"Comparative Evaluation of Root Resorption During Canine Retraction Using Segmental T-Loop and Geometry-X: A CBCT-Based Split-Mouth, Randomized Clinical Trial"

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KEYWORDS

ABSTRACT

Aim: To compare the extent of root resorption during canine retraction using Segmental T-loop and Geometry-X, evaluated through CBCT imaging.
Materials and Methods: Patients with Angle's Class I malocclusion and anterior crowding, requiring first premolar extraction, were treated with Segmental T-loop and Geometry-X mechanics on opposite sides of the maxillary/mandibular arch in a split-mouth design. Root resorption was assessed by comparing pre-treatment and post-canine retraction CBCT scans for each technique.
Results: The Geometry-X technique resulted in a mean root resorption of 0.76 mm, whereas the Segmental T-loop technique showed a higher mean resorption of 1.08 mm. Although this suggests that the Segmental T-loop technique may cause more root resorption compared to the Geometry-X technique, statistical analysis indicated that the difference between the two techniques was not significant.
Conclusion: The Segmental T-loop technique demonstrated slightly higher root resorption compared to the Geometry-X. However, the differences between the two methods were not statistically significant. This indicates that both techniques may have a similar impact on canine root integrity.

INTRODUCTION:

Malocclusion refers to the improper alignment of the upper and lower dental arches or teeth. It can cause functional problems like difficulty biting, chewing, or speaking and may lead to aesthetic concerns, impacting facial appearance.[1] Malocclusion can negatively impact periodontal health, increase the risk of dental caries, and contribute to temporomandibular joint (TMJ) disorders.[2]

Fixed mechanotherapy is a widely used orthodontic technique that corrects malocclusions such as crowding, spacing, and bite issues. Treatment typically spans two years and progresses through three stages: leveling and alignment, space closure, and finishing.[3]

Orthodontic therapy has a number of iatrogenic consequences, the most common of which is external apical root resorption. External apical root resorption is the reduction in the root structure involving the apices of the root.[4]

Root resorption is a multifactorial phenomenon characterized by the loss of dental hard tissue, including cementum and sometimes dentin, due to osteoclastic activity. In orthodontics, this

process is commonly referred to as orthodontically induced inflammatory root resorption (OIIRR). It occurs as an unintended consequence of applying mechanical forces to teeth during orthodontic treatment.[5]

While minor root resorption is a natural and often reversible process, excessive or irreversible root shortening can compromise tooth stability and longevity.[6] The severity and extent of resorption depend on several factors, including the magnitude and direction of orthodontic forces, the duration of treatment, patient age, and individual biological variability. Additionally, certain systemic and genetic predispositions may heighten a patient's risk for root resorption.[7] Understanding the mechanisms and risk factors associated with root resorption is crucial for orthodontists to balance effective tooth movement with the preservation of dental integrity.[8] As research continues to evolve, clinicians aim to optimize treatment protocols to minimize the risk of significant root resorption while achieving desired orthodontic outcomes.[9]

The intraoral periapical (IOPA) radiograph, orthopantomogram (OPG), and lateral cephalograms are among the various radiographic tools that can be used to evaluate root resorption. Cone beam computed tomography and CT are two of the more recent tools that are being utilized to better examine root resorption.[10]

This study aims to conduct a comprehensive comparison of root resorption occurring during the retraction of canines into the first premolar extraction site, utilizing two different orthodontic techniques: the Segmental T-loop and the Geometry-X. To achieve a thorough and accurate assessment, cone-beam computed tomography (CBCT) was employed, which offers superior imaging capabilities for evaluating root structure. By leveraging the high-resolution imaging of CBCT, this study seeks to provide a deeper understanding of the extent and nature of root resorption associated with each technique, ultimately determining which method is more favourable in terms of minimizing root damage.

MATERIAL AND METHOD:

The sample for this study consisted of 14 patients, reported to the Department of Orthodontics & Dentofacial Orthopedics, People's Dental Academy, Bhopal, Madhya Pradesh. All participants exhibited Class I malocclusion characterized by either highly or buccally placed canines bilaterally and moderate crowding **(Figure 1).** Their treatment plans involved the extraction of first premolars to create space, followed by the retraction of permanent canines. A split mouth design was followed to conduct the study.

Figure 1: Pre-treatment photographs of the patient with buccally placed canine bilaterally and moderate crowding in the mandibular ach

In the study design, patients were categorized based on their assigned participant numbers. Patients with even-numbered assignments (Group A) were treated using a Segmental T-loop on the right side and a Geometry-X on the left side. Conversely, patients with odd-numbered assignments (Group B) received the Segmental T-loop on the left side and the Geometry-X on the right side.

An 0.022 X 0.028" slot bracket was bonded to the canine on the Segmental T-loop side, while a Begg bracket was bonded to the canine on the Geometry-X side. The anterior segment which includes the central and the lateral incisors were left unbonded and the first molars were banded. The posterior segment, including the second premolar, first and second molars, were prepared by laceback and a 0.019 x 0.025-inch stainless steel wire, creating a stable anchorage unit. The Segmental T-loop and Geometry-X with same retraction force (2 ounces) were placed in the maxillary/mandibular arch, ensuring that each technique was tested in both arches for a balanced comparison within the split-mouth design.

Segmental T - loop was fabricated from a straight 0.017 X 0.025-inch Titanium Molybdenum Alloy (TMA) wire according to Burstone using a fabrication template for standardisation, and pre-activated as shown in the Figure 2. Anti-Rotation bends were placed at both mesial and distal arms. The distal end of the T-loop was inserted into the auxiliary tube of molar band and the mesial end was ligated into the canine bracket using ligature wire.

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Geometry-X (Figure 3) consists of a 0.016-inch Nickel Titanium (NiTi) wire extending from the auxiliary tube of the molar and passing vertically through the Begg bracket, from the gingival to the occlusal direction. An active tie-back, consisting of a module and a ligature wire, extending from the hook of first molar was ligated to the canine to apply a retraction force and facilitate its movement.

The retraction forces applied to the canines in both techniques were standardized for each individual patient and measured using a Dontrix force gauge. This ensured consistency and accuracy in the force levels applied during treatment. The patients were scheduled for regular follow-up visits every 4 to 6 weeks, during which the appliances were reactivated with the same retraction force at each interval. The reactivation was done till sufficient space was available for the alignment of central and lateral incisor.

CBCT scans were taken for each patient, one prior to the initiation of treatment (T1) and a second after the canine retraction was completed (T2), to evaluate changes in root structure and measure root resorption. (Figure 4,5)

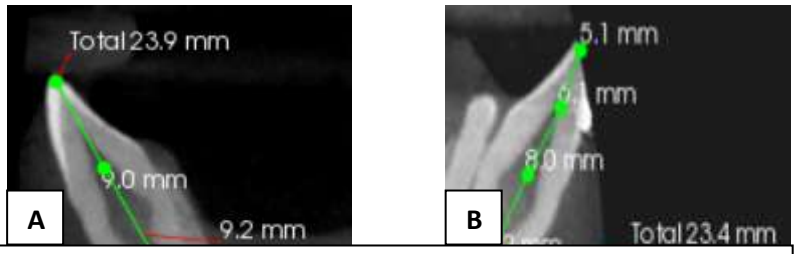

Figure 4: (A) Pre-treatment and (B) Post-retraction CBCT of patient treated with Segmental T-loop

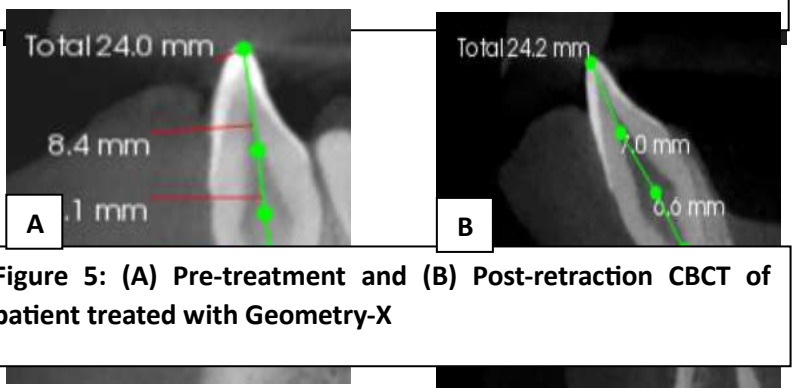

Figure 5: (A) Pre-treatment and (B) Post-retraction CBCT of patient treated with Geometry-X

STATISTICAL ANALYSIS:

The data was analysed using SPSS (Statistical Package for Social Sciences) 25.0 version, IBM, Chicago. The data was analysed for probability distribution using Kolmogorov-Smirnov test. Mean values and SD was calculated. The unpaired t- test was performed. p value≤0.05 was considered statistically significant. Confidence interval was set at 95%.

RESULTS:

The trial involved a total of 14 patients, resulting in a planned total of 28 samples overall. However, due to irregularities in the reporting by patients and a notable increase in the frequency of bracket breakages, only 20 samples were successfully collected during the course of the study.

The Geometry-X technique demonstrated mean root resorption of 0.76 mm, while the Segmental T-loop technique exhibited mean root resorption of 1.08 mm, which was more than Geometry-X technique. Despite the apparent difference between these two techniques, statistical analysis revealed that this difference was not significant (p-0.390). **(Table 1)**

Table 1 - Comparison of mean root resorption of canine between Geometry-X and Segmental T-loop technique

Technique	n	Root resorption	95% Confidence Interval of the Difference		t-value	p-value
		(Mean+SD)	Lower	Upper		
Geometry-X	10	0.76±0.82	-1.083	0.443	-0.880	0.390(NS)
Segmental T-loop	10	1.08±0.83	-1.083	0.443		

n- Number of samples, SD- Standard deviation, NS-non significant

In Group A, a comparison of mean root resorption of canine between the two techniques used in this study revealed that the right-side Segmental T-loop resulted in a mean resorption of 1.20 mm, whereas the left-side Geometry-X technique exhibited a slightly lower mean resorption of 1.04 mm. Although these findings suggest that the Segmental T-loop may lead to greater

root resorption compared to the Geometry-X technique, statistical analysis indicated that the difference between the two techniques was not significant (p = 0.781). **(Table 2)**

Table 2- Comparison of mean root resorption of canine between right Segmental T-loop and left Geometry-X technique

Technique (Group A)	n	Root resorption	95% Confidence Interval of the Difference		t-value	p-value
		(Mean±SD)	Lower	Upper		
Rt-Segmental T-loop	5	1.20±0.68	-1.12103	1.44103	0.288	0.781(NS)
Lt-Geometry-X	5	1.04±1.03	-1.15709	1.47709		

n- Number of samples, SD- Standard deviation, NS-non significant

In Group B, the left-side Segmental T-loop resulted in a mean root resorption of 0.96 mm, while the Right-side Geometry-X technique showed a mean resorption of 0.48 mm. The Segmental T-loop showed more resorption than the Geometry-X approach, but the difference was not statistically significant (p = 0.356). **(Table 3)**

Table 3- Comparison of mean root resorption between left Segmental T-loop and right Geometry-X technique

Technique (Group B)	n	Root resorption	95% Confidence Interval of the Difference		t-value	p-value
		(Mean+SD)	Lower	Upper		
Rt-Geometry-X	5	0.48±0.49	-1.609	0.6497	-.980	0.356(NS)
Lt-Segmental T-loop	5	0.96±0.97	-1.681	0.7215		

n- Number of samples, SD- Standard deviation, NS-non significant

The mean root resorption of the same techniques used in this study was compared between Groups A and B. The right-side Segmental T-loop exhibited a mean resorption of 1.20 mm, whereas the left-side Segmental T-loop showed a slightly lower mean resorption of 0.96 mm. Although this suggests a difference in resorption between the two sides, statistical analysis confirmed that the variation was not significant (p = 0.667). **(Table 4)**

Table 4- Comparison of mean root resorption between right and left Segmental T-loop technique

Technique (Group A & B)	n	Root resorption	95% Confidence Interval of the Difference		t-value	p-value
		(Mean+SD)	Lower	Upper		
Rt-Segmental T-loop	5	1.20±0.68	-0.9880	1.4680	0.451	0.664 (NS)

Lt-Segmental T-loop	**5**	**0.96±0.97**	**-1.0138**	**1.4938**		

n- Number of samples, SD- Standard deviation, NS-non significant

The right-side Geometry-X showed a mean of 0.48 mm, while the left-side Geometry-X showed a mean of 1.04 mm, which was more than the right-side Geometry-X, when the mean root resorption of the same techniques utilised in this study was compared between groups A and B. Nevertheless, there was no statistically significant difference between the groups (p-0.308). **(Table 5)**

Table 4- Comparison of mean root resorption between right and left Geometry-X technique

Technique (Group A & B)	n	Root resorption	95% Confidence Interval of the Difference		t-value	p-value
		(Mean+SD)	Lower	Upper		
Lt-Geometry-X	**5**	**1.04+1.03**	**-.62709**	**1.74709**	**1.088**	**0.308**
Rt-Geometry-X	**5**	**0.48+0.49**	**-.71350**	**1.83350**		

n- Number of samples, SD- Standard deviation, NS-non significant

DISCUSSION:

In this study we have investigated the root resorption associated with well controlled canine retraction. The orthodontic load on each subject was calibrated so that the treatment was similar with respect to both the techniques employed.

The primary limitation of this study was the small sample size, which could have limited the extent to which the results can be applied. A larger sample size is needed to ensure more robust and meaningful conclusions. Root resorption is a multifactorial biological phenomenon frequently encountered during orthodontic treatment.[11] A number of variables, both treatment-related and patient-related, affect the etiology of root resorption during orthodontic therapy. On the biological front, individual susceptibility plays a significant role, with root shape, systemic health problems, and genetic predisposition serving as important factors. Patients with shorter, blunted, or dilacerated roots, as well as those with pre-existing trauma, are at higher risk of developing root resorption.[5] Root resorption also depends on magnitude of orthodontic force used, the treatment plan, and the method of measuring root resorption.[12] Control of this factors was a major challenge in previous studies. As of now, radiographic techniques are the sole way to assess and quantify apical root resorption. The 2D evaluation of root resorption might introduce large errors. [13,14] Root resorption is a three-dimensional phenomenon and its extent needs to be precisely determined. John et al (2010) determined that, in comparison to periapical radiographs, which include magnification errors and inaccurate landmark identification, CBCT is the most accurate technique for measuring and assessing external apical root resorption.[15] Jiang et al (2017) investigated external apical root resorption using CBCT because of its accuracy in providing reliable results. In this study, the apical root resorption was measured by tooth length rather than root length which eliminates the effect of various methods to define root since it is often believed that orthodontic treatment has little influence on crown length.[14] The application of mechanical stress that causes tissue remodelling in the periodontium has an impact on orthodontic tooth movement. Excessive and prolonged orthodontic forces cause damage to the surrounding alveolar bone and the periodontal ligament, which sets off an

inflammatory reaction that can cause cementum and dentin degradation.[16] Research has demonstrated that, in contrast to mild, intermittent stresses, high forces, especially when applied constantly, worsen resorption.[17,18] Therefore, it is essential to maintain a balance between force magnitude and duration with the objective to reduce risk.[6]

The present study has not investigated the influence of age and sex related differences on root resorption. Jiang et al reported that during canine retraction, elderly individuals are more likely to get external apical root resorption. He also showed that apical root resorption is more common in female patients, however that was not statistically significant.[12]

Frictionless mechanics require less force to bring about tooth movement compared to friction mechanics. This is because in friction mechanics half of the force is utilized to overcome friction and the other half is required for tooth movement.[19] Alexander SA (1996) conducted a study to compare the level of root resorption associated with continuous arch and segmented arch mechanics & concluded that neither technique appeared to predispose the dentition to higher levels of risk of root resorption.[20]

Segmental T-loop, introduced by Dr Burstone has long been used for the retraction of individual canine. A study shows that T-loops can give better control over tooth movement and possibly lead to less root resorption when compared to other orthodontic loops in terms of root resorption.[21]

The findings of this study indicated that the amount of canine root resorption, as quantitatively assessed using CBCT, was greater in the Segmental T-loop technique compared to the Geometry-X technique. Although the Segmental T-loop method resulted in higher root resorption, the difference between the two techniques was not statistically significant, suggesting that both approaches may have a comparable impact on root integrity.

CONCLUSION:

- The Segmental T-loop technique showed a slightly higher level of root resorption compared to the Geometry-X technique. Despite the observable difference in mean resorption, statistical analysis indicated that the difference was not significant.
- Both techniques likely have a comparable impact on canine root integrity which implies that either technique could be used with similar outcomes in terms of root preservation.
- Further research, preferably with larger sample sizes, more diverse patient populations, or employing different assessment methods, may be required to draw more definitive conclusions regarding the relative effects of these techniques on canine root health.

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