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RESEARCH ARTICLE
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DENTAL ADHESIVE MATERIALS

Nawaf Fahad alsudairi[1*], Khalid Mohammed Faqihi[2], Khaled Rasheed Alssum[3], Abdurahman Suliman Alhissan[4], Tariq othman alothman[5], Huda Mohammad Aba Hussein[6], Laila Hamad Ahmad Almakrami[7], Saud Fahad Abdulaziz Al Abdulwahed[8], Mohammed AlMughmis[9], Abdulrahman Saleh Alissa[10]

[1*,2,3,4,5,6,7,8,9,10]General Dentist, North of Riyadh Dental Center, Riyadh

[*]**Corresponding author:** Nawaf Fahad alsudairi
*General Dentist, North of Riyadh Dental Center, Riyadh

Abstract

Background: Deep, uncleanable carious cavities are formed when the tooth structure is severely destroyed by the ongoing mineral loss from the caries process. Resin-modified glass ionomer cements (RMGICs) are the most widely utilized pulp protection compounds.

Aim: to boost the integrity of the tooth/composite restorative contact and the efficiency of dental adhesives.

Patients and Methods: This research complied with the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Items for Reporting for Systematic Reviews and Meta-analyses (PRISMA) recommendations. Comprehensive literature search from the databases' establishment to January 2022 was done using PubMed/Medline, Scopus, and Embase. From our literature search, we were able to locate 430 records.

Results: Neither the self-etch nor the etch-and-rinse methods showed any variations. The etch-and-rinse method is significantly better than self-itch in Intermediately strong universal adhesives with the corresponding MD and 95%CI=9.27(5,13.5), p-value<0.0001. heterogeneity was observed among the pooled studies with chi-p<0.00001, and I2=92%. The dentin micro tensile strength of bond for ultra-mild universal adhesives with pooled MD and 95%CI=12.1(7.6, 16.6), p-value=0.00001, was enhanced by the etch-and-rinse method. Our pooled research showed chi-p=0.00001 and I2=94% heterogeneity.

Conclusion: We found that There were no distinctions between the self-etch and etch-and-rinse methods, indicating that both can form strong enough bonds to effectively block the water diffusion pathway via the restoration-tooth interface and prevent hydrolysis-induced component degradation.

Keywords: Dental Adhesive Materials, Deep caries lesions, Etch-and-rinse approach, Resin-modified glass ionomer cements (RMGICs).

Introduction

Untreated dental caries continues to be a significant issue for oral health worldwide. Deep, uncleanable carious cavities that may need restorative treatment are formed when the tooth structure is severely destroyed by the ongoing mineral loss from the caries process. Selective caries removal procedures are among the least invasive protocols used in the current restorative care of deep caries lesions. Demineralized dentin is left in the deepest region using this procedure to lessen the possibility of iatrogenic injury to the crucial pulp-dentin complex beneath. **(1)**.

To aid in the remineralization of the demineralized dentin, the materials should also induce the release of ions like fluoride. Furthermore, the substances shouldn't be very harmful to pulpal cells. **(2)**. Resin-modified glass ionomer cements are the most widely utilized pulp protection compounds (RMGICs). Desirable clinical traits such command set, fluoride discharge, and self-adhesion to dentin are shown by RMGICs. **(3)**.

To improve resin composites' long-term clinical performance, techniques have concentrated on reducing the impacts of materials with elevated filler loading's viscosity and polymerization shrinkage. **(4)**. Promising results have also been observed as regard the integrity of the tooth/composite restorative interface and the efficiency of dental adhesives. Examples include creating a bioactive substance that can destroy germs that have been left behind during preparation and those that have infiltrated the tooth-restoration interface through microleakage, as well as encouraging the remineralization of the collagen underneath the hybrid layer .**(5)**.

The creation of innovative technologies for a broad range of applications is anticipated to be influenced by advanced biomaterials that draw inspiration from biological systems and processes. These factors suggest that novel biomaterials and technologies are essential to the advancement of contemporary dentistry, and the creation of these tools necessitates high-caliber, interdisciplinary research. Gaining an understanding of the latest developments in dental biomaterials would enable one to identify the most effective applications and treatment plans for enhancing patient results. **(6)**.

The aim of the research was to boost the integrity of the tooth/composite restorative contact and the efficiency of dental adhesives.

Methods

The present investigation complied with the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Items for Reporting for Systematic Reviews and Meta-analyses (PRISMA) recommendations.

Inclusion criteria: were English-language research papers that examined the impact of nanoparticles on composite-based materials (resin composites, adhesive systems, and RMGIC) conducted in in vivo, vitro, and in situ.

Exclusion criteria: studies for which the inclusion requirements were not met.

Literature search

Using the following keyword combinations, a thorough literature search was done via the Scopus, PubMed/Medline, and Embase databases from the time these databases were created to January 2022: "biomaterials" AND nanotechnology AND dentistry AND dental adhesives OR dentin bonding AND resin composites. Endnote (Clarivate Analytics, PA, USA) was utilized to eliminate duplicates. After that, the retrieved references were screened twice: first, the full-text articles of the recognized abstracts were screened for final eligibility to meta-analysis, and the titles and abstracts of all realized papers were screened separately by all authors to determine relevance to this meta-analysis.

Process of data collection and data elements

Data were extracted on a typical data extraction sheet. Data that were obtained comprised outcome measures, risk of bias categories, features of the research included, and features of the included research' population.

Evaluating the potential for bias in the specific investigations

As per the March 2011 update of the Cochrane Handbook of Systematic Reviews of Interventions 5.1.0, the Cochrane ROB1 tool was used to evaluate the quality of the retrieved RCTs.

Data synthesis

We combined the 95% confidence intervals (CIs) with the median changes (M.C.s) for our continuous evaluated outcomes in our meta-analysis. With a 95% confidence interval, proportional results were

combined. If the impact estimate was pooled from homogenous studies, the fixed impact model was utilized initially; if not, the random impact model was utilized. Utilizing the I^2 statistics chi^2 test, we examined the statistical heterogeneity across studies. Results with chi^2-p > 0.1 were deemed heterogeneous, while $I^2 \geq 50\%$ suggested considerable heterogeneity. Review Manager software (RevMan) version 5.4. was performed for single-arm analysis of continuous outcomes, while R software was used for single-arm meta-analysis of dichotomous outcomes and subgroup meta-analysis.

Results

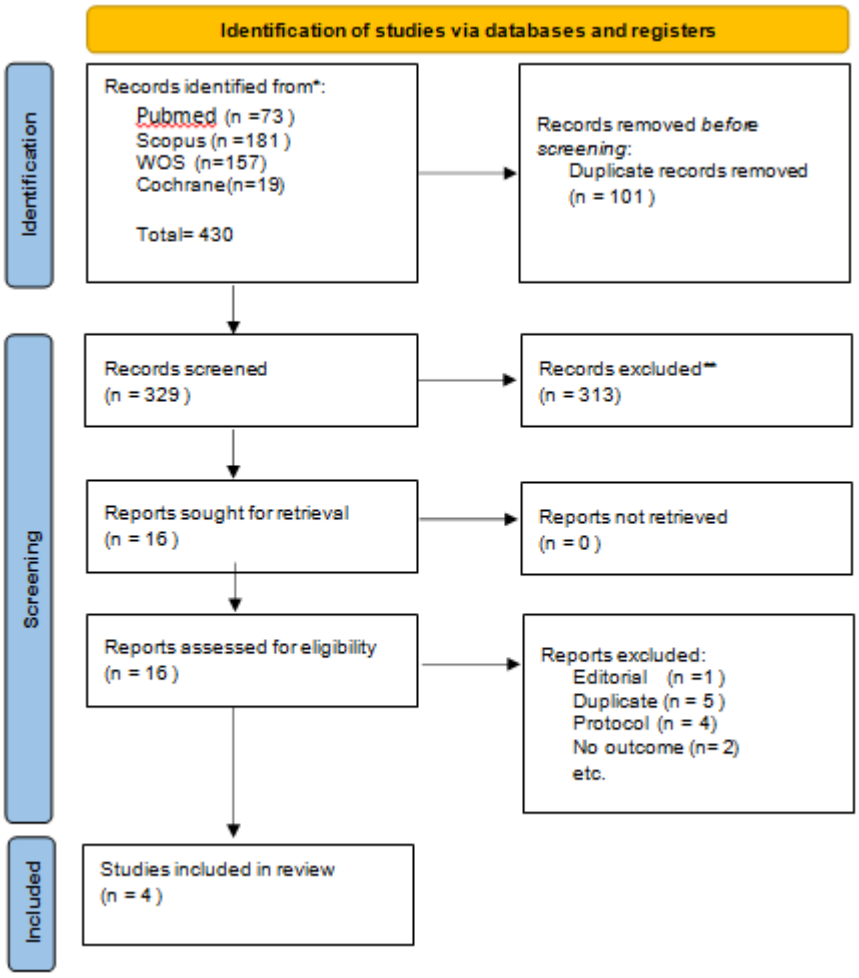

Figure 1: The process flow diagram for PRISMA used in study selection

Our literature search process retrieved 430 records. One hundred and one duplicated records were excluded using Endnote. 16 articles passed the title and abstract screening and may go on to the full-text screening phase. Four of the studies found their way into the meta-analysis. After a manual search of the included studies' references, no further papers were found.

Table 1: Summary of the features of the included investigations

Study ID	Country	Annual tooth number	Primary findings	Predominant failure mode
Ayar **(7)**	Turkey	60 (10)	Enamel SBS	Adhesive
Ballyram **(8)**	South Africa	120 (20)	Dentin SBS	Adhesive
Chen **(9)**	United States	200 (10)	Dentin μTBS	Mixed
Cardenes **(10)**	Brazil	63 (24)	Enamel μSBS	Adhesive

This systematic review and meta-analysis consisted of four papers. Regarding predominant failure mode, the three studies of Ayar, Ballyram and Cardenes were adhesive and the study of Chen was mixed.

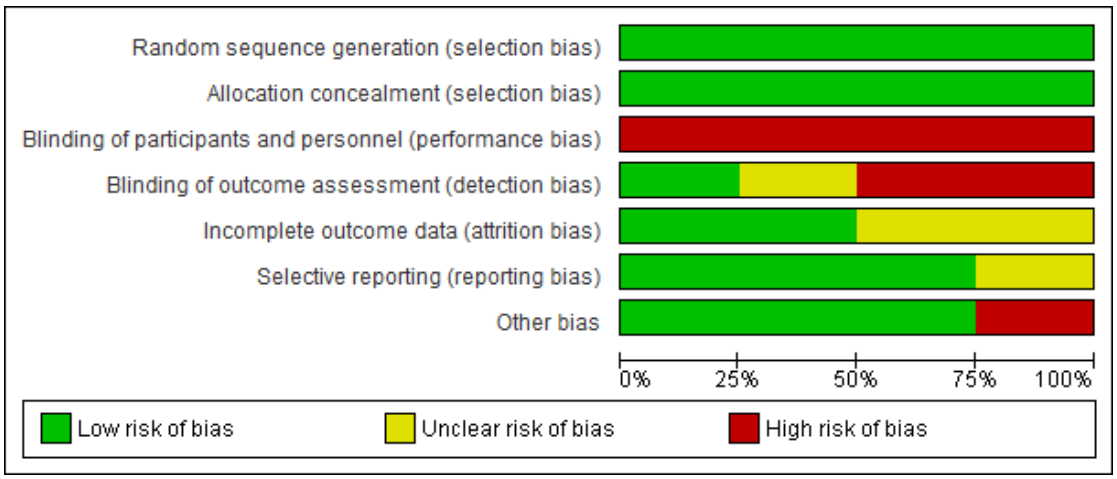

Figure 2: Bias Assessment Risk

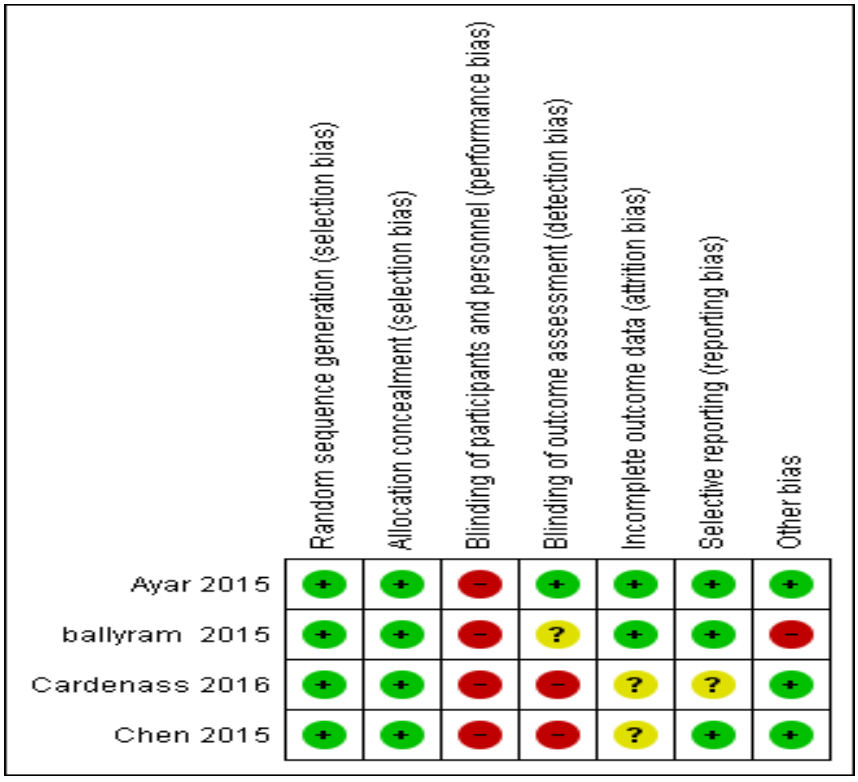

Figure 3: Bias summarized risk

Our four RCTs had a low risk of bias as regard the Cochrane ROB tool 1 To See ROB graph and summary.

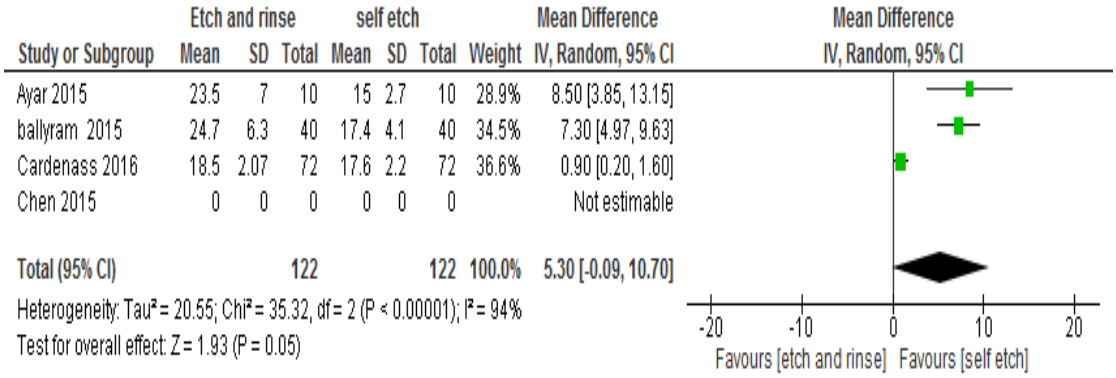

Figure 4: Forest plot for mild universal adhesives.

The results indicate that there is no substantial variation between the etch-and-rinse and self-etch methods. This indicates that both approaches have the potential to form strong enough bonds to effectively block the water diffusion pathway via the restoration-tooth interface, thereby limiting the hydrolysis of the restoration's constituent parts with MDs and a corresponding 95%CI=5.3(-0.09,10.7) and p-value=0.05. Our combined research showed chi-p=0.00001 and I2=94% heterogeneity.

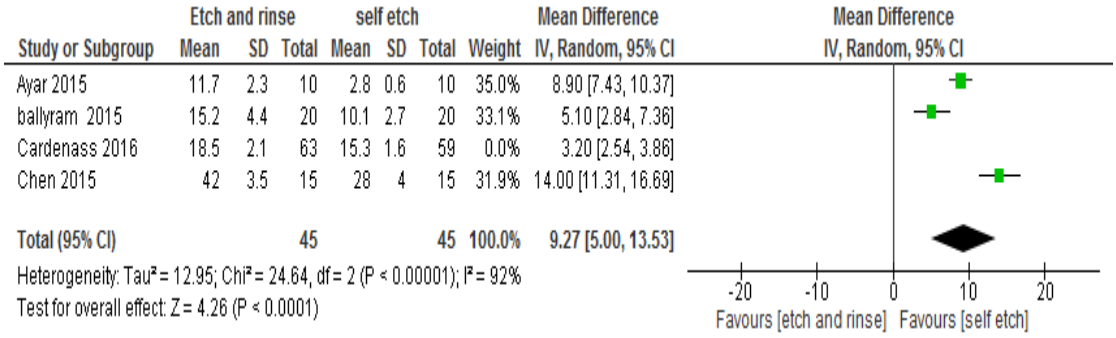

Figure 5: Forest plot for intermediately powerful universal adhesives

The etch-and-rinse method is significantly better than self-itch in Intermediately strong universal adhesives with the corresponding MD and 95%CI=9.27(5,13.5), p-value<0.0001. heterogeneity was observed among the pooled studies with chi-p<0.00001, and I2=92%.

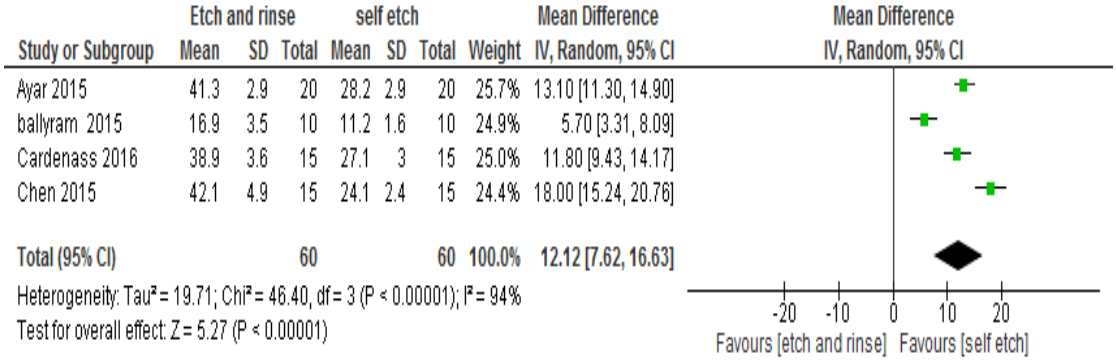

Figure 6: Forest plot for ultra-mild universal adhesives

The dentin micro tensile bonding strength for ultra-mild universal adhesives with pooled MD and 95%CI=12.1(7.6, 16.6), p-value=0.00001, was enhanced by the etch-and-rinse method. Our combined research showed chi-p=0.00001 and I2=94% heterogeneity.

Discussion

The adhesives that are available today may be divided into two categories based on how they adhere: self-etch adhesives and etch-and-rinse adhesives. After the dental substrates (enamel and dentin) have been completely etched with phosphoric acid, etch-and-rinse adhesives are applied. However, because the dental substrate is simultaneously etched and primed by monomers with acidic functional groups found in self-etching adhesives, they do not need the acid etching phase. **(11)**.

Clinicians may now choose between these two adhesive kinds. Van Meerbeek **(12)** reports that both kinds of adhesives have shown promising results in both laboratory and clinical studies, despite their significant product reliance. The available data indicates that the self-etch method may provide sufficient dentin bonding. **(13)**. Nevertheless, this approach has shown some difficulties with enamel bonding **(14).** It has been stated that etch-and-rinse adhesives have a stronger adhesion to enamel than self-etch adhesives. **(12)**. Therefore, it has been advised to selectively etch enamel using phosphoric acid in a separate step before applying self-etching adhesives. **(15)**.

The current meta-analysis included 4 studies **(7-10)** and the pooled data showed that There were no distinctions between the two methods, indicating that both can form strong enough bonds to effectively block the water diffusion pathway via the restoration-tooth interface and prevent hydrolysis-induced component degradation.

This is consistent with a meta-analysis and systematic review conducted by **Cuevas-Suarez et al., (11)** who included 59 in vitro studies and revealed that both methods, can achieve bond strength stability.

As well, **DA ROSA et al., (16)** showed that the etch-and-rinse and self-etch modes of universal adhesive did not differ statistically from one another, and the long-term bond strength declined in comparison to the immediate, according to an analysis of the dentin's immediate and long-term bond strengths without taking the aging mode into account.

Additionally, a meta-analysis and systematic review conducted by **Masarwa et al., (17)** revealed that Regarding the durability of Dentin Bonds, there was no discernible distinction between the two techniques.

Mild universal adhesives' ability to attach to dentin did not rely on the bonding technique used, indicating that there may be more than one way to utilize these adhesives. Research with moderate self-etch adhesives has shown that dentin becomes partly demineralized upon application, resulting in a significant quantity of hydroxyapatite crystals around the collagen fibrils. Consequently, self-etch adhesives may have two types of interactions with dentin: chemical and micromechanical. **(12)**. Similar to what happens with traditional etch-and-rinse adhesives, the in-situ polymerization of the monomers that penetrated into the dentin tissue is what causes the micromechanical contact. **(11)**.

The current evidence from the included studies **(7-10)** suggested that the etch-and-rinse technique is substantially better than self-itch in Intermediately strong universal adhesives.

According to the present investigation, the research performed by **Cuevas-Suarez et al., (11)** revealed that the etch-and-rinse method increased the enamel binding strength of universal adhesives ($p < 0.05$). This impact was seen in dentin for universal adhesives with moderate strength ($p < 0.05$).

The acid etching stage of an etch-and-rinse method partially dissolves the mineral composition of dentin, that include the layer of smears. **(18)**. When reapplying the adhesive, the water between the collagen fibrils is replaced by monomers that enter the collagen network. **(19)**. Subsequently, the hybrid layer is formed by in situ polymerization, and when resin tags are present within the dentinal tubules, this gives the composite repair micromechanical retention. **(20)**.

All aging processes tested here resulted in a considerable reduction in the dentin bond strength of intermediately powerful universal adhesives, regardless of the bonding approach utilized. The elevated acidity of the unpolymerized monomers explains these reduced results, which persists after light activation and demineralizes dentin. This leads to dentin-adhesive contacts with poor hydrolytic stability and low-stability chemical reactions with collagen. **(12)**.

The present systematic review and meta-analysis indicated that the etch-and-rinse procedure raised the dentin microtensile strength of bonds for ultra-mild universal adhesives.

In line with **Cuevas-Suarez et al., (11)** who revealed that the etch-and-rinse method increased the enamel binding strength of universal adhesives ($p < 0.05$). This impact was seen in dentin for very mild strong universal adhesives ($p < 0.05$). Regardless of the technique used, adhesives with an intermediate strength shown a reduce in bond strength during all aging processes. The ultra-mild universal adhesives utilized in the etch-and-rinse method likewise showed this effect ($p < 0.05$). It should be noted that while the etch-and-rinse technique enhanced the ultra-mild universal adhesives' initial binding strength, using phosphoric acid led to a reduce in the strength of the bonds after aging. According to a past research, treating with phosphoric acid before applying a one-step adhesive may have a negative long-term effect on the endurance of dentin bonds. **(21)**. The reason for this behavior is that hydroxyapatite, which is necessary to create chemical bonds, is removed when dentin is etched with phosphoric acid. **(22)**. Furthermore, over-drying etched surfaces may cause the collagen network to collapse, which stops monomers from penetrating the decalcified dentin. **(23)**.

Conclusion

In our study, we increased the durability of the tooth/composite restorative contact and the efficacy of dental adhesives. Accordingly, we found that There were no distinctions between the self-etch and etch-and-rinse methods, indicating that both can form strong enough bonds to effectively block the water diffusion pathway via the restoration-tooth interface and prevent hydrolysis-induced component degradation. Furthermore, we demonstrated that The etch-and-rinse technique enhanced the dentin microtensile strength of bonds for ultra-mild universal adhesives.

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