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Comparison of root resorption between extraction and non-extraction orthodontic treatment

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ABSTRACT

Introduction: Apical root resorption is a common consequence of orthodontic treatment, usually asymptomatic, arising from various biological and mechanical factors. Its severity may differ between extraction and non-extraction therapies.

Objectives: To evaluate and compare apical root resorption in patients with Angles Class I bimaxillary malocclusion treated with extraction versus Class I malocclusion treated with non-extraction orthodontic approaches using panoramic radiographs.

Methodology: This cross-sectional observational study included 120 patients (60 extraction, 60 non-extraction) treated in the Department of Orthodontics, Kantipur Dental College, Kathmandu. Apical root length (ARL) was calculated as the difference in root length between the pretreatment and post-treatment Orthopantomograms. All permanent teeth (11 to 47) were measured with Image J software, with intra-examiner reliability assessed via the Intraclass Correlation Coefficient (ICC). Statistical analysis was performed with independent t-tests for group comparisons.

Results: The ICC values ranged from 0.85 to 0.99, indicating excellent intra-examiner reliability. Root resorption was significantly greater in the extraction group ($p < 0.05$) for 20 of 24 teeth with 12, 35, and 45 showing the highest mean differences. In the non-extraction group, significant resorption was observed in 15 teeth, although with lower overall values. Four teeth (25, 27, 37, and 47) showed no significant difference between groups.

Conclusion: Apical root resorption was more pronounced with extraction-based orthodontic treatment, although resorption was also evident in non-extraction cases, underscoring its multifactorial nature.

Keywords: Extraction; Non-extraction; Orthodontics; Panoramic radiograph; Root resorption.

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INTRODUCTION

Apical root resorption is a common orthodontic complication but can also occur without treatment. Orthodontically induced inflammatory root resorption (OIIRR) is unique, involving a sterile, localized inflammatory process with characteristic inflammatory signs.[1] Etiological factors include dental trauma, periapical pathology, periodontal disease, and the duration/type of orthodontic force.[2]

Clinically, OIIRR is often asymptomatic until advanced, necessitating radiographic monitoring for early detection, especially at the root apex or lateral surfaces. Maxillary incisors with blunt roots are particularly susceptible, and high-risk patients may require reviews every three months.

Patient-related factors linked to OIIRR include malocclusion type, age, sex, root morphology, dental anomalies, and trauma history, though evidence is

inconsistent—some studies show no age or gender correlation, while others suggest higher risks in females or with age.[4,5,6] Intrusive forces and treatment duration may exacerbate resorption, but findings vary.[7] Although unavoidable in orthodontics, limited Nepalese evidence compares extraction versus non-extraction modalities. This study evaluates and compares apical root resorption in Class I bimaxillary protrusion patients treated with premolar extraction versus non-extraction methods, using panoramic radiographs.

METHODOLOGY

This cross-sectional, observational study which was conducted at the Department of Orthodontics, Kantipur Dental College Teaching Hospital and Research Centre, Kathmandu, Nepal, over six months from 1st July 2023 to 30th December 2023. The ethical approval was taken from the institutional review committee of Kantipur Dental College Teaching Hospital and Research Center (Ref.: 13/023). The study population consisted of patients who had undergone orthodontic treatment at the institution and met the eligibility criteria. A total of 120 patients were included, with 60 cases treated using the extraction protocol and 60 treated using a non-extraction protocol. The sample size was calculated using the formula for estimating a proportion from a study done by de Freitas et al,[8] 2007, where:

$$n = \left(\frac{(Z_{\alpha/2} + Z_{\beta}) \cdot \sigma}{d}\right)^2$$

$$= \left(\frac{(1.96 + 0.84) \cdot 0.51}{0.2}\right)^2$$

$$= 50.98 \sim 60$$

$Z_{\alpha/2}$ = 95% confidence interval

$Z\beta$ = where Z=80% power

σ = SD of the outcome (population variability) value placed was 0.28

d= the effect size (the minimum difference). where, d=0.2

Patients aged between 18 and 40 years diagnosed with Angle's Class I bimaxillary malocclusion and treated either with extraction of all first premolars or non-extraction orthodontic therapy were included in the study. All participants had completed at least one year of active orthodontic treatment. Orthopantomogram (OPG) was done with CS 9600 (Carestream Dental LLC, Atlanta, Georgia, USA). Only patients with available pre- and post-treatment panoramic radiographs demonstrating clear and undistorted root visibility were selected. Patients with malocclusions other than Angle's Class I bimaxillary, incomplete treatment records, or poor-quality radiographs in which root anatomy was unclear or distorted were excluded from the study. The lengths of the maxillary and mandibular tooth were calibrated and measured using from CEJ (Cervico enamel Junction) to Apex of the tooth using Image J software (Fig.1). On radiograph, the cementoenamel junction was identified at the narrowest tooth diameter between crown and root and the root apex was identified as the terminal tip of the root outline. Root resorption was assessed by calculating the difference in root length between pre-treatment and post-treatment radiographs. All measurements were performed digitally and recorded up to two decimal places. A single examiner performed all the measurements to ensure consistency. To assess intra-observer reliability, 10 radiographs were randomly selected and re-measured after 15 days. A normality test was done with the Shapiro-Wilk test which showed normal distribution of data. IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, N.Y., USA was used for processing and analysis of the data. Descriptive statistics were used to summarize the data, independent samples t-test was applied to compare the amount of root resorption between the extraction and non-extraction groups. Intra-observer reliability was evaluated using the Intraclass correlation coefficient (ICC).

RESULT

The intra-examiner reliability assessed using ICC for 20% of the sample showed good to excellent agreement. The Intraclass Correlation Coefficient (ICC) values for teeth 11 to 47 (according to two-digit tooth numbering system) ranged from 0.85 to 0.99, indicating excellent reliability across all measurements. Notably, the majority of teeth exhibited ICC values above 0.90**,** with several teeth—such as 15, 16, 24, 43, and 47—showing very high agreement (≥ 0.95)**.** Even the lowest ICC value, 0.85 (tooth 13), still reflects strong reliability.

In the non-extraction group (mean ± SD) significant root resorption ($p < 0.05$) is observed in multiple teeth, including 11, 12, 13, 16, 21, 22, 24, 26, 31, 32, 33, 41, 42, and 46 (Table 1).

In the extraction group, statistically significant root resorption ($p < 0.05$) was observed in most teeth, including teeth numbers 11, 12, 13, 15, 16, 17, 21, 22, 23, 31, 32, 33, 35, 36, 41, 42, 43, 45, and 46. Teeth 25, 26, 27, 37, and 47 showed no significant difference ($p > 0.05$, Table 2).

In comparison of root resorption between the extraction and non-extraction groups, root resorption was consistently greater in the extraction group across the majority of teeth. Statistically significant differences ($p < 0.05$) were identified in 20 out of 24 teeth, specifically in teeth numbers 11, 12, 13, 15, 16, 17, 21, 22, 23, 26, 31, 32, 33, 35, 36, 41, 42, 43, 45, and 46. No significant differences were observed in four teeth: 25, 27, 37, and 47 (Table 3).

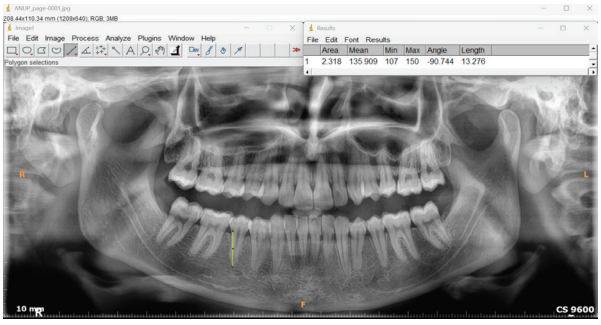

Figure 1: Orthopantomogram (OPG)

Table 1: Comparison of apical root resorption in non-extraction group

Tooth Number	Mean ± SD	p-value
11	0.50 ± 2.05	0.001*
12	0.40 ± 3.20	0.002*
13	0.30 ± 1.20	0.002*
14	0.40 ± 2.50	0.080
15	0.30 ± 4.05	0.060
16	0.20 ± 2.08	0.040*
17	0.20 ± 4.25	0.090
21	0.50 ± 4.05	0.001*
22	0.60 ± 5.02	0.001*
23	0.40 ± 4.20	0.060
24	0.20 ± 2.68	0.040*
25	0.30 ± 2.56	0.060
26	0.20 ± 2.36	0.040*
27	0.20 ± 4.56	0.080
31	0.50 ± 5.30	0.001*
32	0.50 ± 2.80	0.001*
33	0.40 ± 5.30	0.001*
34	0.20 ± 2.60	0.060
35	0.20 ± 2.40	0.070
36	0.20 ± 2.60	0.090
37	0.30 ± 4.23	0.080
41	0.50 ± 4.02	0.001*
42	0.50 ± 3.02	0.001*
43	0.30 ± 2.30	0.060
44	0.50 ± 5.02	0.080
45	0.20 ± 4.20	0.080
46	0.20 ± 2.30	0.040*
47	0.20 ± 2.60	0.090

p - value significant at <0.05, *=paired t test

Table 2: Comparison of apical root resorption in extraction Group

Tooth Number	Mean ± SD	p-value
11	0.80 ± 3.22	0.001*
12	0.80 ± 2.36	0.001*
13	0.30 ± 3.02	0.001*
15	0.40 ± 4.06	0.001*
16	0.30 ± 3.02	0.001*
17	0.40 ± 5.02	0.040*
21	0.60 ± 2.03	0.001*
22	0.60 ± 5.02	0.001*
23	0.50 ± 4.02	0.040*
25	0.40 ± 2.45	0.090
26	0.30 ± 2.56	0.060
27	0.50 ± 2.80	0.080
31	0.60 ± 2.78	0.001*
32	0.60 ± 4.02	0.001*
33	0.50 ± 3.56	0.001*
35	0.60 ± 4.55	0.030*
36	0.20 ± 4.03	0.040*
37	0.60 ± 2.65	0.080
41	0.40 ± 2.89	0.001*
42	0.60 ± 5.02	0.001*
43	0.40 ± 4.02	0.040*
45	0.60 ± 3.56	0.040*
46	0.30 ± 3.02	0.040*
47	0.50 ± 5.02	0.090

p - value significant at <0.05, *=paired t test

Table 3: Comparison of Root Resorption Between Extraction and Non-Extraction Groups for each tooth.

Tooth No.	Non-Extraction (Mean ± SD)	Extraction (Mean ± SD)	Mean Difference	p-value
11	0.5 ± 2.05	0.8 ± 3.22	+0.3	0.001*
12	0.4 ± 3.2	0.8 ± 2.36	+0.4	0.001*
13	0.3 ± 1.2	0.3 ± 3.02	+0.0	0.001*
15	0.3 ± 4.05	0.4 ± 4.06	+0.1	0.001*
16	0.2 ± 2.08	0.3 ± 3.02	+0.1	0.040*
17	0.2 ± 4.25	0.4 ± 5.02	+0.2	0.040*
21	0.5 ± 4.05	0.6 ± 2.03	+0.1	0.001*
22	0.6 ± 5.02	0.6 ± 5.02	+0.0	0.001*
23	0.4 ± 4.2	0.5 ± 4.02	+0.1	0.040*
25	0.3 ± 2.56	0.4 ± 2.45	+0.1	0.060
26	0.2 ± 2.36	0.3 ± 2.56	+0.1	0.040†
27	0.2 ± 4.56	0.5 ± 2.8	+0.3	0.080
31	0.5 ± 5.3	0.6 ± 2.78	+0.1	0.001†
32	0.5 ± 2.8	0.6 ± 4.02	+0.1	0.001†
33	0.4 ± 5.3	0.5 ± 3.56	+0.1	0.001†
35	0.2 ± 2.4	0.6 ± 4.55	+0.4	0.030†
36	0.2 ± 2.6	0.2 ± 4.03	+0.0	0.040†
37	0.3 ± 4.23	0.6 ± 2.65	+0.3	0.080
41	0.5 ± 4.02	0.4 ± 2.89	-0.1	0.001†
42	0.5 ± 3.02	0.6 ± 5.02	+0.1	0.001†
43	0.3 ± 2.3	0.4 ± 4.02	+0.1	0.040†
45	0.2 ± 4.2	0.6 ± 3.56	+0.4	0.040†
46	0.2 ± 2.3	0.3 ± 3.02	+0.1	0.040†
47	0.2 ± 2.6	0.5 ± 5.02	+0.3	0.090

p - value significant at <0.05, †=Independent t test

DISCUSSION

The present study evaluated apical root resorption in patients with Class I bimaxillary malocclusion treated with either extraction or non-extraction orthodontic approaches, using panoramic radiographs before and after treatment, which is similar to study done by Jiang et al.[9] While many studies on apical root resorption have utilized intraoral periapical radiographs (IOPA) due to their superior resolution and ability to detect minor resorptive changes in individual teeth as done by Kulshrestha et al., Zahedani et al.[10,11] This study employed orthopantomograms (OPGs) for the evaluation. OPG was chosen to facilitate the assessment of all teeth within a single radiograph. Root resorption was assessed across all teeth from incisors to molars (11 to 47), and intra-examiner reliability was confirmed through ICC values ranging from 0.85 to 0.99, showing excellent intra-observer reliability. Root length measurements were done using Image J software, which allowed for calibration and accurate linear measurement of apical changes on digital panoramic images.[12]

When comparison was done between the extraction and non-extraction groups, the findings showed a higher degree of root resorption in the extraction group across most teeth. Statistically significant differences ($p < 0.05$) were noted in 20 out of 24 teeth, indicating that extraction-based orthodontic mechanics are associated with increased risk of root resorption, which is similar to a study done by Baumrind et al. and McFadden et al. where they found that patients who undergo extraction treatment tended to have more root resorption.[13,14] The mean differences in resorption ranged from 0.1 mm to 0.4 mm, with teeth such as 12, 35, and 45 showing the largest discrepancies. The findings was in accordance with previous studies done by Sameshima and Sinclair, suggesting that tooth movement over larger distances, particularly during space closure following premolar

extraction, increases the likelihood and extent of root resorption.[15] In contrast to the study done by Jiang et al. if other factors were included, such as gender, age, treatment duration, and pre-treatment resorption, extraction became less important for resorption than previously believed.[9]

Interestingly, four teeth—25, 27, 37, and 47 did not show statistically significant differences between the two groups, suggesting that not all teeth are equally affected by the mechanics of extraction-based treatment. This variability could be due to differences in root morphology, position within the arch, or the direction and magnitude of force applied during treatment.

Within the non-extraction group, statistically significant root resorption was observed in 15 teeth, with most p-values under 0.05. Although the overall magnitude of resorption was lower compared to the extraction group, this finding emphasizes that root resorption is a multifactorial phenomenon that may occur regardless of the treatment protocol. Similarly, in the extraction group, most teeth showed significantly higher resorption, supporting the theory that additional tooth movement and force application post-extraction contribute to more pronounced root changes.

One of the primary limitations is the use of orthopantomograms (OPGs) instead of intraoral periapical radiographs (IOPAs). Although OPGs allow a comprehensive view of the entire dentition in a single frame, they lack the resolution and accuracy of IOPAs, potentially underestimating minor resorptive change.[9,10] Furthermore, being a two-dimensional imaging technique, OPGs are prone to magnification errors, image distortion, and superimposition of anatomical structures, which may compromise the precision of root length measurements. The study also did not account for individual biological and mechanical variables such as root morphology, bone density, magnitude and direction of orthodontic forces, and duration of force application, all of which are known to influence root resorption. Subsequent studies could benefit from using higher-resolution imaging modalities such as CBCT to detect early and subtle resorptive changes more accurately.[16] Including a wider range of patient-related and treatment-related variables would enable a more comprehensive understanding of the multifactorial nature of root resorption. The study is limited by its relatively small sample size, inclusion of patients with varying malocclusion types, and reliance on two-dimensional radiographs, which may not fully capture the complexity of root morphology.

CONCLUSION

This study found greater apical root resorption in extraction groups compared to non-extraction groups, with statistically significant differences in most teeth. Root resorption was also present in the non-extraction groups.

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