

Root resorption in patients treated with self-ligating or conventional brackets: A systematic review

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Abstract

Background: To compare the degree of external apical root resorption (EARR) in patients using self-ligating brackets with conventional brackets in a long run.

Methods: Electronic search was made in databases including PubMed, OVID, the Cochrane Library, EMBASE, FMRS, CBM, CNKI, VIP and WanFang Data until November 2019 to retrieval randomized controlled trials and clinical controlled trials that compared the EARR between patients using self-ligating or conventional brackets. What's more, manual search was made in NLM, SIGLE, Campbell library, WHOLIS, Chinese Journal of Evidence-based Medicine and the Journal of Orthodontics. Literature filtering, data extraction and methodological quality evaluation were finished independently by two researchers and disagreements were solved by a third reviewer. Original outcome data, if possible, were subjected to statistical pooling by Review Manager 5.3 for Meta analysis.

Results: Through a predefined search strategy, ten studies were included in the systematic review and nine eligible studies were pooled in meta-analysis. There was a significant difference between self-ligating and conventional brackets in terms of the value of EARR in maxillary central incisors ($P=0.01$; SMD: -0.42mm ; 95%CI: $-0.76, -0.09$) in a long run. No significant difference in maxillary lateral incisors ($P=0.07$; SMD: -0.17 ; 95%CI: $-0.35, 0.01$), mandibular central incisors ($P=0.69$; SMD: 0.04 ; 95%CI: $-0.17, 0.26$) and mandibular lateral incisors ($P=0.38$; SMD: -0.10 ; 95%CI: $-0.32, 0.12$).

Conclusions: Self-ligating brackets have a long-term effect in protecting maxillary central incisors from the EARR compared to conventional brackets. However, self-ligating brackets were not superior to conventional brackets in reducing the EARR of maxillary lateral incisors, mandible central incisors and mandible lateral incisors.

Background

External apical root resorption (EARR) which could be defined as the blunting and shortening of root apex caused by the pathologic loss of the cementum and dentine is considered as one of the most serious adverse effect during orthodontic treatment.¹

Although EARR has been considered as an iatrogenic problem associated with orthodontic treatment, the relationship between orthodontic treatment and EARR has never been fully answered. EARR presents with a multifactorial etiology, and it is the comprehensive result of individual biological variation, genetic susceptibility and mechanical factors.² Studies have shown that force magnitudes and the distance of tooth movement maybe contribute to the incidence of EARR during orthodontic treatment.^{3,4} In addition, it appears that there might be a positive correlation between treatment time, type of orthodontic force and treatment techniques,⁵ and EARR.

With the continuous updating of orthodontic appliances, self-ligating brackets have been widely used for the advantages of less friction, faster tooth movement, less orthodontic pain, more comfortable wearing

and shorter chair time.⁶ Methods of arch wire ligation are different between self-ligating brackets and conventional brackets. And then, there is the question that whether self-ligating brackets would have different effect on EARR compared with conventional brackets. Despite these was a systematic review compared the EARR between patients using self-ligating or conventional brackets,⁷ it included both short-term (about 6 months) studies and long-term (after finishing treatment) studies. It is limited evidence because the treatment duration has been considered as a risk factor to the development of EARR.⁵ This systematic review firstly only included long-term studies so that it can comprehensively and objectively evaluates the EARR in fixed orthodontic treatment with self-ligating and conventional brackets in a long run.

Methods

Protocol

The study protocol followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement⁸ and the recommendations of the Cochrane collaboration.⁹ The PICO question (population [P], intervention [I], comparison [C], and outcome [O]) was developed as follow: In patients treated with fixed orthodontic (P), does the self-ligating brackets (I) compared to conventional brackets (C) make less degree of external apical root resorption (O) based on randomized control trials (RCTs) and clinical controlled trials (CCTs)?

Search Strategy

An electronic literature search was conducted through databases including PubMed, OVID, the Cochrane Library, EMBASE, FMRS, CBM, CNKI, VIP and WanFang Data. Furthermore, related articles were hand-searched in NLM (National Library of Medicine), SIGLE (System for Information on Grey Literature in Europe), Campbell library, WHOLIS (World Health Organization's library database), Chinese Journal of Evidence-based Medicine and the Journal of Orthodontics. Terms used in the search included root resorption, root shortening, root alternation, self-ligating and self-ligating bracket. Retrieval time was set from database establishment to November 2019. No language restriction was applied during the literature search.

Criteria for included studies

The inclusion criteria were as follows: (1) Types of studies: randomized controlled trials (RCTs) or controlled clinical trials (CCTs), prospective and retrospective controlled studies; (2) Types of participants: healthy patients who required fixed orthodontic treatment; (3) Types of intervention: the experimental group and the control group used self-ligating brackets and conventional brackets; (4) Outcomes: maxillary and/or mandibular incisors root lengths before and after treatment were measured, and then calculated the reduction of root length (in millimeters and in percentage).

The exclusion criteria were as follows: (1) Studies involving patients with systemic diseases or primary periodontal disease before orthodontic treatment; (2) The reduction of root length been measured was not comparing before treatment with after treatment but in other treatment time; (3) Not the long-term (after finishing treatment) studies; (4) Animal experiments; (5) Reviews, case reports or abstracts.

Data Extraction and quality analysis

Studies were extracted and recorded independently by two reviewers (J.X and X.W) and in duplicate using a customized data collection form, on the following items: author and year of publication, study design, comparisons, participants (numbers, gender, age) and outcomes (EARR, measurement approach, evaluated teeth).

The quality assessment of RCT articles was performed referring to Cochrane Handbook for Systematic Reviews of Interventions(version 5.1.0).¹⁰ Meanwhile, quality scores were calculated by a modified version of the method described by Jadad.⁹ Otherwise, the quality evaluation of CCT articles were reformed according to the standards described in the Cochrane Handbook for Systematic Reviews Interventions and Liu.¹² The methods and results sections of each article were read and scored by two readers (J.X and X.W) independently. Then evaluators discussed their extracted data, and when discrepancy occurred, it was solved by discussing with a third reviewer (K.Y).

Data Analysis

In this systematic review, evaluation of EARR mainly includes maxillary central incisors, maxillary lateral incisors, mandibular central incisors and mandibular lateral incisors. The Review Manager 5.3 software was used for the meta-analysis of quantitative data. Statistical heterogeneity within or between groups was assessed by the Cochran's test. The outcome measure was standardized mean difference (SMD).The heterogeneity of recruited studies was explored by I^2 statistic. If there was no substantial heterogeneity ($I^2 < 50\%$), outcomes would be pooled for the meta-analysis with the fixed effect model. Otherwise, the random effect model would be adopted. Descriptive assessment was done when the statistical synthesis of data failed.

Results

Description of Studies

Finally, ten studies¹³⁻²² were included in this systematic review, among which, one was categorized as RCT¹³ and the others were CCTs¹⁴⁻²². Nine studies^{13-17,19-22} were pooled in meta-analysis. The flow of the selection process is demonstrated in Fig. 1. Summary details of included studies are given in Table 1.

Methodological Quality of Included Studies

Of the ten included studies, the one RCT¹³ was high quality, and the nine CCTs¹⁴⁻²² were A grade. The methodological quality for RCT and CCT trials are presented in Table 2 and Table 3, respectively.

External apical root resorption

Ten studies¹³⁻²² were included in this systematic review, but one study¹⁸ did not included in the meta-analysis due to the lack of comparability of data. The feasible data was statistically pooled in meta-analysis to compare the values of EARR between self-ligating and conventional brackets in a long run. A Forest plot is demonstrated in Fig. 2. According to the teeth position, the values of EARR during fixed orthodontic treatment were grouped as maxillary central incisors, maxillary lateral incisors, mandibular central incisors and mandibular lateral incisors.

Nine articles^{13-17,19-22} reported EARR of maxillary central incisors, and the meta-analysis results showed the SMD (95%CI) was -0.42 (-0.76, -0.09), with a significant difference between self-ligating and conventional brackets (P=0.01) (Fig. 2). Eight studies^{13-15,17-22} investigated EARR of maxillary lateral incisors and five studies^{15,17,19-21} were categorized into both EARR of mandibular central incisors and EARR of mandibular lateral incisors. Besides, the meta-analysis indicates that there was no significant difference in maxillary lateral incisors (P=0.07; SMD: -0.17; 95%CI: -0.35, 0.01) (Fig. 2), mandibular central incisors (P=0.69; SMD: 0.04; 95%CI: -0.17, 0.26) (Fig. 2) and mandibular lateral incisors (P=0.38; SMD: -0.10; 95%CI: -0.32, 0.12) (Fig. 2).

Table 1. Summary details of included studies.

Study ID	Design Study	Comparisons	Participants	Outcomes (Method)	Evaluated Teeth
Liu Y et al. 2016 ¹³	RCT	SLB(DamonQ, Ormco) vs CB(3M)	SLB:n=25(M11,F14;15.29±1.57y) CB:n=25(M9,F16;15.16±1.72y)	Root resorption in millimeter (CBCT)	(11,21), (12,22)
Yang et al. 2012 ¹⁴	CCT	SLB(Smartclip, 3M) vs CB(3M)	SLB:n=16(13.2y) CB:n=16(13.2y)	Root resorption in millimeter (panoramic radiographs)	(11,21), (12,22)
Liu XQ et al. 2012 ¹⁵	CCT	SLB(Damon3MX,Ormco) vs CB	SLB:n=15(M7,F8;15.13y) CB:n=15(M9,F6;14.93y)	Root resorption in millimeter (panoramic radiographs)	(11,21), (12,22), (31,42), (32,42)
Lu et al. 2017 ¹⁶	CCT	SLB(DamonQ, Ormco) vs CB	SLB:n=15(13.3±1.4y) CB:n=15(13.4±1.3y)	Root resorption in millimeter (CBCT)	(11,21)
Blake et al. 1995 ¹⁷	CCT	SLB(Speed, Strite) vs CB	SLB:n=30(M12,F18;12.8±2.3y) CB:n=33(M16,F17;13±2.5y)	Root resorption in percentage (periapical radiograph)	(11,21), (12,22), (31,41), (32,42)
Pandis et al. 2008 ¹⁸	CCT	SLB(Damon2, Ormco) vs CB(Microarch, GAC)	SLB:n=48(M17,F31;13.29±1.57y) CB:n=48(M12,F36;13.14±1.73y)	Root resorption in millimeter (panoramic radiographs)	(11,21), (12,22)
Chen et al. 2015 ¹⁹	CCT	SLB(Damon3, Ormco) vs CB(3M)	SLB:n=35(M17,F18;13.52±2.84y) CB:n=35(M16,F19;13.42±2.50y)	Root resorption in millimeter (periapical radiographs)	(11,21), (12,22), (31,41), (32,42)
Sepolia et al. 2016 ²⁰	CCT	SLB vs CB	SLB:n=70(13.92±3.01y) CB:n=70(13.81±2.940y)	Root resorption in millimeter (periapical radiographs)	(11,21), (12,22), (31,41), (32,42)
Eissa et al. 2018 ²¹	CCT	SLB(DamonQ, Ormco) vs CB	SLB:n=11(M4,F7;17.71±2.22y) CB:n=11(M6,F5;17.34±2.38y)	Root resorption in millimeter (CBCT)	(11,21), (12,22), (31,41), (32,42)
Qin et al. 2019 ²²	CCT	SLB(Damon3, Ormco) vs CB(3M)	SLB:n=49(M25,F24;15.15±4.52y) CB:n=49(M26,F23;15.21±4.43y)	Root resorption in millimeter (panoramic radiographs)	(11,21), (12,22)

Table 2. Methodological quality of selected RCT trial^a

Study	Random Sequence Generation	Allocation Concealment	Blinding	Incomplete Outcome Date	Selective Reporting	Other Bias	Jadad Score	Quality
	Liu Y et al. 2016 ¹³	Yes	Unclear	Unclear	Yes	Yes	Yes	4

Quality was categorized as low quality (1–3 Jadad scores) and high quality (4–7 Jadad scores).

Table 3. Methodological quality of selected CCT trials^a

Study	Diagnostic Criteria	Grouping Method	Blinding	Baseline Consistency	Confounder Control	Lost to Treatment	Score	Grade
Yang et al. 2012 ¹⁴	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Liu X et al. 2012 ¹⁵	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Lu et al. 2017 ¹⁶	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Good	No Lost	7	A
Blake et al. 1995 ¹⁷	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Pandis et al. 2008 ¹⁸	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Chen et al. 2015 ¹⁹	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Sepolia et al. 2016 ²⁰	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A
Eissa et al. 2018 ²¹	Clinical Diagnosis	Not Mentioned	Mentioned and described	Better	Better	No Lost	10	A
Qin et al. 2019 ²²	Clinical Diagnosis	Not Mentioned	Not Mentioned	Better	Better	No Lost	8	A

ity was categorized as A grade(10-12 score), B grade(6-9 score), and C grade(0-5score).

Discussion

External apical root resorption

A recent boost has been observed in the use of self-ligating brackets may be due to its certain advantages. One of the significant advantages is less friction, which makes teeth slide along the arch wire under the continuous orthodontic light force and reduces the force on the root.²² However, conventional brackets induce teeth under the larger intermittent orthodontic force because of the fatigue of stainless steel ligature or the aging of elastometric rings. Studies have shown that the degree of EARR caused by continuous force is more than that caused by intermittent force.^{24,25} Besides, the continuous heavy force will bring more EARR than the continuous light force.^{24,25} Aside form force type and

magnitude, EARR is also influenced by many factors including malocclusion, amount of tooth movement, treatment techniques and so on.^{5,6} It suggests that orthodontists should consider comprehensively to choose the most suitable bracket type.

The teeth more susceptible to EARR are the maxillary and mandibular incisors, and especially the maxillary central and lateral incisors.²⁶ Sameshima et al.⁵ found that different race and age have different the amount of EARR in different teeth. For example, adult patients experienced more resorption than children did in the mandibular incisors and Asian patients were found to experience significantly less root resorption than white or Hispanic patients.⁵ This meta-analysis results indicate that self-ligating bracket is superior to controversial bracket in protecting maxillary central incisors from EARR (Fig. 2) in a long run. While there was no significant difference in the EARR of maxillary lateral incisors, mandibular central incisors and mandibular lateral incisors between these two types of brackets (Fig. 2). It suggests that self-ligating bracket is a better choice than conventional bracket when using in patients with more vulnerable maxillary central incisors.

The diagnosis of EARR has been mainly through radiographs. Among the nine included studies, three studies adopted CBCT (Cone-Beam Computed Tomography), two studies employed periapical radiographs, and the other four used panoramic radiographs. Although there was no significant difference among results of studies using different radiographic methods (Fig. 2), the varied distortions and magnifications of the types of radiographs could affect the overall results. Root resorption can be underestimated because of the inherent deficiency of panoramic or periapical views to show EARR in a facial direction.²⁷ It is accepted that the 2-dimensional approaches including periapical films and panoramic radiographs may be insensitive to very minor changes in root lengths and may be less precise than CBCT in measuring EARR.²⁸ Silveira et al.²⁹ studied the ability of CBCT to diagnose EARR and suggested that CBCT has high sensitivity and excellent uniqueness. Thus, future studies should use CBCT to assess the amount of EARR in orthodontic treatment. However, the higher radiation dose of the CBCT, especially to children and adolescents, should be considered.

Limitations

The aim this systematic review is to compare the EARR in patients using self-ligating with the EARR in patients using conventional brackets during fixed orthodontic treatment. After a comprehensive literature search and evaluation, ten studies¹³⁻²² were recruited in this systematic review, and nine studies^{13-17,19-22} were pooled for meta-analysis. Among these studies, only one was RCT¹¹ and the others were CCTs¹⁴⁻²². The RCT did not describe whether allocation concealment or blinding method was adopted. Though this article was evaluated as high quality, it only got 4 Jadad scores. All of CCTs¹⁴⁻²² described diagnostic criteria, exclusion criteria and baseline conditions clearly and properly. They also included all subjects in the analysis, so there was no lost bias. Among CCTs¹⁴⁻²², seven of them identified confounding factors clearly, had reliable outcome indicators and appropriate statistical analysis, except for Lu et al.¹⁶. Whereas, all of CCTs¹⁴⁻²² did not mention grouping method, and seven of them also did not describe

blinding method apart from Eissa et al.²¹. Because of the limitation of research quantity and quality, more high-quality studies are needed to demonstrate the effect of different types of brackets on EARR.

Conclusions

Self-ligating bracket seems superior to conventional bracket in protecting maxillary central incisors from the EARR in a long run. However, there was no different influence on EARR of maxillary lateral incisors, mandible central incisors and mandible lateral incisors between these two types of brackets. There is a strong need for further research in certain directions through well-designed studies to provide more reliable evidences regarding this issue.

Abbreviations

EARR: External apical root resorption; CNKI: China National Knowledge Infrastructure; NLM: National Library of Medicine; SIGLE: System for Information on Grey Literature in Europe; WHOLIS: World Health Organization's library database; SLB: Self-ligating bracket; CB: Conventional bracket; SMD: Standardized mean difference.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JX, KY, XW, WH conducted the literature search, performed the statistical analysis and draft the manuscript. YX designed the study and revised the manuscript. All authors read and approved the final version of submission.

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Figures

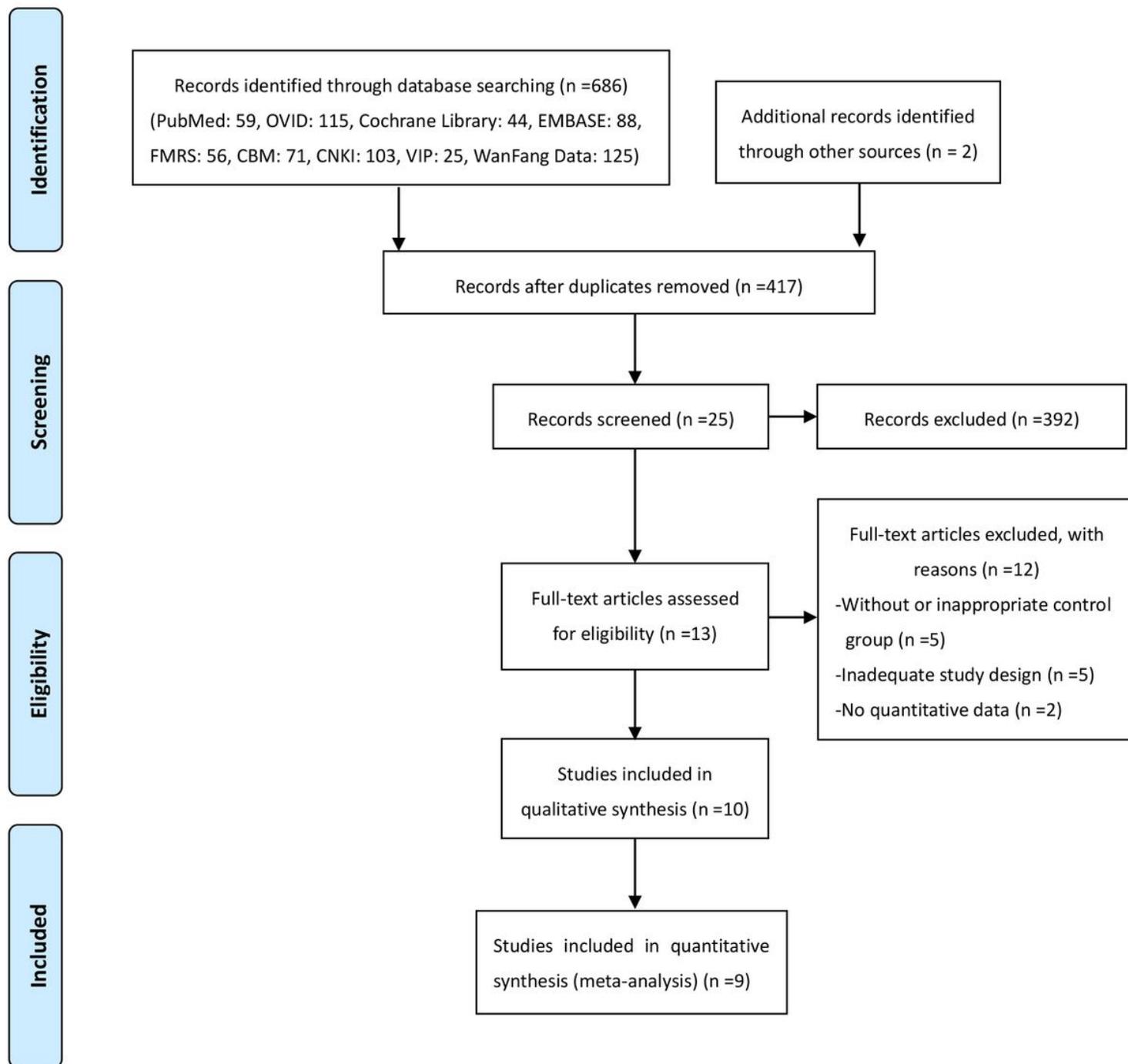


Figure 1

Flow chart summarizing the literature search

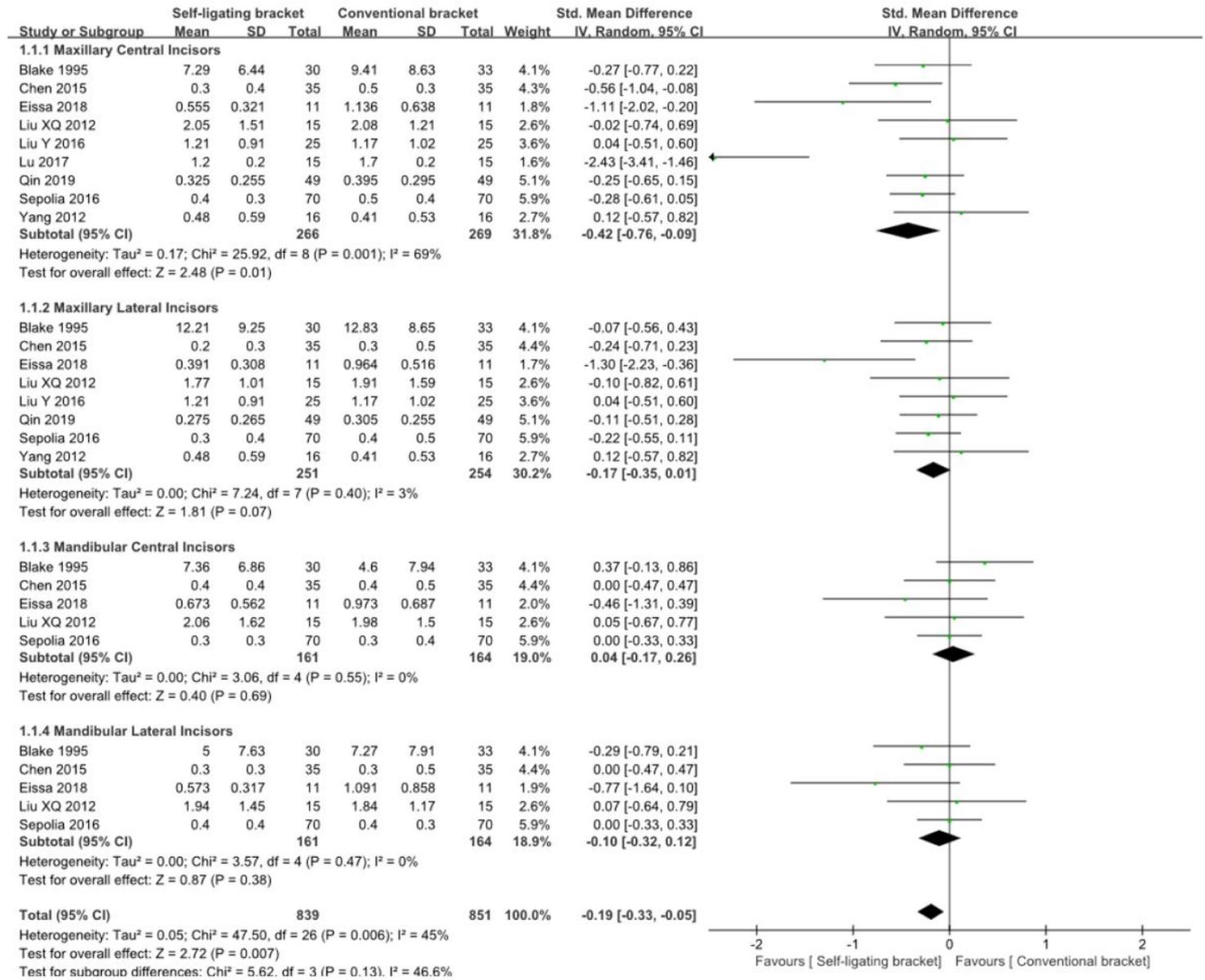


Figure 2

Meta-analysis and forest plot of ERAA values comparing self-ligating with conventional brackets