than that of tipping.^[19]

In the present study, the correlation graph between the amount of ARR and duration of retraction ($r^2 = 19\%$) showed a positive correlation, suggesting that the longer the duration of treatment, the more severe the amount of ARR. Similar to this study, Jiang *et al.*^[20] conducted a study where they evaluated root resorption before and after orthodontic treatment and concluded that treatment duration was more associated with root resorption, especially for the anterior teeth.

Panainte *et al.*^[21] conducted a study to find if ARR is related to orthodontic treatment time and concluded that there is a high correlation between orthodontic treatment time and ARR. Most affected teeth in this process are incisors.

Limitations of the study

The biological reasons, such as individual susceptibility, tooth morphology, age, and periodontal architecture, which influence root resorption vary from patient to patient.

EARR was measured using CBCT only at two intervals in this study, i.e., pre- and post-retraction. Thus, the information regarding the complete process of ARR and repair was beyond the scope of this study design.

Recommendations for further work

Long-term prospective studies with a larger sample size are recommended.

More en masse retraction studies should be performed using different methods in both friction and frictionless mechanics.

CONCLUSION

The present study compared and evaluated the EARR of maxillary anterior teeth during the retraction phase in fixed orthodontic treatment using friction mechanics and frictionless mechanics with en masse retraction.

The amount of root resorption showed a statistically significant difference between pre- and post-linear measurements of maxillary anteriors in friction and frictionless mechanics, in which frictionless mechanics showed more EARR than friction mechanics.

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