COMPARISON OF ROOT RESORPTION DURING ORTHODONTIC TREATMENT BETWEEN SELF-LIGATING AND CONVENTIONAL BRACKETS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Introduction: The popularisation of self-ligating brackets in Orthodontics over the years has led to increase in queries whether they would have an effect on Early Apical Root Resorption (EARR) different from the conventional brackets. Therefore, a critical systematic review and meta-analysis would be favourable at this stage to understand the advantages, drawbacks and effects of self-ligating and conventional brackets on EARR during Orthodontic treatment.

Materials and methods: A substantial amount of manual and electronic search was performed via databases such as PubMed, EMBASE and Cochrane library until June, 2022. The participants of the recruited studies received Fixed Orthodontic treatment wherein comparisons were made between Self-ligating and Conventional brackets. The data extraction and evaluation of risk of bias was done. The outcomes underwent statistical pooling by using Review Manager 5.4.

Results: Seven studies were included in this systematic review and meta-analysis. Less EARR was seen in self-ligating group for maxillary central incisor. For maxillary lateral incisor, not much difference in the values was noticed. For mandibular central incisor, majority of the studies showed no significant difference in the values and for mandibular lateral incisor the EARR value showed no notable variation for both the groups.

Conclusions: On the basis of the data and literature gathered it can be well recognised that Self-ligating brackets stand to be superior than conventional brackets in multiple qualities.

Keywords: Self-ligating technique, Conventional technique, Root resorption, Systematic review, Meta-analysis

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1. Introduction

Orthodontia is a well-known specialty in the field of Dentistry which specifically deals with alignment and leveling of the teeth and correction of jaw discrepancies. To do so, fixed mechanotherapy is necessary which causes pressure to be experienced by the teeth in various amounts. The magnitude of force should be such that the lightest possible force should produce maximum results via Orthodontic tooth movement (OTM).[1]

In the process of OTM, if the magnitude of force is large enough to interrupt or completely discontinue the blood supply to the area around the periodontal ligament (PDL), then unquestionably hyalinisation is inevitable. The greater the area of hyalinisation, the longer will be the time taken to initiate OTM as there will be no differentiation of osteoclasts within the PDL as a result of which there will be a delay in the process of frontal resorption. [1]

Application of such heavier forces on teeth also results in external apical root resorption (EARR). EARR happens to be a frequent obstacle in Orthodontic treatment which can be assessed as the blunting or shortening of the root apex [2] for which routine radiographs can be used to evaluate its extent in patients undergoing Orthodontic treatment. [3]

During an Orthodontic treatment, it is of utmost importance to keep patient comfort as a priority.[4] Lately, numerous studies have concluded that mechanical forces play an essential role in the development of EARR during Orthodontic treatment but very few studies quote the effects of bracket type on EARR. Self-ligating brackets which were first introduced in the 1930s have been gaining momentum since the last few years. They claim the advantages of shorter treatment time, lesser friction and greater rate of teeth movement. Due to their multiple advantages various possibilities have been noted with respect to their effect on EARR. Previous literature in Orthodontics states that self-ligating brackets do have some noticeable effect on EARR whereas some studies quote that the effects are not significantly different from the effects occurring with the use of conventional brackets. [2]

Because of the popularisation of these brackets, questions arise whether they would have an effect on EARR different from the conventional brackets and a thorough investigation of the occurrence of EARR in self-ligating and conventional brackets has not yet been performed completely.[5]

Hence, a critical systematic review and meta-analysis would be favourable for clinicians at this stage to understand the advantages, drawbacks and effects of self-ligating and conventional brackets on EARR during Orthodontic treatment.

2. Materials And Methods

Cochrane Handbook for Systematic Reviews of Interventions[6] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses[7] were referred to while performing this systematic review and meta-analysis. The criteria for study inclusion, data extraction and examining the risk of bias were independently checked and performed. Any discrepancies in the systematic review and meta-analysis were settled by involving and discussing with multiple reviewers.

Search strategy

A substantial amount of electronic search was performed via databases such as PubMed, EMBASE and Cochrane library. MeSH headings with free text words without context were used while searching the data. The terms used were 'Orthodontics', 'self-ligating technique', 'conventional technique' and 'root resorption'. For looking up the database, the search strategies used were based on that for PubMed. The electronic search was performed on 4th June, 2022. For manual search, issues of relevant journals and the lists of references from the retrieved articles were checked for the appropriate data. While searching the literature, no language barrier was present. The studies included and their characteristics are shown in Table 1.

Table 1: Characteristics of included studies

Study	Study design	Participants	Comparisons	Outcomes (Method)	Evaluated teeth	Treatment duration
Blake et al (1995)	CCT	SL=30(M12,F18;12.8 ± 2.3y) C=33(M16,F17;13 ± 2.5y)	SL bracket (Speed, Strite inductries) vs non-SL bracket	Root resorption in percentage (periapical radiograph)	11,12,13,14,21,22, 23,24	SL:20.9 ± 4.36 month C:20.6 ± 4.6 months
Scott et al (2008)	RCT	SL= 32 (M12, F20;16.19 ± 3.68y) C= 28 (M19, F9; 16.38 ± 5.28y)	SL brackets vs non-SL bracket (Synthesis, Ormco)	Root resorption in millimeter (periapical radiograph)	41	SL:8.5 ± 2.1 month C:8.1 ± 2.7 months
Leite et al (2012)	CCT	SL= 19(20.6y,min11,max30) C= 11(M6,F5) L:n = 8(M2,F6)	SL bracket (EasyClip) vs non-SL bracket (3M)	Root resorption in millimeter (CBCT)	11,12,13,14,21,22, 23,24	6 months
Liu et al (2012)	Cohort study	SL= 35(M7,F8;15.13y) C= 35(M9,F6;14.93y)	SL bracket (Damon3, Ormco) vs non-SL bracket	Root resorption in millimeter (periapical radiographs)	11,12,13,14,21,22, 23,24	SL:20.4 ± 5.04 month C:16.8 ± 2.66 months
Chen et al (2015)	Cohort study	SL= 35(M17,F18;13.52 ± 2.84y) C= 35(M16,F19;13.42 ± 2.50y)	SL bracket (Damon3, Ormco) vs Non-SL bracket (3M)	Root resorption in millimeter (periapical radiographs)	11,12,13,14,21,22, 23,24	SL:20.53 ± 3.62 month C:20.34 ± 3.40 months
Aras et al (2016)	CCT	SL=32(M4,F12;15±1.03y) C=M6, F10;14.94±1.06)	SL bracket (Damon Q,	Root resorption in percentag	11,12,21,22	9 months

			Ormco) vs non-SL bracket	e (CBCT)		
Qin et al (2019)	Cohort study	SL=49(M25,F24;15.15±4.52Y) C=49(M26,F23;15.21±4.43y)	SL bracket (Damon, Ormco vs Non-SL bracket (3M, Unitek)	Root resorption in millimeter (periapical radiographs)	11,12,21,22	SL:20.25±5.11 months C:20.10±5.15 months
SL: Self Ligating brackets; C: Conventional brackets; M: Male, F: Female						

Criteria for included studies

The following were the inclusion criteria:

1. Type of studies – Randomised controlled trials (RCT) and controlled clinical trials (CCT).
2. Type of participants – Healthy patients requiring fixed Orthodontic treatment.
3. Type of intervention – Patients that received fixed Orthodontic treatment with Self-ligating (SL) and conventional or Non-self-ligating (NSL) brackets.
4. Outcomes – Root length reduction in millimetre or percentage.

The following were the exclusion criteria:

1. Review articles, case reports, abstracts, descriptive studies and opinion articles.
2. Animal studies
3. Studies involving patients with systemic disorders
4. Presence of root resorption before the treatment.

Data extraction and analysis

The data extraction form was customised and developed and appropriate information with respect to the participants, study design, interventions, outcomes and treatment duration were extracted.

Risk of bias evaluation

The risk of bias evaluation for the included studies was carried out by referring to the assessment form put forward by Saltaji et al[8] and Wu et al.[9] The assessment form mentioned by Jianru Yi et al in their systematic review and meta-analysis was also referred for the same.[5] The assessment for risk of bias was done on the basis of 4 main perspectives namely, study design, study measurements, statistical analysis and baseline information. The item was scored as 1 point (√) when the trial reported that particular domain well. If the trial partially fulfilled the criteria then it was scored as 0.5 (≠) and when it did not fulfill the criteria it was scored as o point (×). Hence, when the score exceeded 15 points the risk of bias was assessed to be low (low risk of bias), when between 10-15 points, the study was assessed as 'moderate risk of bias' and when below 10, the study was assessed as 'high risk of bias'.[6,7] The specific details regarding the risk of bias evaluation have been outlined in the table below (Table 2).

Table 2: Risk of bias evaluation

Study design (11√)
1. Objective – clearly defined (√)
2. Population – adequately described (√)
3. Sample size – considered adequately (√)
4. Selection criteria – clearly described (√), adequate (√)
5. Randomization or consecutive selection – stated (√)
6. Follow-up length – clearly described (√)
7. Timing – prospective design (√)
8. Type of study – RCT (√), CCT (√), Cohort (√)
Study measurements (3√)

9. Measurement method – appropriate (√)
10. Blinding – stated (√)
11. Reliability – described (√)
Statistical analysis (4√)
12. Dropouts – accounted (√)
13. Statistical analysis – appropriate (√)
14. Presentation of data – exact p-value stated (√), variability measures (SD or CI) stated (√)
Baseline (1√)
15. Datum line situation – two groups were calibrated, most consistent (√)
Maximum score : 19

Statistical analysis

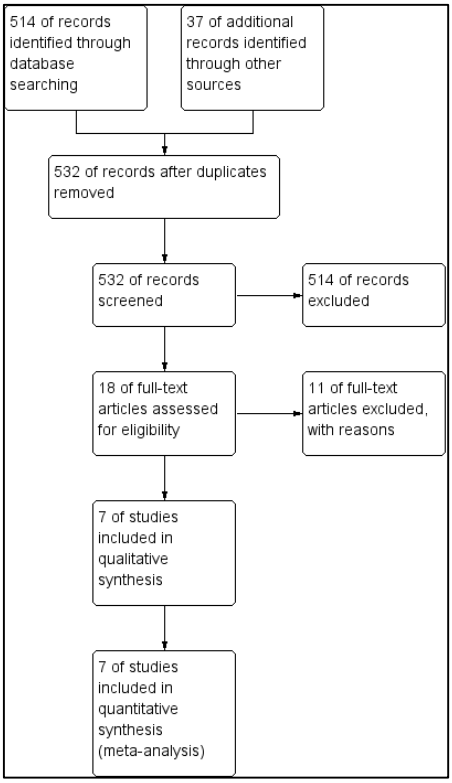
Review manager (RevMan 5.4, Nordic Cochrane Centre, Cochrane collaboration, Copenhagen, Denmark) was used for performing meta-analysis of quantitative data. For the criteria of continuous data, standardised mean difference (SMD) and its 95% confidence interval (CI) was taken on. The heterogeneity was assessed using I^2 statistic which was found to be less than 50%. Considering treatment duration subgroup analysis. To test the stability of the results, sensitivity analysis was performed.

3. Results

Search results

A total number of 551 articles were retrieved via manual and electronic searching. Of these, insignificant and peripheral citations were eliminated and 18 articles were considered potentially relevant for the review. Eventually, 7 studies fulfilled the criteria and were included to perform this systematic review and meta-analysis. A flow chart has been demonstrated to show the process of study selection (Figure 1).

Figure 1: Flowchart showing the process of study selection



Characteristics of included studies

A total of 374 participants were included in the study. The participants were healthy and received Fixed Orthodontic treatment. Among the 7 articles that were retrieved, 3 were CCT, 3 were cohort studies and 1 was RCT. The detailed information of the included studies is summarised in the table.

Risk of bias of the included studies

It was assessed that among the 7 included studies, 5 studies had low risk of bias and 2 had moderate risk of bias. All the studies included had a clearly defined objective, population, sample size, calibrated baseline information, productive follow-up length, appropriate study design, study measurements and statistical analysis.

External apical root resorption

The values of EARR were reported with respect to the maxillary central incisor, maxillary lateral incisor, mandibular central incisor and mandibular lateral incisor by 7 studies during fixed Orthodontic treatment. The data from the studies were statistically pooled for comparison of values between the two groups. The results of the meta-analysis indicated that less EARR was seen in the self-ligating group for maxillary central incisor when compared to the conventional group. For maxillary lateral incisor, not much difference in the values was noticed. On the other hand, for mandibular central incisor two studies showed more EARR with respect to the self-ligating group and the rest showed no significant difference in the values, while for mandibular lateral incisor the EARR value was increased in one study for the conventional group and the other studies showed no notable variation in the values for both the groups. Forest plots showcasing EARR in both type of brackets have been demonstrated (Fig. 2,3,4,5).

Figure 2: Forest plot of EARR in Self-ligating and Convention brackets (Maxillary central incisor)

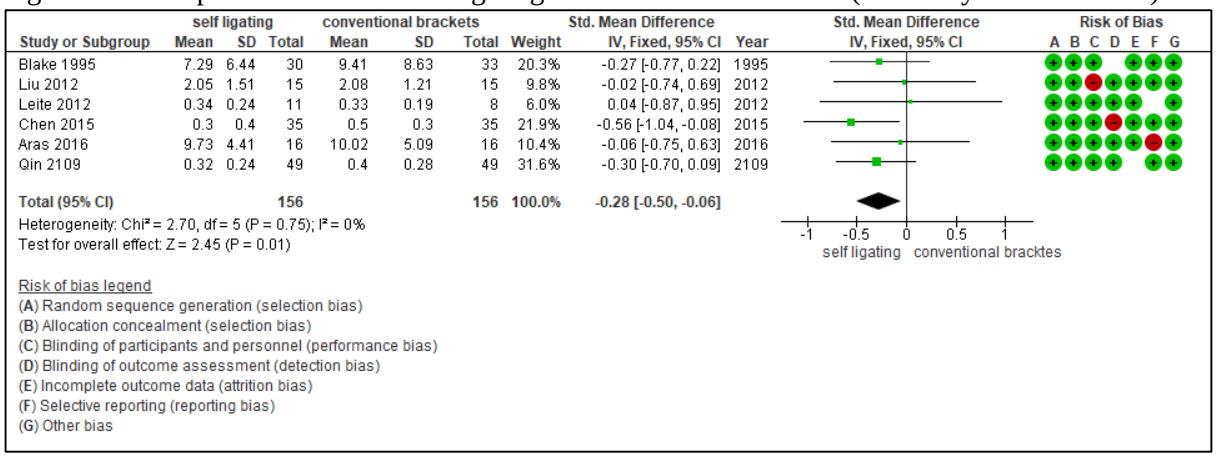


Figure 3: Forest plot of EARR in Self-ligating and Convention brackets (Maxillary lateral incisor)

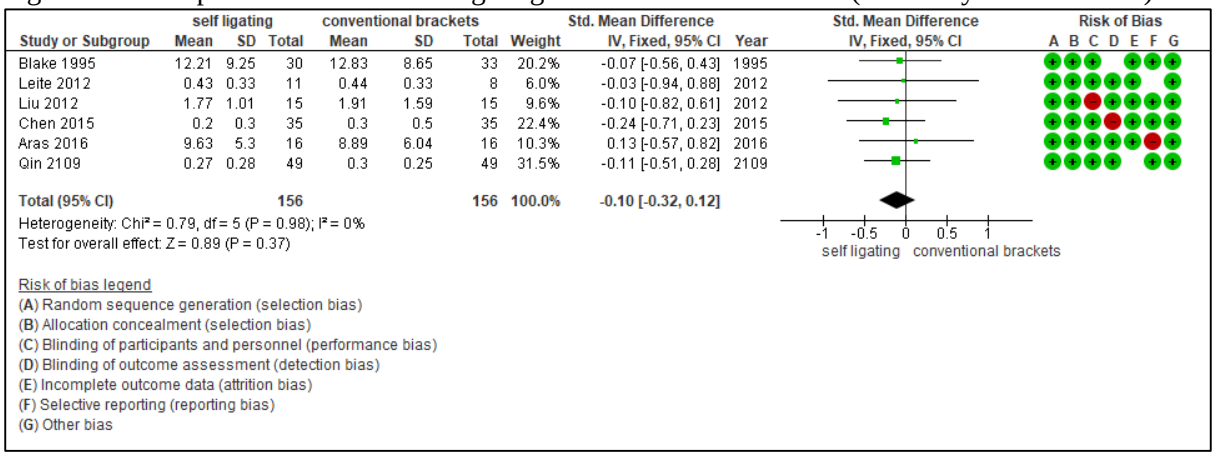


Figure 4: Forest plot of EARR in Self-ligating and Convention brackets (Mandibular central incisor)

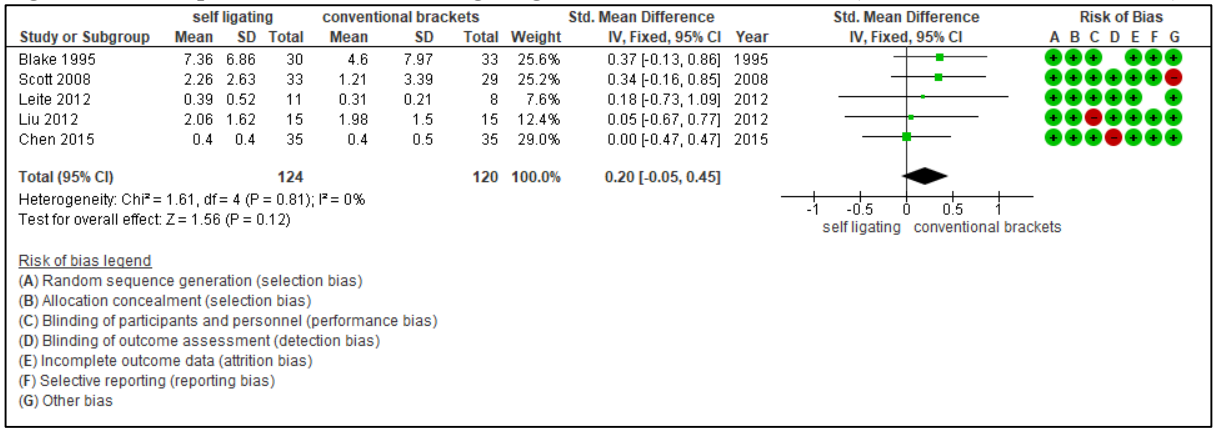
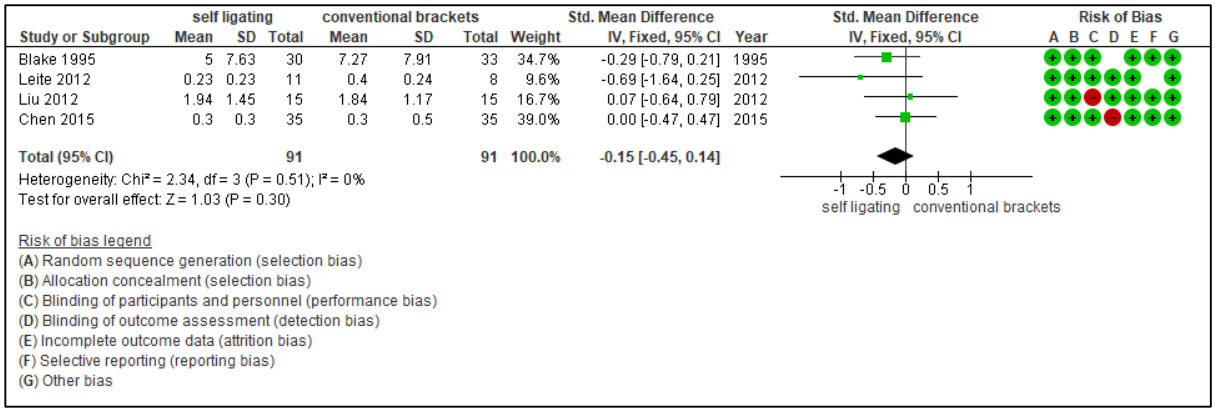


Figure 5: Forest plot of EARR in Self-ligating and Convention brackets (Mandibular lateral incisor)



Sensitivity analysis

The study by Leite et al and Aras et al used CBCT to evaluate the EARR whereas Blake et al, Liu et al, Chen et al, Scott et al used periapical radiographs and Qin et al used OPG for the same. Also, the subjects in the studies by Leite et al and Scott et al were having comparatively heterogeneous age for which sensitivity analysis was carried out wherein these two studies were omitted separately. Even after the exclusion of these studies, the overall results were found to be unaffected (Table 3).

Table 3: Sensitivity analysis

Exclusion of-	Maxillary CI[a]	Maxillary LI[b]	Mandibular CI	Mandibular LI
Scott et al	−0.31(−0.60–0.01)	−0.14(−0.43–0.16)	0.15(−0.14–0.44)	−0.15(−0.45–0.14)
Leite et al	−0.35(−0.66–0.04)	−0.15(−0.46–0.16)	0.20(−0.06–0.46)	−0.10(−0.40–0.21)

4. Discussion

This systematic review was executed so as to yield the information and data on the EARR while undergoing Orthodontic treatment using Self-ligating brackets and conventional brackets. After an extensive research procedure and evaluation, a total number of 7 articles[2,10,11,12,13,14,15] were involved in the study to perform the meta-analysis. The overall results propounded that the Self-ligating brackets are higher-ranking brackets than the conventional ones especially when EARR with respect to maxillary central incisors is of great concern.

It was also indicated that the EARR values for the conventional group for maxillary lateral incisor and mandibular central incisor were also considerably greater than the self-ligating group whereas for mandibular lateral incisor, it was observed that the conventional brackets

proved to be more efficient and superior than the self-ligating brackets in regard to EARR.

Hence, based on the evidence from the recruited studies it is prudent to opt for Self-ligating brackets over conventional brackets, especially in cases where the crown-root ratio of the teeth is reduced or when the teeth are vulnerable.

The sensitivity analysis performed for heterogeneity of the age by omitting studies of Leite et al and Scott et al also did not bring about any significant changes to the overall results. The outcomes of the meta-analysis seemed to be consistent and robust.

Studies done by Pandis et al[16], Jacobs et al[17] and Handem et al[18] were not included for the meta-analysis due to a lack of comparability of the data.

EARR is an unpredictable and undesirable outcome of Fixed Orthodontic treatment for which improvement of techniques and enhancement of skills have to be perpetually developed by the Orthodontist. According to Eugene Chan and M. Ali Darendeliler[19] it was stated that more resorption is witnessed when heavy force is exerted. But, with the concept of ligation-free Orthodontics, the archwire achieves more free space in the bracket slots of Self-ligating brackets than in the conventional brackets which could lead to experiencing lesser frictional force during the initial stage of alignment.[20,21]

Furthermore, in typical cases of maxillary protrusion, during the initial alignment stage, the roots of maxillary central incisors would move labially followed by palatal movement during the retraction stage. This reciprocating and distant movement could lead to an increased incidence of EARR in these teeth.[22]

Also, it has been suggested that the treatment duration could also be a risk factor for causing root resorption.[23] A subgroup analysis was done by Jianru Yi et al[5] in their meta-analysis wherein it was found that the protective effect of Self-ligating brackets on maxillary central incisors was significant for the long-term studies and not for the short-term studies such as Leite et al and Scott et al.[11,15] However, more studies are required to get accurate results regarding this.

Of the 7 recruited studies, 4 studies adopted periapical radiographs, 2 adopted CBCT and 1 made use of OPG for evaluating the extent of EARR. Although the EARR was assessed easily in each study, the possibility of distortion and magnification could limit the comparability of these studies and affect the overall outcomes.[24] Therefore, of late one study has suggested the use of CBCT over any other 2-dimensional approaches as it would give more reliable and valid results. CBCT allows the clinicians to visualise and assess root resorption on multiple root surfaces and discards the possibility of structural superimposition as well.[25] Nonetheless, results from more studies need to be confirmed for having a better perspective on comparing and measuring the EARR with the use of CBCT. However, its cost and radiation exposure should also be taken into consideration.

Limitations

- Although an extensive literature search was performed, only 7 studies were included for meta-analysis due to which the statistical power stands to be deficient.
- Among the recruited studies, one study assessed the percentage of EARR while the other studies evaluated the same in millimetre. Though SMD was calculated, the results should be interpreted cautiously.
- Even though the sensitivity analysis was assessed the heterogeneity of the source might not be confirmed or closely investigated.

5. Conclusion

On the basis of the data and literature gathered it can be well recognised that Self-ligating brackets stand to be superior than conventional brackets in multiple qualities such as their protecting effect on the anterior teeth and less friction generation. Therefore, they can be opted when the patient has a compromised crown-root ratio of the maxillary and mandibular incisors, especially the maxillary central incisors. To gain more knowledge regarding this concept, more clinical trials need to be conducted to support the evidence acquired by this systematic review and meta-analysis.

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