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REVIEW ARTICALE

A SYSTEMATIC REVIEW ON COMPARISON OF ROOT RESORPTION DURING ORTHODONTIC TREATMENT WITH PASSIVE SELF LIGATION AND CONVENTIONAL BRACKET SYSTEMS

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Bakgraund: External apical root resorption is a common side effect of fixed appliance orthodontic therapy. The most susceptible teeth are maxillary and mandibular incisors. Recently, the demand for self-ligating brackets has increased, and the effect of these bracket systems on EARR compared with conventional brackets has been a subject of clinical trials.

Materials and Methods: Studies comparing external apical root resorption between passive self-ligating and conventional bracket systems were identified through an electronic search in databases including PubMed, Cochrane Library, Google Scholar, and Scopus until September 2024. Risk of bias assessment was done using the Cochrane risk of bias tool with Review Manager 5.4.

Results: After data extraction and removal of duplicates, four randomized controlled studies and two controlled clinical trials were included in the review. Three studies were of high risk, 2 studies were of fair risk of bias, and one was of low risk of bias. The value of EARR of mandibular incisors in the passive self- ligating bracket group was observed to be lower than that in the conventional bracket group. However, no statistically significant differences were observed with EARR between passive self-ligating and conventional brackets.

Conclusion: Based on the currently available literature, the use of passive self- ligating brackets doesn't provide any advantage over conventional brackets in terms of EARR. However, passive self-ligating brackets appear to protect mandibular incisors from EARR, which still needs to be substantiated with more high-quality randomized controlled studies. There was no statistically significant difference in EARR in passive self-ligating brackets and conventional bracket.

Keywords: passive self-ligating brackets, conventional brackets, external apical root resorption (EARR), fixed orthodontic treatment.

1. INTRODUCTION

External apical root resorption (EARR) is the pathologic loss of the cementum and dentine that results in shortening of root apex. The removal of the hyalinization zone is thought to be important for physiological tooth movement [1]. It is thought to be one of the most major consequences of orthodontic treatment, which might adversely affect the success of the treatment [2]. EARR is found to be more common in the maxillary and mandibular incisors, especially the maxillary lateral incisors. [3-6].

The etiology of EARR is multifactorial, with biological and mechanical factors playing major roles. Genetic vulnerability, systemic variables such as tooth agenesis, hormone imbalance, and drug use are all biological contributors, and bracket type, orthodontic force magnitude, duration, and type, root torque, extensive tooth movement, and movement type are all mechanical elements to be considered [7]. Many studies have recently focused on the role of mechanical variables in the occurrence of EARR during orthodontic therapy. [8]. But there are only a few clinical trials that evaluated the effect of various bracket types on EARR[9–11].

A thorough research about EARR as an unfavorable effect during orthodontic treatment has been seen as a serious iatrogenic problem. According to many researchers, EARR is thought to develop most commonly during fixed orthodontic treatment [12,13]. There were studies done using periapical radiographs with the long-cone paralleling approach, panoramic radiographs (OPGs) and cone-beam computed tomography (CBCT) to evaluate the prevalence of EARR in incisors after orthodontic treatment using various active and passive SLBs against conventional brackets (CBs) [14,1516,17,18] These studies solely looked at root length loss, and they found no statistically significant difference between SLBs and CBs.[18–20].Despite the fact that numerous studies have identified EARR as an iatrogenic condition during orthodontic treatment, the relationship between orthodontic treatment-related variables and EARR has never been extensively explored. Several factors have been studied, and EARR appears to occur mostly in association with mechanical factors during orthodontic treatment[21]. According to the previous studies, light forces are known to exert less root resorption in general [22–24].The time period of the treatment and the amplitude of the force have both been found to play a role in the development of EARR.[25]. However, until today, just a few researchers have looked at the impact of bracket type on EARR [14,18,26,27].

In the 1930s, self-ligating brackets were introduced. Passive self-ligating brackets were intended to be part of a low-friction appliance that was designed to eliminate elastomeric ligation, reduce friction, promote faster tooth movement, and shorten treatment time[28]. Currently, there are only a few studies comparing passive self-ligating brackets to non-self-ligating brackets in terms of the occurrence of EARR, which concluded with no significant difference between the bracket systems. The majority of these studies used panoramic radiography, or IOPA, to assess EARR of maxillary and mandibular incisors [15,29,30]. Only a few studies have used CBCT to evaluate incisors and molars.

This systematic review attempts to critically analyze the current evidence from randomized controlled trials (RCTs) on the amount of root resorption using passive self-ligating and conventional bracket systems during orthodontic treatment.

MATERIALS AND METHODS

Protocol registration

The Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist were used to conduct this systematic review [31].

Search strategy

To find relevant publications relating to the review topic, a systematic search was conducted in various databases published between October 2008 and April 2022. Detailed search approaches were used for each database, taking into account the differences in constrained vocabulary and syntax norms. The databases searched were: PubMed Central, Cochrane Library, Google Scholar, and Scopus. ClinicalTrials.gov, dissertation abstracts, and the thesis database were used to search for unpublished literature. The search tried to retrieve all relevant studies, regardless of the language. PICO Analysis

POPULATION

Patients requiring fixed orthodontic treatment

INTERVENTION

Patients who received fixed orthodontic treatment with self-ligating bracket systems

COMPARISON

Patients who received fixed orthodontic treatment with conventional bracket systems

Outcome

Reduction in root length in millimeters or millimeter cubes.

Eligibility criteria

Inclusion criteria were as follows:

- RCTs and CCTs involving Angle's class 1 or mild class II cases with a Little's irregularity index of 4-8mm treated with conventional or passive self ligating bracket systems
- root resorption evaluated with IOPAs, CBCTs or CTs
- Studies with appropriate statistical analysis

Exclusion criteria were as follows:

- Case control studies, retrospective studies, case reports, animal studies, narrative reviews, systematic reviews

Data collection

To identify relevant publications relating to the current review , a systematic search was conducted in the databases between October 2008 and September 2024. Detailed search strategies were followed for each database, considering the differences in the controlled, constrained vocabulary and syntax norms. The following electronic databases were searched: PubMed, Cochrane Library, Google Scholar, and Scopus. ClinicalTrials.gov, dissertation abstracts, and the thesis database were used to search for unpublished literature. The search attempted to identify all the related studies, irrespective of the language. The selection process of the studies included was depicted in the Prisma flow chart (Figure 1).

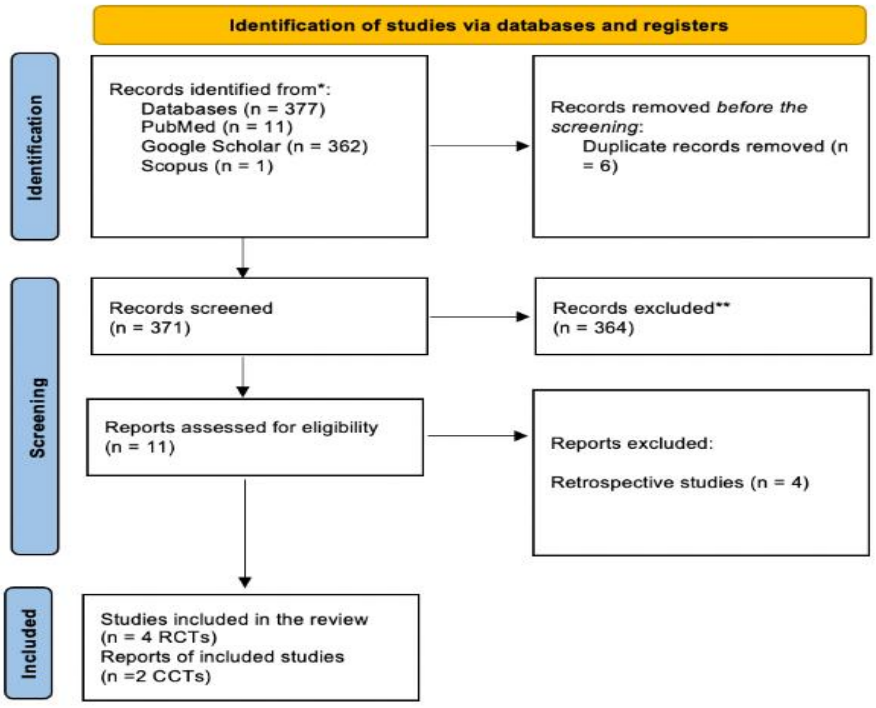

Figure 1. Prisma flow chart of the systematic review.

Risk of bias

The risk of bias of the four randomised trials included in the study was assessed using the Cochrane risk-of-bias tool for randomised trials (RoB 2) and two CCTs were assessed using New Castle Ottawa scale. The quality of the studies was appraised using the Cochrane RoB's seven criteria. Each study was assigned as high risk if one domain has high risk, unclear if one domain has unclear risk, or low risk if one has low risk. Two authors did the risk of bias separately, and disparities were resolved.

RESULTS

Search results

A total of 377 studies were extracted using various electronic databases such as PubMed Central, Cochrane Library, Google Scholar, and Scopus. Out of the 377 studies, 364 articles were excluded after title and abstract searches, and 6 articles were obtained, that is, 4 RCTs and 2 CCTs.

Characteristics of included studies

All the studies included in this systematic review were RCTs and CCTs. The participants included in the study were systemically healthy and received fixed orthodontic treatment with either conventional or self-ligating bracket systems (table 1).

Table 1 Study characteristics tablem(n- sample size, M-males, F-females)

STUDY	STUDY DESIGN	Sample size/ grps	Teeth evaluated	Parameters assessed
1.Scott et al. (2008)	RCT	Group 1- Self ligation (speed);n=30 (M12,F18;12.8± 2.3y) Group2- conventional n=33 (M16,F17;13± 2.5y)	- (11,21),(12,22),(13,23), (14,24) Group 1 20.9 ± 4.36 month Group 2 20.6 ± 4.6 month	Root resorption in percentage (periapical radiograph)
2.Aras et al. (2018)	RCT	Group1-Self ligation(Damon Q) n=16; (M 4,F 12; 15.00 ± 1.03 y) Group 2-conventional n=16; (M6, F10; 14.94 ± 1.06 y)	- Maxillary and mandibular incisors 9 months	- Root volume in millimeter cube and percentage (CBCT)
(2018)		(M 4,F 12; 15.00 ± 1.03 y) Group 2-conventional n=16; (M6, F10; 14.94 ± 1.06 y)	9 months	ano percentage (CBCT)
3.Hamma l, et al(2018)	RCT	Group1-Self ligation(Clarity) n=10(14-20 y) Group 2-conventional(Gemini MBT) n=11(14-20 y)	- Maxillary and mandibular incisors 6 months	-Root resorption in millimeter (CBCT)
4.Singh,e t ak(2018)	RCT	Group1-Self ligating(Smart clip) n=14 Group2-Conventional(3M Unitek ,MBT) n=14 Group 3 Self-ligating with tandem wires n=14	- Maxillary and mandibular incisors and molars. 6 months	- Root resorption in millimeter (CT
5. Blake et al (1995)	CCT	Group 1: Self-ligating Group 2: Conventional	Maxillary and mandibular central and lateral incisors.	IOPA in mm
6.Leite et al (2012)	CCT	Group 1: Self-ligating Group 2: Conventional	Maxillary central and lateral incisors, canine, and 1st premolar.	CBCT

Table 2. Summation of the results of the included studies

Study	Parameter	Results			Inference
		Mean± S.D		P value	
Hammad, et al(2018)	EARR in mm	self ligating Upper incisors(T1-T0)	0.03± 0.72	0.126	No significant difference
		Conventional Upper incisors(T1-T0)	-0.20± 0.59		
		self ligating Lower incisors(T1-T0)	0.14± 0.94	0.016	Significant difference
		Conventional Lower incisors(T1-T0)	-0.32± 0.72		
Aras et al. (2018)	EARR in terms of volume lose in mm3	self ligating Central incisors(T2-T1)	27.08 ± 12.71	0.712	No significant difference
		Conventional Central incisors(T2-T1)	28.29 ± 13.48		
		self ligating Lateral incisors(T2-T1)	20.32 ± 11.67	0.587	No significant difference
		Conventional Central incisors(T2-T1)	18.77 ± 11.05		

Singh, et al.(2018)	EARR in percentage	self ligating Maxillary central incisors(T2-T1)	1.533±0.138	0.617	No significant difference
		Conventional Maxillary central incisors(T2-T1)	1.643±0.802		
		self ligating Maxillary lateral incisors(T2-T1)	1.723±0.111	0.637	No significant difference
		Conventional Maxillary lateral incisors(T2-T1)	1.814±0.704		
		self ligating Maxillary first molars (mesiobuccal) (T2-T1)	1.149±0.105	0.820	No significant difference
		Conventional	1.283±2.172		
		self ligating Maxillary first molars (distobuccal) (T2-T1)	1.149±0.105	0.952	No significant difference
		Conventional Maxillary first molars (distobuccal) (T2-T1	1.283±2.172		
		self ligating Mandibular central incisors(T2-T1)	1.391±0.183	0.714	No significant difference
		Conventional Mandibular central incisors(T2-T1)	1.510±1.048		
		self ligating	0.654±0.025		
		Mandibular lateral incisors(T2-T1)	0.837±1.507	0.854	No significant difference
		Conventional Mandibular lateral incisors(T2-T1)	0.439±0.033		
		Self ligating Mandibular first molars (mesiobuccal) (T2-T1)	0.583±0.587	0.694	No significant difference
		Conventional Mandibular first molars (mesiobuccal) (T2-T1	1.033±0.082		
		Self ligating Mandibular first molars (distobuccal) (T2-T1)	1.217±0.540	0.663	No significant difference
		Conventional Mandibular first molars (distobuccal) (T2-T1			

Scott et al.(2008)	EARR in mm	self ligating Mandibular right central incisor(T3-T1) Conventional Mandibular right central incisor(T3-T1)	1.21± 3.39 2.26± 2.63	>0.05 >0.05	No statistical significance No statistical significance
Blake et al 1995	EARR in mm	self ligating Maxillary central incisor Conventional Maxillary central incisor self ligating Maxillary lateral incisor Conventional Maxillary lateral incisor self ligating Mandibular central incisor Conventional Mandibular central incisor self ligating Mandibular lateral incisor Conventional Mandibular lateral incisor	7.29 ± 6.44 9.41 ± 8.63 12.21 ± 9.25 12.83± 8.65 7.36 ± 6.86 4.60 ± 7.94 5 ± 7.63 7.27 ± 7.91	>0.05 >0.05 >0.05 >0.05	No statistical significance

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Leite et al (2012)	EARR in mm	self ligating Maxillary central incisor	-0.34	>0.05	No statistical significance
		Conventional Maxillary central incisor	-0.33		
		self ligating Maxillary lateral incisor			
		Conventional Maxillary lateral incisor	-0.43	>0.05	
		self ligating Maxillary canine			
		Conventional Maxillary canine	-0.44		
		self ligating premolar		>0.05	
		Conventional premolar	-0.39		
			-0.31	>0.05	
			-0.23		
			-0.40		

Risk of bias of the included studies

Risk of bias for the included RCTs was done using the Cochrane risk of bias tool for randomized controlled trials (ROB 2). Out of the 4 studies, the overall risk of bias for the 3 studies was high, and the remaining one study was low. Aras et al. (2018) did not mention how the study was randomized or the allocation concealment. Singh et al. (2018) did not explain how the participants and the personnel were blinded, and Scott et al. (2008) were unclear about the allocation concealment. Both CCTs were of fair quality studies.

In the study by Scott and Blake et al., periapical radiographs were used to measure external apical root resorption in millimeters. In contrast, Hammad et al., Leite and Aras et al. utilized CBCT for their assessments; however, Hammad et al. quantified root resorption in millimeters, while Aras et al. measured it in cubic millimeters and as a percentage. Additionally, Singh et al. used CT imaging to measure root resorption in millimeters. Due to the

methodological heterogeneity among these studies, conducting a meta-analysis was not feasible.

DISCUSSION

This systematic review aimed to gather data on EARR during orthodontic treatment with self-ligating versus non-self-ligating bracket systems. It included four randomized controlled trials and two controlled clinical trials, ranging from good to low quality. The findings suggest that EARR occurs with both types of bracket systems and can be detected early in the treatment process.

The randomized controlled trial by Aras et al. published in 2018 aimed to compare the external root resorption (ERR) volumetrically in maxillary incisors during orthodontic treatment using self-ligating brackets (Damon Q, DQ) or conventional brackets (Titanium Orthos, TO) [9]. There were two groups: group 1, DQ with a sample of 16 subjects (12 females, 4 males; average age = 15.00 ± 1.03 years), and group 2, TO with a sample of 16 subjects (10 females, 6 males; average age = 14.94 ± 1.06 years) . This RCT analyzed CBCT scans taken before (T1) and near the end (9 months after the initiation of treatment; T2) of the orthodontic treatment. Volumetric root changes between T1–T2 for central and lateral incisors and the amount of volumetric change comparing the DQ and TO groups were evaluated. There was no significant difference between the DQ and TO groups with respect to the loss of root volume in maxillary incisor teeth. Furthermore, the T0 group showed a higher percentage of slanted root resorption (SRR).

Another randomized controlled trial by Singh et al. published in 2018 compared external apical root resorption (EARR) before and after leveling and alignment between self-ligating (SL) brackets and conventional MBT brackets using standard and tandem wires [10]. Three groups of subjects were there: group 1, 14 patients were treated with smart clip SL appliances ; group 2, 14 patients were treated with conventional appliances ; group 3, 14 patients were treated with smart clip SL appliances, and alignment was done using tandem wires. The pretreatment (T1) and post-leveling and aligning (T2) computed tomography (CT) scans were evaluated for EARR in all three groups. Linear measurement of root length evaluation of maxillary and mandibular incisors and molars was done in the CT, and the percentage of root resorption was calculated from it. The results of the study showed significant changes in the root length were noticed in the maxillary lateral incisors ($P<0.01$), wherein the mesial aspect of mandibular first molars was minimally affected in all three groups. The mean root resorption percentage in Group I SL was comparatively lesser than group 2 conventional brackets. The study concluded that root resorption can be detected in the early stages of the orthodontic treatment. Overall, the results of this study showed that, compared to pretreatment, EARR was detected in the post-leveling and alignment phase in all three groups; however, the difference is not statistically significant.

Hammad et al. conducted a randomized clinical trial to assess labial alveolar bone thickness (LABT) and apical root resorption (ARR) of upper and lower incisors in patients undergoing the first phase of orthodontic treatment with passive self-ligating and conventional brackets. The study included two groups; group 1, self-ligating with a sample of 10 subjects, and group 2, conventional preadjusted brackets with a sample of 11 subjects. CBCT scans were assessed before the start of treatment (T0) and 6 months after the initiation of orthodontic treatment (T1). Apical root resorption was calculated in millimeters by evaluating the difference in the total tooth length, measured from the incisal edge to the root apex, between T0 and T1. One month later, 3D measurements of 9 randomly selected images were taken by the same operator to determine intra-examiner errors by means of a paired t-test. The results of the study revealed no significant difference in the root lengths of upper incisors when comparing both groups. However, on comparing the difference in lower incisors in both groups, it showed a statistically significant decrease in the ARR for Group II, conventional brackets.

There was one more randomized clinical trial by Scott et al. (2008), which was done to compare the efficiency of mandibular tooth alignment and the clinical effectiveness of a self-ligating and a conventional preadjusted edgewise orthodontic bracket system[15]. The first group had 33 subjects treated with Damon self-ligating, and the second

group had 29 subjects treated with conventional brackets. The mean root resorption values for the mandibular right central incisor were 1.21 mm (SD, 3.39) for the conventional bracket system and 2.26 mm (SD, 2.63) for the Damon bracket system. The results of the study concluded that there was no statistically significant difference between bracket type and mandibular incisor root resorption. Singh et al. (2024) found less root resorption with clear aligners than fixed appliances. Singh et al. (2025) highlighted the value of skeletal maturity assessment in timing treatment to reduce resorption risk. Savio and Nagesh (2025) linked nasal septum deviation to altered maxillary dimensions, affecting force distribution. Bhatia and Pandian (2024) and Singh and Prasad stressed the role of accurate impressions and bracket positioning in minimizing unwanted forces that can lead to root resorption[32-36].

Strengths and limitations of the study

This systematic review included randomized controlled trials and controlled clinical trials. This systematic review followed the PRISMA guidelines. Various databases were searched following a detailed search strategy for each database, considering the differences in the controlled vocabulary and syntax rules. Article search, data collection, assessment of the study characteristics, and risk of bias were performed individually by two authors and were combined together. Quality assessment of the included RCTs was done using the Cochrane risk of bias tool (RoB2).

The primary limitation of this review is the significant heterogeneity among the included studies. The four RCTs and two CCTs utilized different diagnostic modalities to assess EARR, which made it impossible to conduct a meta-analysis.

Furthermore, the number of available RCTs and CCTs was quite limited, with only one study evaluating EARR as a secondary outcome. Another factor compromising the validity of the included studies was their small sample sizes, which may impact the generalizability of the findings. Additionally, significant methodological heterogeneity among the studies prevented the possibility of conducting a meta-analysis.

CONCLUSION

Current evidence suggests that passive self-ligating brackets may cause less apical root resorption in mandibular lateral incisors compared to conventional brackets. However, only one study demonstrated a statistically significant reduction in root resorption with conventional bracket systems. More clinical trials are needed to reach a definitive conclusion. Based on the existing data, it can be concluded that there is no significant difference in EARR between passive self-ligating and conventional bracket systems.

DECLARATION

DISCLOSURE STATEMENT

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