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Clinical Efficiency of Self-etching One-Step and Two-Step Adhesives in NCCL: A Systematic Review and Meta-analysis

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Clinical Relevance

One-step self-etch adhesive systems provide a clinical time gain, decreasing the number of clinical steps. When a clinician is able to follow a simpler process of adhesion there is less chance of adhesive failure.

SUMMARY

Objective: A systematic review and meta-analyses were performed to evaluate whether one-step self-etching (1SSE) adhesive systems are as effective as two-step self-etching (2SSE) adhesives in noncarious cervical lesion (NCCL) restorations.

Methods: This systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) and recorded in the PROSPERO (CRD42018096747). Electronic systematic searches were conducted in the following databases: PubMed/MEDLINE, Scopus, and Cochrane Library for published articles. Only randomized clinical trials that compared 1SSE with 2SSE adhesives systems were selected. The outcomes were retention, postoperative sensitivity, secondary caries, color match, marginal discoloration, marginal adaptation, and anatomical form.

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Results: The searches resulted in 476 studies. After applying the eligibility criteria, five randomized controlled trials were selected in which 822 restorations in NCCLs were distributed in 237 patients. The results showed no statistical difference between 1SSE and 2SSE in relation to retention (p=0.23; relative risk [RR]=1.55; 95% confidence interval [CI]=0.76, 3.19), postoperative sensitivity (p=0.50; RR=3.00; 95% CI=0.13, 70.64), Secondary caries (p=0.63; RR=0.68; 95% CI=0.14, 3.31), color match (p=0.41; RR=0.64; 95% CI=0.23, 1.83), marginal discoloration (p=0.93; RR=1.02; 95% CI=0.65, 1.61), and anatomical form (p=0.56; RR=1.38; 95% CI=0.46, 4.13). However there was statistical difference in relation to marginal adaptation (p=0.01; RR=1.95; 95% CI=1.14, 3.34).

Conclusion: This systematic review with meta-analysis revealed that both 1SSE and 2SSE adhesive systems have comparable clinical effectiveness in a follow-up period of 12 to 24 months, except in relation to marginal adaptation.

INTRODUCTION

Adhesive systems have undergone important changes in recent years, mainly by simplifying their application, without compromising adhesion to the dental substrates.[1,2] At first, three-step etch-and-rinse adhesives systems were available, and soon after, two-step self-etching (2SSE) systems were introduced. Now, one-step universal adhesive systems are available.[1]

One-step self-etching (1SSE) adhesives provide easy clinical application, reduce technical sensitivity, and are well accepted by clinicians. Although 1SSE adhesives have a simplified approach, early formulations did not promote effective dentin sealing. However, manufacturers have modified the chemical formulations of new one-step adhesives to improve their clinical performance.[3,4]

Two-step adhesives consist of acidic monomers dissolved in aqueous solution and a layer of hydrophobic resin as a second step. Single-step adhesives do not have this hydrophobic layer. The degree of demineralization of acidic monomers in self-etching adhesives depends on their pH, which may be mild, moderate, or strong.[5] Self-etching adhesives are able to infiltrate the smear layer and partially dissolve the hydroxyapatite, generating a hybrid layer with incorporated minerals.[4] The current trend is to use simplified adhesive materials, which are available from many manufacturers. Self-etching adhesive systems have become popular for clinicians[4] because they do not require preconditioning with phosphoric acid or an overwashing step; they also provide a clinical time gain over etch-and-rinse adhesives.

Generally, noncarious cervical lesions (NCCLs) are used as determinants of the clinical effectiveness of adhesives.[6] This type of restoration is usually caused by stress in the cervical region of the teeth, and the cavity formed involves dentin, which makes adhesion more difficult.[7] In addition, NCCLs present high prevalence and easy access to restoration (located in the vestibular region), do not require complicated restorative techniques, can be considered free cavities because they have a low polymerization contraction factor, and do not usually provide macromechanical retention.[3,6]

Currently, there is no consensus in the literature regarding the best adhesive indicated for clinical use in the restoration of NCCLs. The aim of this systematic review with meta-analyses was to evaluate whether 1SSE adhesive systems are as effective as 2SSE adhesives in NCCLs. The null hypothesis was that there is no difference between 1SSE and 2SSE adhesive systems for restoration retention. The second hypothesis was that there is no difference between 1SSE and 2SSE adhesives for postoperative sensitivity, secondary caries, color match, marginal discoloration, marginal adaptation, and anatomical form.

METHODS AND MATERIALS

Registration Protocol

This systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyzes (PRISMA) checklist.[8] This systematic review was recorded in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42018096747.

Eligibility Criteria

The investigated question of this study was "Are there any differences in outcomes between the 1SSE and 2SSE adhesive systems?" based on PICO criteria. In view of this, the population (P) consisted of patients with restorations in which self-etching adhesive systems were used; the intervention (I) consisted of patients with restorations using 1SSE adhesive; comparison (C) was patients with restorations using 2SSE adhesive; and outcomes (O) evaluated were

retention of restoration (primary outcome) and postoperative sensitivity, secondary caries, color match, marginal discoloration, marginal adaptation, and anatomical form (secondary outcomes).

The inclusion criteria used were randomized clinical trials (RCTs), studies with a minimum follow-up of 12 months, studies evaluating direct restorations in NCCLs of permanent teeth using 1SSE and 2SSE adhesives. The exclusion criteria were nonrandomized and retrospective studies, case reports, reviews, *in vitro* studies, animal studies, computer simulations, studies that evaluated self-etch adhesive systems with etch-and-rinse adhesives, studies reported in more than one publication with different follow-up periods and published report reviews.

Information Sources and Search Strategy

The electronic search of the literature was performed by two reviewers (CPPA and CAAL) working independently. Studies were selected and included/excluded based on the article title and abstract in the PubMed/MEDLINE, Scopus, and Cochrane Library databases using the key words "Adhesive dental AND one-step AND two-step". To complement this review, the same researchers conducted a manual search for articles published in the following journals: *Operative Dentistry*, *Dental Materials*, *Journal of Dentistry*, *Journal of Adhesive Dentistry*, *American Journal of Dentistry*, *Brazilian Dental Journal*, and *Clinical Oral Investigations*. In addition, OpenGrey (www.opengrey.eu) was used to search gray literature. The electronic search was conducted until July 2019 without limiting the year of publication during searches.

The studies were initially selected and classified according to the inclusion/exclusion criteria by reading the title and abstract. Studies that did not clearly fit the inclusion/exclusion criteria were downloaded and read in full, and then a decision was made to include or exclude in the review. A third researcher (EPP) analyzed all the differences in choices between the researchers, and a consensus was achieved.

Data Analysis

One of the authors (CPPA) collected important information from the articles, and a second author (CAAL) reviewed all the information collected. A careful analysis was performed to verify disagreements between the authors, and a third author (EPP) was consulted to obtain consensus.

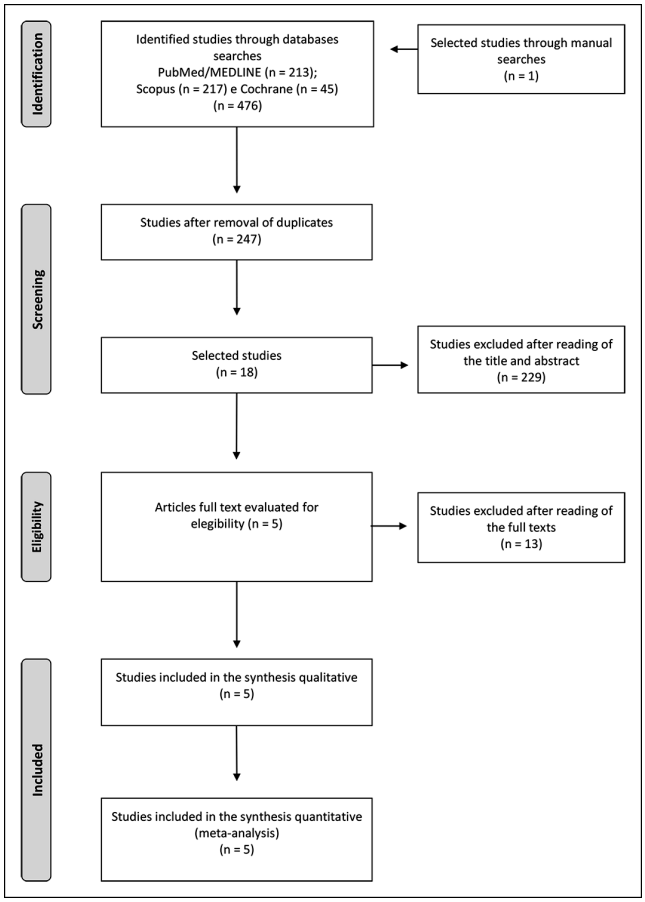

Figure 1 *Flow diagram of the study.*

Risk of Bias

Two investigators (CPPA and CAAL) evaluated the methodologic quality of the studies according to the Cochrane bias risk tool for RCT studies to verify the level of evidence from the studies included in the review.

Summary Measures

The meta-analyses were based on the Mantel-Haenzel and inverse variance methods. 1SSE and 2SSE were used in the study to assess the effects of the treatment on the body. The relative risk (RR) and 95% confidence interval (CI) were calculated for each study, The RR values were considered significant at $p<0.05$. The extracted data were analyzed using Review Manager software (RevMan) 5.3 (The Cochrane Collaboration, Copenhagen, Denmark).

Additional Analysis

The Kappa score[9] test was used to calculate the level of concordance between authors during the article selection process in the PubMed/MEDLINE, Scopus,

Table 1: *Reasons Studies Were Excluded (n=13)*

Reason
Only two-step self-etching adhesive system[1]
Only one-step self-etching adhesive system[10]
Class I and II restorations[11]
Orthodontic bracket adhesion failure[12]
Etch-and-rinse adhesive system[13-19]
Sealant evaluation[20]
Primary teeth[21]

and Cochrane Library databases. Any disagreements were resolved by discussion and the consensus of all authors.

RESULTS

Literature Search

The initial database search resulted in 476 references, 213 in PubMed/MEDLINE, 217 in Scopus, 45 in the Cochrane Library, and 1 via manual searches. After duplicate references were removed, a detailed review of the titles and abstracts of the selected studies was performed, and 247 articles remained. After detailed analysis, the inclusion/exclusion criteria were applied, and 18 complete articles were downloaded and selected for further analysis. After reading the articles completely, 13 were excluded (Table 1), resulting in five articles selected for this systematic review and meta-analysis (Figure 1). The level of agreement among researchers during the initial article selection process was PubMed/MEDLINE (0.91), Scopus (0.90), and the Cochrane Library (1.00). The values indicated a high level of agreement among the reviewers according to the Kappa criterion.

Characteristics of Included Studies

The characteristics of the included studies are detailed in Table 2. All five articles selected were RCTs.[7,22-25] In total, 822 NCCL-type restorations were performed in 237 patients with a mean age of 45 years. Four different 1SSE adhesives systems and three 2SSE adhesive systems were used (Table 2). The mean follow-up was 18 months.

The main inclusion criteria for the studies were NCCLs with no more than three restorations per study participant.[22] We found that 46.4% of the restorations were maxillary and 53.6% were mandibular, with a fairly homogeneous distribution of restorations. In general, restorations did not involve more than 50% of the cavosurface margin in enamel, and 75% of the restoration surface was in dentin.

In all five included studies,[7,22-25] researchers evaluated their outcomes through the United States Public Health Service criteria, and usually the follow-up examinations were performed every three months with a maximum follow-up of 24 months. All five studies evaluated retention of the restoration, besides marginal discoloration, secondary caries, and marginal adaptation. Only three studies assessed anatomical form[22,23,25] and postoperative sensitivity.[7,22,24] Among the included studies, four[22-25] evaluated color match. Detailed data from the studies are described in Table 3.

The one-step adhesive systems used were Xeno III (Dentsply, York, PA, USA), Clearfil S3 Bond (Kuraray, Okayama, Japan), Adper Easy Bond (3M ESPE, St Paul, MN, USA), Xeno V + (Dentsply), and the two-step systems were Clearfil Protect Bond (Kuraray); Clearfil SE Bond (Kuraray), and Adper Scotchbond SE (3M ESPE).

Three composite resins were used. One study[23] used Filtek Supreme Plus (3M ESPE), two studies[7,22] used Esthet-X HD (Dentsply), and two other studies[24,25] used AP-X resin, (Kuraray).

Assessment of the Risk of Bias

The risk of bias was assessed using the Cochrane bias risk tool for RCT studies to verify the level of evidence from the studies. The findings indicated a high risk of bias for blinding of participants[22,23]; an unclear risk of bias to allocation,[7] blinding of

Table 2: *Characteristics of Included Studies (n=5)*

Author, Year, Reference	Study	Patients, n	NCCL, n	Average Age, y	Follow-up, mo	Adhesive System	
						Intervention: 1SSE	Control: 2SSE
Pena and others (2016)[7]	RCT	25	112	NR	24	Xeno V+ (n=28)	Clearfil SE Bond (n=28)
Türkün and others (2005)[22]	RCT	35	163	44	12	Xeno III (n=75)	Clearfil Protect Bond (n=85)
Perdigão and others (2012)[23]	RCT	39	125	47.6	18	Adper Easy Bond (n=28)	Adper Scotchbond SE (n=26)
Zhou and others (2009)[24]	RCT	124	342	42.5	12	Clearfil Tri-S Bond (n=115)	Clearfil SE Bond (n=116)
Brackett and others (2010)[25]	RCT	14	80	46	24	Clearfil S3 Bond (n=40)	Clearfil SE Bond (n=40)

Abbreviations: 1SSE, one-step self-etching; 2SSE, two-step self-etching; NCCL, noncarious cervical lesion; NR, not reported; RCT, randomized clinical trial.

Table 3: *Qualitative Characteristics of Included Studies (n=5)*

Author, Year, Reference	1SSE		2SSE	
	Failure	Total	Failure	Total
Pena and others (2016)[7]	Retention (n=1)	28	Retention (n=0)	28
	Postoperative sensitivity (n=1)		Postoperative sensitivity (n=0)	
	Secondary caries (n=0)		Secondary caries (n=0)	
	Color match (non)		Color match (non)	
	Marginal discoloration (n=5)		Marginal discoloration (n=1)	
	Marginal adaptation (n=2)		Marginal adaptation (n=0)	
	Anatomical form (non)		Anatomical form (non)	
Türkün and others (2005)[22]	Retention (n=3)	75	Retention (n=0)	85
	Postoperative sensitivity (n=0)		Postoperative sensitivity (n=0)	
	Secondary caries (n=0)		Secondary caries (n=0)	
	Color match (n=0)		Color match (n=1)	
	Marginal discoloration (n=2)		Marginal discoloration (n=1)	
	Marginal adaptation (n=1)		Marginal adaptation (n=0)	
	Anatomical form (n=2)		Anatomical form (n=1)	
Perdigão and others (2012)[23]	Retention (n=2)	26	Retention (n=2)	22
	Postoperative sensitivity (n=0)		Postoperative sensitivity (n n=0)	
	Secondary caries (n=2)		Secondary caries (n=2)	
	Color match (n=2)		Color match (n=3)	
	Marginal discoloration (n=8)		Marginal discoloration (n=8)	
	Marginal adaptation (n=14)		Marginal adaptation (n=6)	
	Anatomical form (n=4)		Anatomical form (n=3)	
Zhou and others (2009)[24]	Retention (n=3)	115	Retention (n=2)	116
	Postoperative sensitivity (n=0)		Postoperative sensitivity (n=0)	
	Secondary caries (n=0)		Secondary caries (n=0)	
	Color match (n=1)		Color match (n=2)	
	Marginal discoloration (n=8)		Marginal discoloration (n=8)	
	Marginal adaptation (n=4)		Marginal adaptation (n=3)	
	Anatomical form (none)		Anatomical form (none)	
Brackett and others (2010)[25]	Retention (n=7)	37	Retention (n=6)	37
	Postoperative sensitivity (n=none)		Postoperative sensitivity (n=none)	
	Secondary caries (n=0)		Secondary caries (n=1)	
	Color match (n=2)		Color match (n=2)	
	Marginal discoloration (n=8)		Marginal discoloration (n=12)	
	Marginal adaptation (n=4)		Marginal adaptation (n=6)	
	Anatomical form (n=6)		Anatomical form (n=1)	
Total		281		288

Abbreviations: 1SSE, one-step self-etching; 2SSE, two-step self-etching.

participants,[7,24] and incomplete outcome[25]; and a low risk for other biases, where it was shown that the studies were of high quality (Figure 2).

Meta-analyses

Primary Outcome—Five studies[7,22-25] were selected for quantitative analysis comparing 1SSE adhesive systems and 2SSE adhesive systems. The meta-analysis showed no statistically significant difference between 1SSE and 2SSE regarding retention (p=0.23; RR=1.55; 95% CI=0.76, 3.19) (Figure 3).

Secondary Outcome—Regarding postoperative sensitivity, three studies[7,22,24] were included for quantitative analysis. The data showed no statistically significant difference between 1SSE and 2SSE (p=0.50; RR=3.00; 95% CI=0.13, 70.64) (Figure 4). The same was observed for secondary caries[7,22-25] (p=0.63; RR=0.68; 95% CI=0.14, 3.31) (Figure 5), color match[22-25] (p=0.41; RR=0.64; 95% CI=0.23,

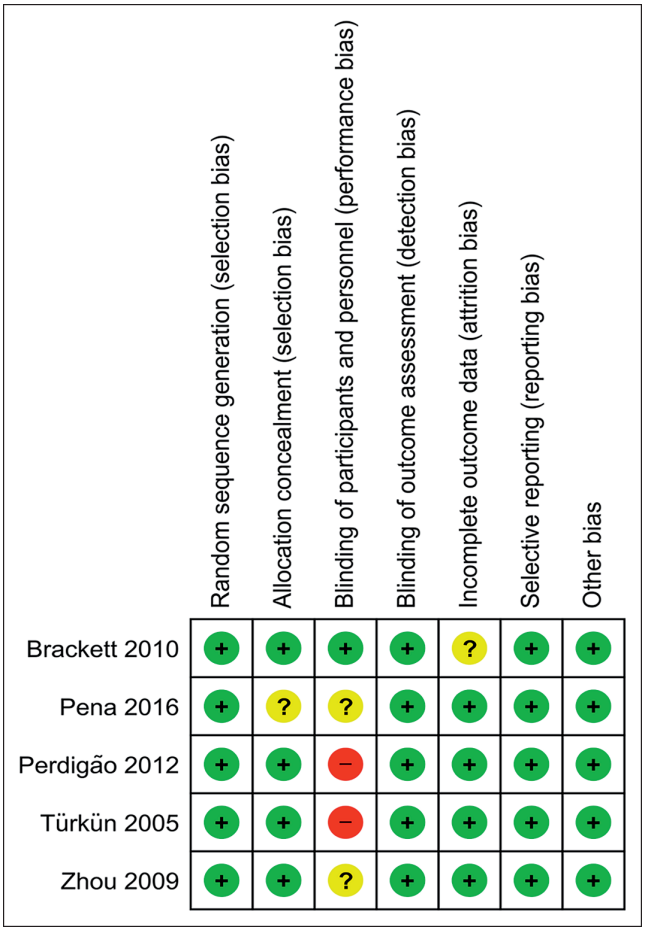

Figure 2. *Risk of study bias.*

1.83) (Figure 6), marginal discoloration[7,22-25] (p=0.93; RR=1.02; 95% CI=0.65, 1.61) (Figure 7), and anatomical form[22-25] (p=0.56; RR=1.38; 95% CI=0.46, 4.13) (Figure 8). However, there was statistical difference in relation to marginal adaptation favorable to group 2SSE (p=0.01; RR=1.95; 95% CI=1.14, 3.34) (Figure 9).

DISCUSSION

The null hypothesis of this study stating that there is no difference between 1SSE and 2SSE adhesives regarding restoration retention systems was accepted. The meta-analysis showed that there was no statistically significant difference between the results for 1SSE and 2SSE (p=0.23; RR=1.55; 95% CI=0.76, 3.19) (Figure 3). These data are in agreement with other studies.[24,26,27] It is worth mentioning that the similarity between self-etching adhesive systems will allow a greater use of 1SSE systems since they will promote simplification in the technique, optimizing clinical time.[3]

All restorations evaluated in the included studies[7,22-25] were performed in NCCLs because clinical evaluation of adhesive systems is often performed in this type of cavity.[5] They present a greater amount of sclerosed dentin, occlusal forces that emphasize the cervical third of teeth, minimal retention, and margins that are not only enamel but also extend to the dentin[4]; they are also subject to high stress during chewing[28,29] and are anatomically located in a region where there is a high dissipation of occlusal forces, factors that contribute to difficulty in retention. However, all the restorations evaluated presented clinical requirements proposed by the American Dental Association requiring a survival rate $\geq$90% of the restorations placed after 18 months of follow-up, regardless of the type of adhesive system (1SSE or 2SSE).[7]

Pena and others[7] state that there is a similarity between systems only initially to restorative treatment and that with increasing follow-up, one-step systems are not able to support mechanical fatigue or hydrolysis, causing failure. This is related to the application technique of adhesive systems. In two-step adhesive systems (2SSE), the primer acid is applied, with subsequent application of hydrophobic monomers.[7,30,31] In the one-step system (1SSE), the composition of hydrophilic and hydrophobic monomers are present in the same solution.[7] Hydrophilic monomers can collect water on the substrate or adhesive.[1] The clinician can control this mechanism of water sorption at the moment the adhesive is applied through the correct drying of the substrate, thereby avoiding risks of failure.[3] However, when evaluating the data from the included studies, it was not possible to observe a correlation between the one-step technique and the failures of the restorations.

A systematic review[3] found an increase in postoperative sensitivity when using conventional adhesive systems compared with self-etching adhesive systems. Also, among the self-etching adhesives, some studies[7,23] stated that one-step adhesives (1SSE) allowed a greater control of postoperative sensitivity. However, the included studies found similarity between the systems (1SSE and 2SSE) (p=0.50; RR=3.00; 95% CI=0.13, 70.64), which is justified by the presence of dentin sclerosis in NCCLs and composite resin that will serve as insulators, thus masking the role of the adhesive system in the postoperative sensitivity.

The meta-analyses showed no difference between the 1SSE and 2SSE adhesive systems for postoperative sensitivity, occurrence of secondary caries,

Figure 3 - Forest plot Retention

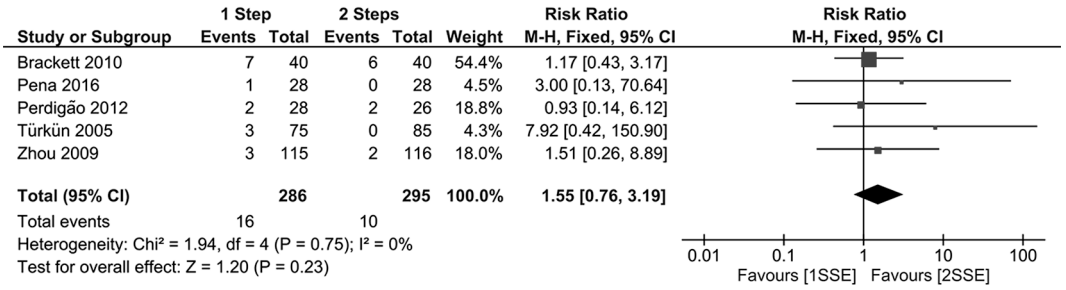

Figure 4 - Forest plot Postoperative Sensitivity

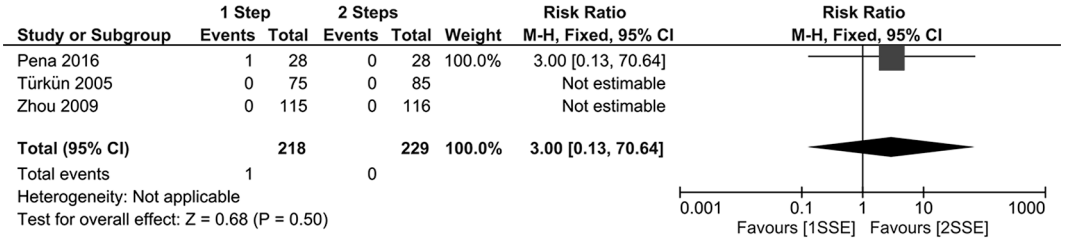

Figure 5 - Forest plot Secondary Caries

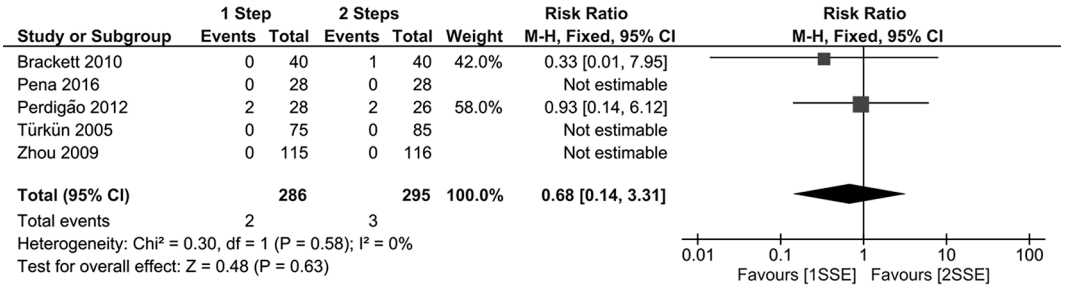

Figure 6 - Forest plot Color Match

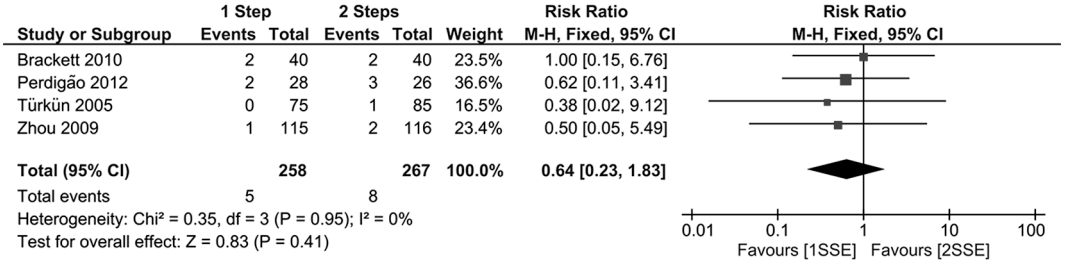

Figure 3. *Forest plots of the retention outcome.*

Figure 4. *Forest plots of the postoperative sensitivity outcome.*

Figure 5. *Forest plots of the secondary caries outcome.*

Figure 6. *Forest plots of the color match outcome.*

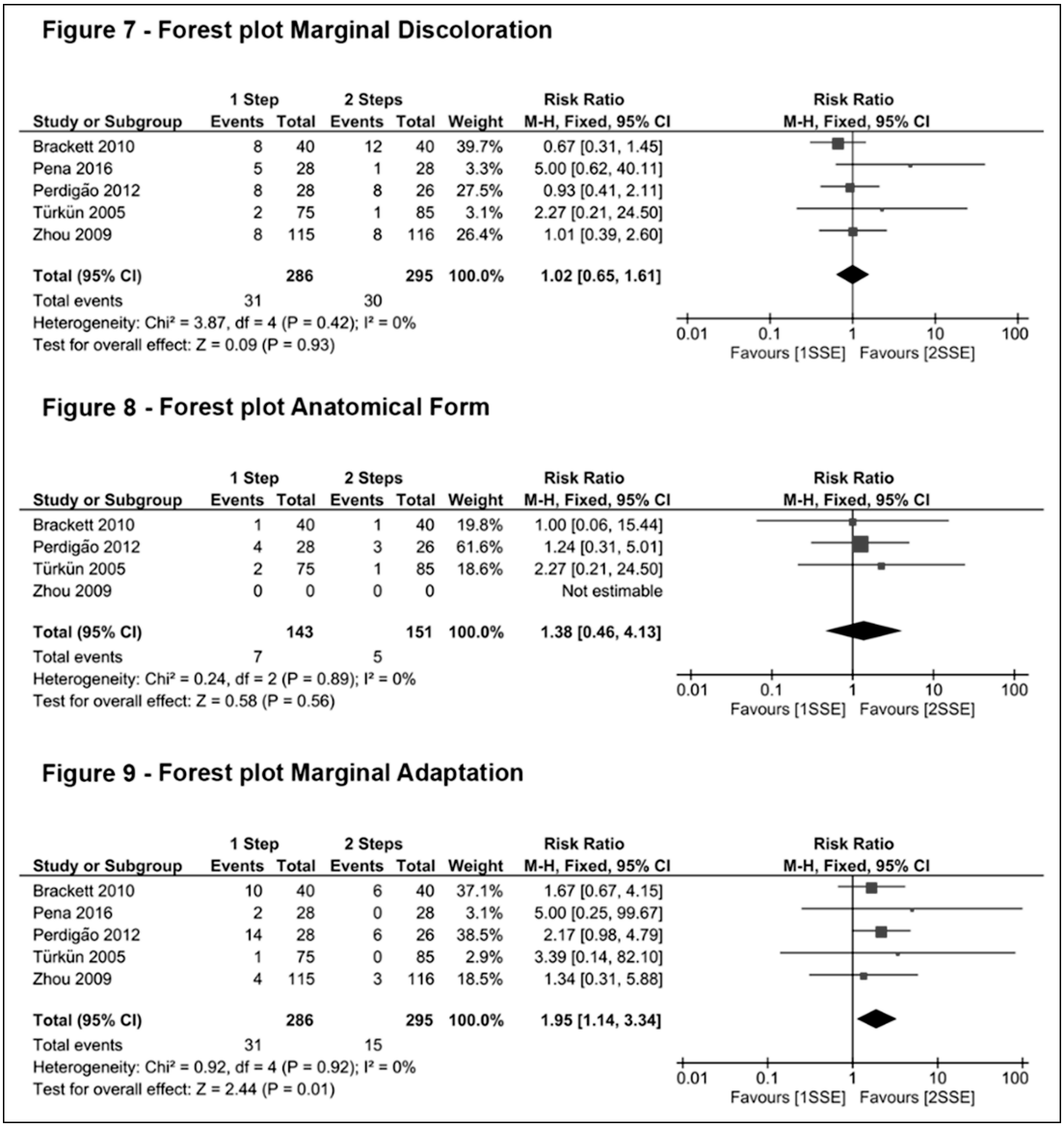

Figure 7. *Forest plots of the marginal discoloration outcome.*

Figure 8. *Forest plots of the anatomical form outcome.*

Figure 9. *Forest plots of the marginal adaptation outcome.*

color match, marginal discoloration, and anatomical form. However, regarding marginal adaptation, there was statistical difference favorable to group 2SSE (p=0.01; RR=1.95; 95% CI=1.14, 3.34), so the second hypothesis of this study was rejected. One of the difficulties of adhesion on the margins of NCCLs is that they have a substrate in both dentin and enamel.[32] Studies[23,26] have found that a disadvantage of the use of self-etching adhesives (1SSE and/or 2SSE) is in deficient acid conditioning of enamel compared with conventional systems. However, the results of this systematic review and meta-analysis, which only looked at self-etching adhesive systems (1SSE and 2SSE), showed minimal adjustments regarding retention, color match, marginal discoloration and anatomical form in enamel[7,25] and excellent results of absence of secondary caries. Similar results were found in other studies.[4,32]

All included studies were RCTs; clinical trials can provide reliable and direct evidence to guide clinicians in choosing dental materials, RCTs represent

the standard design for evaluating health care interventions. Well-designed RCTs and systematic reviews of well-designed RCTs are on the top of the hierarchy of the levels of evidence.[33] The quality of the studies was analyzed from the Cochrane scale, where the high risk of bias observed for blinding is justified by the clinical technique used in applying the adhesive, which makes it difficult to screen the examiners. The results of this review should be interpreted with caution because of the small number of clinical trials evaluated. Other RCTs with longer observation periods are still needed.

CONCLUSIONS

This systematic review with meta-analysis revealed that both 1SSE and 2SSE adhesive systems have comparable clinical effectiveness in a follow-up period of 12 to 24 months, except for marginal adaptation.

Acknowledgements

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Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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