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Comparison of root resorption between self ligating and conventional preadjusted brackets using cone beam computed tomography – A randomised clinical trial.

Abstract:

Objective: The aim of this study was to evaluate and compare the extent of external apical root resorption (EARR) in the maxillary anterior teeth during the early phase of orthodontic treatment using either self-ligating or conventional preadjusted edgewise brackets.

Materials and Methods: Seventy participants, averaging 21 years in age and diagnosed with Angle's Class I malocclusion accompanied by 3 to 6 mm of upper anterior crowding, were enrolled. These subjects were randomly assigned into two groups: Group I (n = 35) treated with self-ligating brackets, and Group II (n = 35) treated with conventional preadjusted brackets. A total of 840 maxillary anterior teeth were assessed using cone-beam computed tomography (CBCT) with the NNT software. CBCT imaging was performed before treatment initiation (T1) and six months into treatment (T2). Intergroup and intragroup variations were statistically analyzed using independent and paired t-tests, respectively, at a 5% significance level.

Results: Both groups exhibited statistically significant differences in EARR between T1 and T2. However, the variation in root resorption between the two bracket systems was minimal.

Conclusion: All evaluated teeth showed evidence of root resorption, but the difference attributed to bracket type (self-ligating vs. conventional) was relatively minor.

Key-words: ....

Introduction:

Aesthetics has continually evolved and holds growing importance within orthodontics. In recent years, achieving facial harmony and a visually pleasing smile has become a key challenge for orthodontists.

Orthodontic treatments generally span 2 to 3 years, depending on the severity of malocclusion. Extended treatment durations are often associated with various side effects, including white spot lesions, gingival inflammation, alveolar bone loss, and notably, external apical root resorption (EARR), which is frequently documented.[1]

EARR is defined as a physiological or pathological reduction in root length due to the breakdown of the cementum or dentine layers.[2] It often manifests as blunting or shortening of the root apex and is typically linked to the pathological loss of the root's structural components. The movement of teeth during orthodontics is believed to rely on the removal of hyalinized zones.[3,4] However, this process is initiated by macrophage-like cells within the periodontal ligament, which can inadvertently damage the cementoblast layer that protects the adjacent root surface.[5,6] Given the clinical importance

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of EARR, numerous studies have explored it as an iatrogenic side effect of orthodontic procedures. Factors influencing its severity include treatment duration, magnitude and type of orthodontic forces, direction and extent of tooth movement, appliance design, and treatment technique. [7]

Furthermore, individual susceptibility plays a critical role in EARR. Contributing factors may include a history of root resorption, root morphology, genetic and systemic influences (such as medication use or hormonal imbalances), as well as patient age, sex, and bone density.[7]

Significant resorption is noted when the root structure is reduced by more than one-third. The upper and lower incisors are the most commonly affected teeth, implying that mechanical forces exerted during treatment have a substantial impact on EARR.[1]

Orthodontic appliances are generally categorized into conventional pre-adjusted edgewise brackets and self-ligating brackets.

The straight-wire appliance, introduced in the 1970s by Andrews, featured custom bracket bases tailored for each tooth, reducing the need for wire bending.[8] The MBT (McLaughlin, Bennett, Trevisi) system, a refinement of the Andrews technique, employs sliding mechanics and gentle continuous forces for improved efficiency.[8]

To enhance treatment outcomes and reduce adverse effects, modern bracket systems such as self-ligating brackets have been developed. Initially introduced in the 1930s, these brackets eliminate the need for elastomeric or steel ligatures by incorporating a built-in closure mechanism. This design reduces friction and is associated with benefits such as accelerated tooth movement, shorter treatment durations, and fewer clinical appointments. [9,10]

Additional advantages of self-ligating brackets include improved oral hygiene, reduced chairside time, decreased risk of cross-infection from sharp ligatures, and greater appeal to adult patients. Moreover, studies suggest a lower incidence of EARR compared to conventional pre-adjusted brackets.[11]

Research also indicates that patients showing noticeable resorption within the first six months of treatment are more prone to continued resorption, highlighting the importance of timely radiographic evaluation during early treatment phases. [12]

Root resorption detection relies on radiographic imaging. Traditional 2D methods—such as periapical, panoramic, and occlusal radiographs—require significant root shortening before changes are visible. Moreover, panoramic imaging can overestimate root loss by over 20%, and digitized periapical radiographs may underestimate the severity of resorption compared to high-resolution scans.[13]

CBCT (Cone Beam Computed Tomography) offers significant diagnostic advantages in orthodontics. It is commonly employed for 3D assessments of dental anomalies, impacted teeth, TMJ evaluation, implant planning, and detecting subtle root changes. [12] CBCT is considered the most precise method for identifying volumetric root loss due to resorption.

As such, CBCT findings may influence clinical decisions regarding whether to proceed with or modify an orthodontic treatment plan.[12]

Hence, the purpose of this study is to compare the magnitude of external apical root resorption in upper anteriors using self-ligating bracket system and conventional pre-adjusted edgewise brackets using CBCT.

Materials and Methods :

This prospective, randomized controlled clinical trial included 70 participants with an average age of 20.6 years. These individuals were randomly allocated into two groups:

- **Group I (n = 35):** Treated with passive self-ligating Damon brackets (slot size 0.022 x 0.028 inches)
- **Group II (n = 35):** Treated with conventional pre-adjusted brackets (slot size 0.022 x 0.028 inches)

All participants had Angle Class I malocclusion with anterior crowding between 3 to 6 mm. Inclusion criteria specified patients with complete permanent dentition (excluding third molars) and aged between 12 and 30 years. Individuals with prior orthodontic treatment or initial signs of external apical root resorption (EARR) were excluded. No extractions or interproximal enamel reduction (stripping) were involved in the treatment protocol. Detailed informed consent was obtained from the patients or their guardians.

Orthodontic treatment began with the alignment and leveling phase, which lasted six months.

- **For the self-ligating group (Group I):** Archwire sequence used was 0.013", 0.014", and 0.016" copper nickel-titanium (CuNiTi) wires.
- **For the conventional group (Group II):** Archwires used were 0.012", 0.014", and 0.016" nickel-titanium (NiTi) wires.

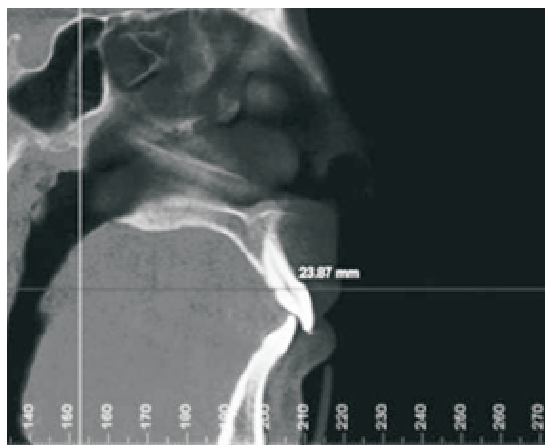
Each archwire remained in place for approximately two months before being replaced in sequence. Elastic ligatures were used to secure the archwires in Group II (conventional brackets).

CBCT imaging was conducted for all patients at two intervals: prior to treatment initiation and after six months. All scans were performed by the same experienced radiologist using identical equipment with the following settings: 22 x 16 cm field of view (FOV), 40-second scan time, 120 kVp, and 32 mA.

Root resorption in the maxillary anterior teeth was evaluated using the NNT software. For each tooth, sagittal images were generated, and a vertical sectional cut was made along the long axis, spanning from the incisal edge to the root apex (Figure 1). The EARR was calculated by subtracting the root length measured at baseline (T1) from the length at six months (T2), in millimeters.

In total, 840 anterior teeth were analyzed for resorption between the two time points.

Fig 1



Statistical Analysis:

Power analysis showed that a sample size of at least 70 patients would give an 80% probability at significance level of 5%. Data was tabulated in microsoft excel 2010 and statistical analysis was performed in R statistical package version 4.3.3. (R Core Team (2021). Descriptive statistics was given by Mean and Standard deviation. Test for normal distribution was done by Kologorovsmirnov analysis. For comparison of the Degree of Root Resorption (mm) Between T1 and T2, for normally distributed samples, paired t-test was performed, whereas for nonnormally distributed samples, wilcoxon test was performed. For intergroup comparison, between T1 and T2, since normal and non-normal distributions are randomly present, Mann Whitney U test was performed. For comparison of the Difference in Root Resorption Between Group I (Self-ligating Brackets) and Group II (Conventional Brackets) was performed with Mann Whitney U test. For all analyses, P<0.05 was considered significant

Results:

In this study table 1 depicts the comparison of Root resorption between the Group I (Self -ligating Brackets) and Group II (conventional MBT brackets) at Stage T1 (pre-treatment) and T2 (post-treatment). As per the table 1, significant changes noted from T1-T2 with Self ligating Brackets.

I.e, with respect to Maxillary Right central incisor difference from T1- T2(-0.30086), lateral incisor (-0.34771), canine difference (-0.18514).

With respect to Maxillary left central incisor difference from T1- T2(-0.25286), lateral incisor (-0.29), canine difference (-0.17514)

Among the self- ligating group highest difference from T1-T2 noted with respect to Maxillary lateral incisors followed by which central incisors and least is noted with the canines.
As the P values for the self- ligating Group is (P<0.001) which signifies that the values are statistically significant.

Significant changes also noted from T1-T2 with conventional MBT Brackets. I.e, With respect to Maxillary Right central incisor difference from T1- T2(-0.39629), lateral incisor (-0.45343), canine difference from T1- T2(-0.24057)

With respect to Maxillary left central incisor difference from T1- T2(-0.348), lateral incisor (-0.40114), canine (-0.204)

Among the Conventional MBT group highest difference from T1-T2 noted with respect to Maxillary lateral incisors followed by which central incisors and least is noted with the canines.

As the P values for the Conventional MBT Group is (P<0.001) which signifies that the values are statistically significant.

Table 1-Depicts the Comparison of the Difference in Root Resorption Between Group I (Self-ligating Brackets) and Group II (Conventional Brackets)

KS Test p Value	Maxillary Right Central Incisor	Maxillary Right lateral incisor	Maxillary Right Canine	Maxillary Left Central Incisor	Maxillary Left lateral incisor	Maxillary Left Canine
Self Ligating	0.03044	0.02889	0.03359	0.06136	0.351	0.2906
Conventional	**0.00003**	**0.02784**	**0.0176**	*0.1497*	*0.05568*	**0.034**

Table 2-Depicting mean and standard deviations of the groups

Teeth	Group	Mean_T1	SD_T1	Mean_T2	SD_T2	Difference	p Value	p<0.001	Test Used	Result
Maxillary Rt CI	Self-Ligating	24.03943	1.14875	23.73857	1.12551	-0.30086	2.56E-07	<0.001	Wilcoxon	Sig
Maxillary Rt LI	Self-Ligating	22.87286	1.50488	22.52514	1.50491	-0.34771	2.57E-07	<0.001	Wilcoxon	Sig
Maxillary Rt C	Self-Ligating	26.52743	1.72296	26.34229	1.75569	-0.18514	2.55E-07	<0.001	Wilcoxon	Sig
Maxillary Lt CI	Self-Ligating	23.81829	1.5061	23.56543	1.51357	-0.25286	8.22E-16	<0.001	paired t-test	Sig
Maxillary Lt LI	Self-Ligating	22.93886	1.44417	22.64886	1.38805	-0.29	1.93E-14	<0.001	paired t-test	Sig
Maxillary Lt C	Self-Ligating	26.33457	1.50103	26.15943	1.51763	-0.17514	1.24E-13	<0.001	paired t-test	Sig
Maxillary Rt CI	Conventional	24.01086	1.27322	23.61457	1.26226	-0.39629	2.55E-07	<0.001	Wilcoxon	Sig
Maxillary Rt LI	Conventional	22.73486	1.51951	22.28143	1.54369	-0.45343	2.55E-07	<0.001	Wilcoxon	Sig
Maxillary Rt C	Conventional	26.52429	2.06598	26.28371	2.15478	-0.24057	2.54E-07	<0.001	Wilcoxon	Sig
Maxillary Lt CI	Conventional	23.91857	1.63375	23.57057	1.67257	-0.348	9.18E-08	<0.001	paired t-test	Sig
Maxillary Lt LI	Conventional	22.58086	1.26462	22.17971	1.25732	-0.40114	2.41E-18	<0.001	paired t-test	Sig
Maxillary Lt C	Conventional	26.06371	2.30105	25.85971	2.33724	-0.204	2.53E-07	<0.001	Wilcoxon	Sig

Table 3-P Values of intergroup comparison

	Teeth	Group 1-T2	Group 2-T2	
Intergroup comparison between T2 of Group 1 and 2 (p Values)	Maxillary Right Central Incisor	0.9686	0.8539	All P values are not significant
	Maxillary Right lateral incisor	0.8803	0.7267	
	Maxillary Right Canine	0.8136	0.7945	
	Maxillary Left Central Incisor	0.7193	0.8151	
	Maxillary Left lateral incisor	0.4626	0.3588	
	Maxillary Left Canine	0.511	0.465	

Discussion:

Orthodontic treatment plays a vital role in enhancing dental aesthetics by aligning misaligned teeth, closing gaps, and correcting bite issues such as overbites and underbites. A properly aligned dentition not only improves facial appearance but also boosts confidence and social interactions. Orthodontics integrates aesthetics with functionality, promoting both a beautiful smile and optimal oral health.

Despite these benefits, orthodontic treatments are often prolonged, leading to concerns about unwanted effects. One visible side effect is the appearance of white spot lesions. However, a more concealed but significant concern is external apical root resorption (EARR), which is usually detected through radiographic imaging. According to literature, the incidence of root resorption among orthodontic patients ranges between 20% and 100%.[16]

Root resorption is a non-infectious condition characterized by the loss of both soft and hard dental tissues due to the action of clastic cells. This includes the resorption of dentin and cementum, typically resulting from factors like trauma, pulp inflammation, orthodontic movement, or physical pressure. External apical root resorption—defined by root apex blunting or shortening—is frequently observed as an adverse effect of orthodontic procedures.

EARR remains a complex, multifactorial process influenced by biological, mechanical, and treatment-related factors. It is important that both patients and clinicians understand the risks and consequences of this condition. Continuous monitoring and timely adjustments to the treatment plan can reduce its occurrence. Improvements in techniques and materials aim to minimize EARR and ensure safer outcomes.[7,17]

Radiographic assessment is recommended approximately six months after starting treatment, enabling clinicians to detect early signs of EARR and modify treatment if necessary.[13]

Traditional imaging modalities such as periapical, panoramic, and occlusal radiographs are commonly used in EARR diagnosis. However, these 2D methods require noticeable root shortening for detection. Panoramic images often overestimate root loss by over 20%, while digitized periapical films can underestimate the extent of resorption compared to high-resolution imaging like micro-CT.[2,13]

Cone Beam Computed Tomography (CBCT) has proven to be a reliable tool for detailed imaging of dental structures, including root resorption. [13] Its widespread use in areas such as TMJ evaluation, implant planning, and fracture diagnosis highlights its value in clinical orthodontics. CBCT enables precise 3D visualization, outperforming conventional 2D techniques like intraoral periapical (IOPA) and orthopantomogram (OPG). [12] As a result, CBCT can significantly influence treatment planning and decision-making in orthodontics.[13]

Lavender et al. noted that CBCT can detect root changes as early as three months into treatment, with an accuracy of up to 0.1 mm.[15] These advanced capabilities make CBCT a preferred tool for monitoring EARR in orthodontic care.

According to prior studies, orthodontists can help minimize EARR by applying light, continuous forces, ensuring bodily tooth movement, using passive self-ligating brackets to reduce friction, and limiting the movement of teeth within cortical bone.[3.6,7]

This study compared passive self-ligating brackets to conventional edgewise brackets during the alignment phase of orthodontic treatment. Seventy patients were selected and evenly distributed between both groups. The archwire

sequences were 0.013", 0.014", and 0.016" CuNiTi for the self-ligating group, and 0.012", 0.014", and 0.016" NiTi for the conventional group. Treatment was monitored over a six-month period.

Due to practical limitations, it was not feasible to have all treatments administered by a single operator. Systematic error was evaluated using the paired t-test, while random (casual) errors were estimated using Dahlberg's formula.

The six-month treatment period was scientifically chosen, as prior research suggests that this timeframe is sufficient to detect root resorption tendencies specific to each individual.[18,19]

EARR of less than 0.4 mm is generally considered negligible.[13] Power analysis indicated that a sample size of 70 would provide 80% power to detect significant differences of at least 0.4 mm between groups at a 5% significance level. This sample size was therefore adequate.

The current study focused solely on the maxillary anterior teeth (840 teeth total), as they are most frequently moved and are at the highest risk for EARR. Consistent with prior literature, the CBCT results showed that **canines exhibited the least resorption**, with averages of **0.17 mm in the self-ligating group** and **0.22 mm in the conventional group**. These results align with findings by Janson GR, Artun J, and Apajalahti S.
Among incisors, root resorption averaged **0.27 mm and 0.36 mm for central incisors**, and **0.31 mm and 0.42 mm for lateral incisors**, in the self-ligating and conventional groups respectively. These values correspond well with previously reported averages of 0.25 mm during the alignment phase.[13]

Root length differences from T1 to T2 indicated that EARR was present in both groups. However, statistically significant differences were more pronounced in **lateral incisors**, followed by **central incisors**, and least in **canines** (Table 4). This highlights the importance of tailoring treatment mechanics for teeth with vulnerable anatomy—such as lateral incisors with short, tapered, or dilacerated roots.

The reduced resorption in the self-ligating group may be attributed to the **lower forces exerted by CuNiTiarchwires**, which are more flexible and biocompatible than regular NiTi wires. Additionally, **passive self-ligating brackets** produce less friction, further reducing stress on the roots.

Combining CuNiTi wires with self-ligating brackets appears to minimize force application and reduce EARR risk. The outcomes of this study reinforce the importance of considering appliance design and wire material in optimizing treatment while minimizing adverse effects like root resorption.

Overall, the study found that self-ligating brackets with CuNiTi wires resulted in less root shortening than conventional brackets with NiTi wires, especially in the upper anterior teeth, as visualized through CBCT imaging.

Limitation:

The primary limitation of this study is its relatively small sample size. Additionally, the evaluation was limited to the alignment stage, excluding the torque and retraction phases. Since only non-extraction cases were included, the impact of these bracket systems during space closure could not be assessed.

Conclusion:

Based on the findings of this study and within its defined limitations, the following conclusions were drawn:

- External apical root resorption (EARR) was observed in both treatment groups—those using self-ligating brackets and those using conventional preadjusted MBT brackets.
- The use of self-ligating brackets resulted in a **lower degree of EARR** in the maxillary anterior teeth compared to the conventional preadjusted bracket system.
- In both groups, **lateral incisors exhibited the greatest amount of root resorption**, while **canines showed the least**.
- Although lateral incisors were the most affected in both systems, the extent of resorption was **significantly reduced in the self-ligating bracket group** when compared to the conventional MBT group.

References:

1. 1.Yi J, Li M, Li Y, Li X, Zhao Z. Root resorption during orthodontic treatment with self-ligating or conventional brackets: a systematic review and meta-analysis. BMC Oral Health. 2016; Nov 21;16(1):125
2. Jacobs C, Gebhardt PF, Jacobs V, Hechtner M, Meila D, Wehrbein H. Root resorption, treatment time and extraction rate during orthodontic treatment with self-

ligating and conventional brackets. Head Face Med. 2014 Jan 23;10(1).

3. Sameshima GT, Sinclair PM. Predicting and preventing root resorption: Part I. Diagnostic factors. Am J Orthod Dentofacial Orthop. 2001 May;119(5):505–510.
4. Wise GE, King GJ. Mechanisms of Tooth Eruption and Orthodontic Tooth Movement. JDent Res. 2008 May;87(5):414–34.
5. Alatli I, Hellsing E, Hammarström L. Orthodontically induced root resorption in rat molars after 1-hydroxyethylidene-1,1-bisphosphonate injection. Acta Odontol Scand. 1996 Jan;54(2):102–8.
6. Brezniak N, Wasserstein A. Orthodontically induced inflammatory root resorption. Part I: The basic science aspects. Angle Orthod. 2002 Apr;72(2):1759.
7. Weltman B, Vig KWL, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: a systematic review. Am J Orthod Dentofacial Orthop. 2010 Apr 1;137(4):462–76.
8. Zahed Zahedani S, Oshagh M, Momeni DanaeiSh, Roeinpeikar S. A Comparison of apical Root Resorption in Incisors after Fixed Orthodontic Treatment with Standard Edgewise and Straight Wire (MBT) Method. J Dent 2013 Sep;14(3):103-10.
9. Chen SS, Greenlee GM, Kim JE, Smith CL, Huang GJ. Systematic review of self-ligating brackets.Am J Orthod Dentofacial Orthop. 2010 Jun;137(6):726.e1-726.e18
10. Miles PG. Self-ligating brackets in orthodontics: Do they deliver what they claim? Aust Dent J. 2009 Mar;54(1):9-11.
11. Eberting JJ, Straja SR, Tuncay OC. Treatment time, outcome, and patient satisfaction comparsions of Damon and conventional brackets. Clin OrthodRes.2001 Nov;4(4):228-34.
12. Leite V, Conti AC, Navarro R, Almeida M, Oltramari-Navarro P, Almeida R. Comparison of root resorption between self-ligating and conventional preadjusted brackets using cone beam computed tomography. Angle Orthod. 2012 Nov;82(6):1078-82
13. Dudic A, Giannopoulou C, Leuzinger M, Kiliaridis S. Detection of apical root resorption after orthodontic treatment by using panoramic radiography and cone-beam computed tomography of super-high resolution. Am J Orthod Dentofacial Orthop. 2009 Apr;135(4):434-7.
14. Makedonas D, Lund H, Hansen K. Root resorption diagnosed with cone beam computed tomography after 6 months and at the end of orthodontic treatment with fixed appliances. Angle Orthod. 2013 May;83(3):389-93.
15. Levander E, Bajka R, Malmgren O. Early radiographic diagnosis of apical root resorption during orthodontic treatment: a study of maxillary incisors. Eur J Orthod. 1998 Feb;20(1):57-63.
16. Scott P, DiBiase AT, Sherriff M, Cobourne MT. Alignment efficiency of Damon3 self-ligating and conventional orthodontic bracket systems: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2008 Oct;134(4):470.e1-470.e8
17. Agarwal SS, Chopra SS, Kumar P, Jayan B, Nehra K, Sharma M. A radiographic study of external apical root resorption in patients treated with single-phase fixed orthodontic therapy. Med J Armed Forces India. 2016 Dec;72(Suppl 1):S8-S16
18. Remington DN, Joondeph DR, Artun J, Riedel RA, Chapko MK. Long-term evaluation of root resorption occurring during orthodontic treatment. Am J Orthod Dentofacial Orthop. 1989;96(1):43–46.
19. Dalhlberg G. Statistical Methods for Medical and Biological Students. London, UK: G Allen and Unwin Limited; 1948.