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Investigation of the most efficient dentin bonding protocol for noncarious cervical lesions

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Abstract

Introduction and objective: The treatment and improving non-carious cervical lesions (NCCLs) has a significant role in oral health. The present study was conducted aimed to determine the best bonding protocol for these lesions.

Methods: A global search was done in the databases and 27 articles associated to the topic were selected. The selected records were the articles published during the years 2000 and 2022. 10358 records were obtained from the initial search. At the initial step after that, 4088 records were removed due to duplication as well as the ones that did not meet the inclusion criteria or were inappropriate due to their indirect connection with the subject (858 records). Then 831 articles were retrieved for full text review.

Results: The results indicated that in 33.33% of the reviewed articles, there was no difference between different bonding techniques in terms of performance or durability and preservation. Besides, the results demonstrated that in 29.62% of the studied articles, the administered self-etch adhesives techniques had yield weaker results in terms of performance, survival and durability, marginal staining and decay. It's while, in 18.51% of the reviewed studies, one- and two-step self-etch adhesive techniques showed a better performance and in 40.7% of them a better performance was reported for etching and rinsing techniques.

Conclusion: The evidence obtained from the present study indicates that compared to the self-etch technique, other methods such as etching and rinsing technique

yields better clinical results in terms of durability, marginal consistency and marginal staining.

Keywords: Noncarious cervical lesions (NCCLs), Self-etching, etching and rinsing, marginal staining, marginal compatibility, persistence

Introduction

Non-carious cervical lesions (NCCLs) are one of the most common lesions that affect dental structures (1-3). It seems that several factors have role in the happening of NCCLs, among which we can mention tooth erosion, attrition and abfraction (AF) (4-5). These lesions are usually associated with dentin hypersensitivity because of the exposure of the dentin to the oral environment (6). Although dental restoration with composite resins does not cure the main cause of the disease, it replaces the lost tissue, restores the structural integrity of the tooth, and reduces further dental wear (7). Despite these advantages, the restoration of NCCLs remains challenging due to the availability of blocking mineral salts in the dentinal tubules as well as a hyper mineralized surface that resists self-etch primers and conditioning of Phosphoric acid. Besides, one of the main challenges associated with NCCL restorations is difficulty in controlling moisture as cervical lesions are usually closer to or even in subgingival zones (8).

Due to the particular functional, mechanical and aesthetic features of resin-based dental composites, they are the most prevalent dental restorative materials used in everyday dentistry (9). To achieve a long-term adhesion to enamel and dentin, there is a need to use adhesive systems with composite materials (10). Based on their interaction with the smear layer and the number of steps used during teeth bonding process, dental adhesives can be classified into two categories including etch and rinse (EAR) systems (2 and 3 stages) and self-etching (SE) system (1 and 2-stage) (11-12). In an attempt to overcome the problems related to the technique's sensitivity as well as providing a more user-friendly approach in a clinically acceptable time frame, a universal (or multimode) bottle of glue has been introduced. These materials represent the latest generation of dental adhesives and based on the manufacturers claim, they can be effectively used in EAR, SE, or selective enamel etching (Syntac SE) mode (13). They are known as "universal" due to the addition of functional monomers such as 10-Methacryloyloxydecyl dihydrogen phosphate (10-MDP, MDP Monomer) which can chemically bond to tooth tissues as well as metal/composite/ceramic restorations of teeth. Finally, when they are used in the EAR mode, the need for moisture control is considered less critical for successful bonding compared to previous adhesive systems (14).

Precise diagnosis and choosing an appropriate treatment method should be based on surgical and reconstructive considerations to ensure successful treatment of NCCL. Yang et al (15) indicated that NCCLs associated with gingival recession require special attention in both hard and soft tissue lesion aspects. Türkün et al (16) in their study through comparing the clinical performance of a two-step self-etch adhesive system and a one-step self-etch adhesive system over one year showed that the performance of both systems was excellent during their one-year clinical trial. However, the two-stage system showed slightly better retention than the one-stage system. Brackett et al. (17) investigated the two-year clinical performance of a self-etching primer and a self-etching adhesive both of which using the same acidic monomer. They reported that there was no statistically significant difference between the two adhesives in

terms of their overall performance. Tuncer et al (18) performed a study in 2013 regarding comparing the clinical performance of cervical reconstructions after 24 months using etch-and-rinse adhesive resulted a more durability than all-in-one dental adhesive (18).

On the other hand, Perdigão et al (19) selected 125 NCCL and envestigated four groups as follow: 1) three-step etching and rinsing adhesive, Adper Scotch bond Multi-Purpose Adhesive (MP, 3M ESPE, St Paul, MN, USA); 2) two-step etching and rinsing adhesive, Adper™ Single Bond Plus Adhesive (SB, 3M ESPE); 3) two-step self-etch adhesive, Adper™ Scotch bond™ SE - Self-Etch Adhesive (SE, 3M ESPE); and 4) One-step self-etch adhesive, Adper™ Easy Bond Self-Etch Adhesive (EB, 3M ESPE). They indicated that air sensitivity for all adhesives decreased significantly from pre- to post-operative stage and then was stable. Surface staining of teeth did not change statistically from beginning to six months. However, surface staining at the enamel margin for filling after 18 months was statistically worse compared to the beginning for both EB and SE self-etch adhesives. Marginal compliance was statistically worse after 18 months compared to beginning only for EB. In general, it was declared that although the 18-month durability was similar for various bonding strategies, deficiencies of the enamel margin were more common in self-etch adhesives. Although many studies have done aimed to investigate various aspects of materials and protocols used in the treatment of NCCLs, because of the daily development of new treatment materials and techniques, continuous review studies are required to identify and select the best and most effective treatment protocols. Therefore, in this study, it was tried to introduce the best treatment protocol for NCCL lesions by systematically reviewing the research that has been done so far in this regard.

Methods

The present study was conducted aimed to introduce the most effective bonding protocol for NCCLs. The research environment included the achieved articles that had the entry and exit criteria in reliable databases.

Search strategy

Articles were searched in scientific databases of PubMed, Science Direct, Scopus, and Google Scholar from December 2000 to March 2022, regardless of language restrictions. Moreover, relevant journals and reference lists of included studies were manually evaluated for any eligible studies on diagnostic accuracy. Medical Subject Headings (Mesh) terms from PubMed and Scopus databases and free text keywords were used in search strategies. Mesh terms that have being used consisted of search terms for screening the articles that include "non-carious cervical lesions", "self-etch adhesives", "etch-and-rinse adhesive", "sensitivity", "retention rates" and "marginal discoloration".

Entry and exit criteria

The inclusion criteria included all articles in which one of the following items was examined:

- Randomized clinical trials,
- The studies in which the population was consisted of adult patients who require treatment for their NCCLs
- The studies in which composite restorations with self-etching adhesives were used.
- The studies that investigated the composites repair with etch and rinse adhesive
- The studies in which the risk and severity of sensitivity after the operation, durability and marginal color change were investigated.

- The studies that only used the most common bonding systems of Self-etch and etch-and-rinse adhesive
- The studies those findings were officially reported in various scientific-research journals or as dissertation.

On the other hand, the following items were excluded from the study circle:

- Informal reports,
- Papers in letter to editor format
- Unpublished papers and content that are posted on internet websites
- The studies that have been published on non-reputable publisher (based on the blacklist and source finder systems of the Ministry of Health)
- Studies that are flawed methodologically and cannot answer the questions of the present study due to their content

Evaluation of the quality of studies

The quality of the included studies was evaluated using the CONSORT checklist (2020) and the Newcastle-Ottawa scale (NOS). The risk of bias was evaluated using the Cochrane Risk of Bias Tool. Besides, data screening was done with the help of two trained authors.

Data extraction

All papers were evaluated in different aspects of methodology, including sampling methods, reliability of the tools used, and study objectives. In the initial search, 10358 records were obtained. At this stage, 4088 records were removed due to duplication and all articles that did not meet the inclusion criteria or were inappropriate due to indirect connection with the subject (858 records). After that, 831 records were retrieved for full text review. After a thorough review, 27 records were selected finally all of which met the inclusion criteria. As can be seen from figure (1), the subjects were presented through the following methods; analysis and interpretation, and determining the purpose of the study and collecting the findings based on the preferred reporting items for Systematic Review and Meta-Analysis (PRISMA) (Figure 1).

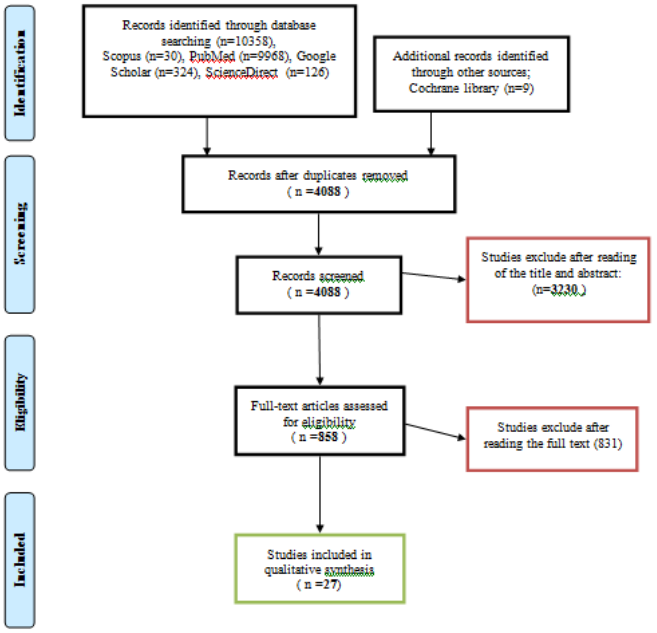

Figure 1: PRISMA flow diagram for the selection of reviewed articles.

Data analysis and the used statistical methods

The heterogeneity statistic I2 was used to assess the significance of the differences in the estimations of the diagnostic ability of different studies. The standard was set as value $\alpha = 0.10$ and any high heterogeneity ($I2>50\%$, $P<0.10$) for determining its origin and reduction of heterogeneity were analyzed using different analyzes such as subgroup analysis and random effects model. If there was no or little heterogeneity ($I2\leq50\%$, $P > 0.10$), a fixed effects model was used in the meta-analysis.

Results

In this research, 10358 records in different subjects were searched. Based on the inclusion criteria, 27 studies were selected separately and examined more precisely. The data about the selected records is presented in Table (1).

According to the data achieved from table (1), 6 articles were Randomized double-blind clinical trial, 5 were Randomized clinical trial, 5 of them were Randomized controlled clinical trial, 3 were Clinical performance articles, another 3 articles were Randomized controlled prospective study, 1 record was Prospective double-blind RCT article, and another one was a prospective randomized clinical study. In 2 records, the type of study was not reported. The total number of examined patients was 805 and the total number of composite repairs or lesions was 3485. The shortest follow-up time was one week and the longest was 8 years. The results obtained from the present study were evaluated using different criteria such as Ryge, USPHs, FDI and The World Dental Federation Criteria.

The author and year	Objective	Methods	Results
Türkün, 2005 (16) **Clinical performance**	Evaluation of the clinical performance of one- and two-step self-etch etching adhesive systems in one year	35 patients with NCCL lesions Repair of 163 lesions using a two-step self-etching adhesive system (Clear fil Protect Bond) or one-step (Xeno III) Evaluation of restorations at the beginning and after 3, 6, 9, and 12 months using Ryge criteria.	A retention rate of 100% for the teeth restorations of the two-stage group and 96% for the one-stage group in one year. There were two cases of marginal discoloration and minor problems of anatomical form in the 75 remaining restorations belonged to the one-stage group.
Kubo et al, 2006 (20) **Controlled clinical trial**	Evaluation of the clinical performance of two self-etching adhesives and one total-etching adhesive in class V non-carious lesions	Using of two self-etching primers (Clear fil SE Bond and Hybrid Bond), and one total etching adhesive (Admira Bond) in 195 NCCLs cases in 47 patients. Evaluation of restorations at the beginning, and after 1 and 2 years using USPHS criteria	None of the restoration were lost after 1 and 2 years for all materials The difference between the restoration achievements at the beginning and after 2 years for Admira Bond and Clear fil SE Bond was not significant Significant deterioration in restorations with hybrid graft after 2 years in marginal compliance and marginal cavity discoloration
Ritter et al, 2008 (21) **Randomized clinical trial**	Evaluation of 5-year clinical performance of a self-etching primer system consisted of selective phosphoric acid etching on enamel and a one-bottle adhesive system	8 patients (4 men and 4 women) with 72 NCCL lesions Reconstruction of cavities using clear fil liner bond II (LB) or single bond (SB) in combination with a hybrid resin composite (Clear fil AP-X) Pretreatment of tooth enamel with 37% phosphoric acid for 10 seconds in 27 cavities for LB Each patient received two types of restoration Evaluation of restorations after 5 years using modified USPHS criteria	100% durability for both repair groups Caries was not detected in any of the restorations Marginal discoloration, minor issues only Availability of superficial and local marginal discoloration in about 18% of the restorations, mainly in the dentin margin
Brackett et al, 2010 (17)	Comparing the performance of an All-purpose (Universal) adhesive (I Bond) with a	Using all-purpose (Universal) adhesive (I Bond) Using integrated adhesive (I Bond) in sclerotic and non-	Availability of a high percentage of Bravo score of marginal discoloration (4-32%) and marginal discoloration (18-60%) in the groups 2, 3 and 4.

Clinical performance	three-step H Prime adhesive	sclerotic lesions of NCCL with three-step adhesive of H Prime Bond (Glum a Solid Bond, SB) 105 lesions in four groups as follow; 1) SB for lesions with scale 1 and 2 sclerosis 2) Using I Bond for lesions with sclerosis scale 1 and 2 3) Using I Bond for lesions with sclerosis scale 3 and 4 and 4) Using I Bond with previous acid etching on lesions with sclerosis scale 3 and 4 Using micro filled composite (Dura fill VS) as a restorative material Evaluation of restorations at the beginning and after 6, 18 months, and 3 years using modified USPHS evaluation criteria.	13% of restorations did not maintain after 3 years
Peumans et al, 2010 (12) **Randomized controlled clinical trial**	Evaluation of two-year clinical performance of self-etching primer and self-etching adhesive both of which use the same acidic monomer	Evaluation of clinical performance of self-etching primer (Clear fil SE Bond) and self-etching adhesive (Clear fil S3 Bond) Forty pairs of restoration Using hybrid resin composites Evaluation of restorations at the beginning and after 6, 12 and 24 months using modified Ryge/USPHS criteria.	81-84% of restorations were retained over two years for both products Two adhesives were not significantly different regarding their overall performance
Fron et al, 2011 (22) **Randomized controlled practice-based study**	Evaluation of 8-year clinical performance of a mild 2-step self-etching adhesive in non-carious class V lesions with and without selective phosphoric acid etching of cavity margins	Restoration of 100 non-carious Class V lesions in 29 patients with Clear fil AP-X Composite restorations bond following two different approaches: (1) Using Clear fil AP-X following the self-etching approach (control group; C-SE non-etch), (2) Selective etching with phosphoric acid of the enamel cavity. Margin before using Clear fil SE (experimental group, C-SE etch) Evaluation of restorations after 6 months, 1, 2, 3, 5 and 8 years	Due to retention loss, two of the restorations were unacceptable (one from C-SE non-etch group and the other one from C-SE etch group) In both groups clinical success rate was 97% On Mina's side, small marginal defects (C-SE non-etch: 86%; C-SE etch: 65%) and color change in the marginal surface (C-SE non-etch: 11%; C-SE etch%) were more available in the control group that the experimental group
Perdigao et al,	Evaluation of the	In both groups of control and	Significant difference in marginal

2012 (23) **Randomized Clinical Trial**	effectiveness of a new one-step self-etching adhesive in the restoration of NCCL lesions	experiment, 28 patients with two restorations were allocated randomly Control group: using Bond Force (Tokuyama) adhesive without phosphoric-acid-etching on tooth enamel beforehand Experimental group: Using phosphoric-acid-etching on tooth enamel beforehand Using restorative composites of Est elite Flow Quick and Est elite Sigma Evaluation of clinical efficacy at the beginning and after 6 months, 1 and 2 years using FDI criteria	staining in tooth enamel compared to the control group (5% vs. 29%) More significant defects in the control group (29% vs. 0%) Significant efficacy of this novel adhesive after 2 years of clinical service Observing more minor defects and marginal staining at the edge of tooth enamel during selective acid etching of enamel
Figueira de Araújo et al, 2013 (14) **Randomized clinical trial**	A randomized trial of four adherence strategies	Examination of 125 lesions in 39 patients in four groups: (1) Three-step etch-and-rinse adhesive, Adper Scotch bond Multi-Purpose Adhesive, (2) Two-step etch-and-rinse adhesives, Adper™ Single Bond Plus Adhesive (3) Two-step self-etch adhesive, Adper™ Scotch bond SE (SE), and (4) One-step self-etch adhesive, Adper™ Easy Bond Self-Etch Adhesive Using nano-filled composite resin for all restorations Evaluation of restorations after 6 and 18 months using USPHS criteria	Total retention rate after 6 months compared to 18 months for MP was 100% to 90.9%, for SB 100% to 91.7%, for SE 100% to 90.9% and for EB 96.4% to 92.3% No statistically significant change in surface staining from the beginning to six months Marginal compliance was worse statistically after18 months compared to the beginning for EB only
Tuncer et al, 2013 (18)	Evaluation of clinical performance of restorations using three-step etch and rinse adhesive (TSER), one-step self-etch adhesive (OSSE) and simplified ethanol wet-bonding	Using 93 restorations (each group 31 restorations) in 17 patients Evaluation of clinical performance of restorations using three-step adhesive etch and rinse (TSER), one-step self-etch adhesive (OSSE) and simplified ethanol-wet bonding technique (EWBT) before applying a composite resin in NCCL lesions Evaluation of restorations after 6 and 12 months using modified Ryge criteria	There is no significant difference between the groups after 6 and 12 months for any of the evaluation criterias. There was a significant difference between the beginning and a 12-month interval for marginal consistency in OSSE and in marginal staining in TSER. No significant difference was observed in survival rate Appropriate performance of restorations used through simplified ethanol wet-bonding (EWBT) technique was as useful as that of other adhesive strategies employed

DA COSTA et al, 2014 (24) **Randomized, controlled prospective study**	Comparison of clinical performance of NCCL restorations after 24 months using etch and rinse all-in-one adhesive technique	24 patients with at least one pair of NCCL lesions (123 restorations for NCCL lesion) Using 62 etching and rinsing adhesive (Solo bond M); 61 all-in-one adhesive (Futura bond NR) and one nanohybrid resin composites (Grandio) Evaluation of restorations based on modified USPHS criteria after 6 and 24 months	Retention rate after 6 and 12 months, were 82% and 75% for Solo bond M and 77% and 62% for Futura bond NR, respectively. There was a significant difference between two groups in terms of retention rate after 24 months, so that for Solo bond M and Futura bond NR it was 69% and 49% respectively. The difference among adhesives regarding color matching, marginal staining or marginal compatibility was not significant There was not secondary caries, loss of anatomical form or change in surface texture in none of restorations
Abdalla et al, 2015 (25) **Clinical evaluation**	Comparison of the clinical performance of two-step etch and rinse dental adhesive in NCCL lesions	35 patients had at least two NCCLs with similar size Restoration of 70 lesions using of the following groups including Adper Single Bond 2 (SB), Ambar (AM), and using Placing 70 restorations based on one of Adper Single Bond 2 (SB) and Ambar (AM) groups and using Opallis Composite resin Evaluation of restorations at the beginning and after 6 and 18 months based on FDI criteria	Only four restorations were lost (two of each material) after 18 months The retention rate for both materials after 18 months was 94.2% (the clinical retention rate for both adhesive systems was acceptable after 18 months) Marginal discoloration in 9 restoration cases (four Ambar and five Adper Single Bond 2)
Lawson et al, 2015 (26) **Randomized controlled trial**	Investigation of an all-in-one adhesive in total etching and self-etching in NCCLs lesions	Chosing 37 adults with 3 or 6 NCCLs Restorations of teeth randomly with Scotch bond™ Universal Adhesive Total-Etch, Scotch bond Universal Adhesive Self-Etch or Scotch bond Multi-Purpose Adhesive and then with dental composite resins Evaluation of restorations at the beginning and after 6, 12, and 24 months using the USPHS	Clinical performance of all adhesives were worsen over time for marginal compliance and discoloration Less satisfactory for marginal discoloration over time and performance for Scotch bond Universal total-Etch compared to Scotch bond and Scotch bond Multi-Purpose Adhesive Retention rates for Scotch bond Multipurpose and Scotch bond Universal self-etch and total-etch after 24 months was 87.6 %, 94.9 % and 100 % respectively
Loguercio et al, 2015 (27) **Randomized Double-blind Clinical Trial**	Evaluation of clinical performance of Scotch bond universal adhesive (SU, 3M ESPE) in NCCLs lesions during 36 months	Evaluation of 39 patients with 200 restorations They were divided into four groups: (1) ERm: etching and rinsing + wet dentin, (2) ERd: etching and rinsing + dry dentin,	Eight restorations (ERm: 1; ERd: 1; Set: 1 and SE: 5) were lost after 36 months Marginal staining in three groups of ERm, ERd and Set groups was 6.8% and in SE group it was 17.5% Using the USPHS and FDI criteria for marginal compliance it was observed

		(3) Set: Selective etching of tooth enamel. and (4) SE: self-etch. Using the same composite resin for all restorations Evaluation of restorations at the beginning and after 6, 18, and 36 months using both FDI and USPHS criteria.	that, for 49 restorations studied, the difference for the group compared to baseline was significant
Lopes et al, 2016 (28) **Double-blind, randomized clinical**	Evaluation of clinical performance of a novel universal dental adhesive (Xeno Select, Dentsply) in NCCLs lesions during six months	Randomized examination of 124 restorations in 31 patients Treatment groups; ER-D = Dry dentin bonding Etch-and-Rinse Strategy, ER-M = Web dentin bonding Etch-and-Rinse Strategy, SE-et = Selective enamel etching, and SET = self-etching. Using composite resin EVOLUX (Dentsply) Evaluation of restorations after one week (the beginning) and after six months using FDI and USPHS criteria	15 restorations were lost after six months (one case of ER-D, 3 cases of ER-M, 5 cases of SE-et, and 6 cases of SET) There is a significant difference between different groups regarding the retention rate after six months Marginal staining and postoperative sensitivity to air in three cases (one cases of ER-M and two cases of SET) and two restorations (two cases of ER-D). There were significant differences for all groups, comparing to the data at the beginning and after six-month
Pena et al, 2016 (29) **Randomized, controlled prospective clinical trial**	Evaluation of the clinical efficacy of restorations NCCL lesions with two self-etching adhesive systems applied with or without selective enamel etching	Examination of 56 restorations in 25 patients Two groups: using a one-step self-etch adhesive (Xeno V+) and a two-step self-etch system (Clearfil SE Bond) Evaluating the effect of selective phosphoric acid etching of enamel margins and the use of nanohybrid composite (Esthet. X HD) Evaluation of restorations after 3, 6, 12, 18, and 24 months using modified US Public Health Services	There was a significant difference only after 18 months for marginal staining in Clearfil SE non-etch and Xeno V+ etch One restoration lost during the test (Xeno V+ etch) Marginal staining increased for Clearfil SE non-etch and Xeno V+ groups
Loguercio et al, 2017 (8) **Double-blind randomized clinical trial**	The effect of dentin roughening (RO) on the clinical behavior of a new multi-mode universal adhesive (Tetric N-Bond Universal; Ivoclar-Viva dent) in NCCL lesions	Evaluation of 192 restorations in 48 patients Treatment groups; ER: Etch-and-rinse (without preparation), SE: self-etch (without preparation); ER + RO and SE + RO. Using resin composite of Empress Direct (Ivoclar Viva dent) Evaluation of restorations after one week (the beginning), 6 and 18 months using FDI and	15 restorations were lost after 18 months (3 for SE, 2 for ER, 5 for SE + RO and 5 for ER + RO) Based on FDI criteria (24 for SE, 18 for ER, 22 for SE + RO, and 20 for ER + RO), in 84 restorations, minor differences were available in marginal compliance after 18-month In 19 restoration cases, a slight difference was available in in marginal discoloration after 18 months (10 cases for SE, 3 for ER, 5 for SE + RO, and 1 for ER + RO).

		USPHS criteria	
Haak et al, 2018 (30) **Randomized controlled trial**	Evaluation of the initial quality of composite restorations with a universal adhesive in different application modes clinically and with optical coherence tomography (OCT)	Evaluation of 22 patients with four NCCL lesions All patients received composite restorations (Filtek Supreme™ XTE, 3 M). Using universal adhesive of Scotch bond Universal™ (SBU, 3 M) with three different etch protocols; self-etch (SE), selective enamel etching (SEE) and etch-and-rinse (ER). Opti Bond™ FL etch and rinse (OFL, Kerr) was used as control OCT imaging of restorations at the times (t0), after 14 days (t1) and 6 months (t2) with clinical evaluation (FDI criteria)	There was no clinical difference between the studied groups The defects were more available OFL compared to SBU/ER Adhesive defects were more available in dentin/cement interface of OFL compared to SBU with all conditioning modes and at t2 to SBU/SE and SBU/ER
OZ et al, 2018 (31) **Randomized, controlled, prospective clinical trial**	Evaluation of the performance of two different universal adhesives and an etch-rinse adhesive for restoration of NCCL lesions	20 patients with at least 7 NCCLs Lesions were divided into seven groups: 1) GSE: GLUMA Universal-self-etch, 2) GSL: GLUMA Universal-selective etching, 3) GER: GLUMA Universal-Etch-and-rinse, 4) ASE: All-Bond Universal-self. -etch, 5) ASL: All-Bond Universal-selective etching, 6) AER: All-Bond Universal-etch-and-rinse, 7) SBE (control): Single Bond2-etchand-rinse. Reconstruction of 155 NCCLs with a nanohybrid composite (Tetric N-Ceram) Evaluation of restorations using modified United States Public Health Service (USPHS) criteria after one week, 6, 12 and 24 months.	Cumulative retention rate of self-etch groups (GSE: 72.2%, ASE: 75%) was significantly lower compared to other experimental groups (GSL: 93.7%, GER: 100%, ASL: 94.1%, AER: 100%, %SBE: 100 at 24-month follow-up) GSE and ASE groups were different in terms of Tooth/restoration scored Bravo of marginal compliance and marginal discoloration (after 6- and 12-months follow-up, the difference was not significant). There was no secondary decay on restorations None of the evaluated criteria between the groups at the end of the 24-month observation was significant, except for maintaining criteria
Atalay et al, 2019 (32) **Randomized controlled trial**	Clinical evaluation of different adhesive strategies of a universal adhesive during 36 months.	Evaluation of 165 NCCLs in 35 patients Formation of three groups based on the adhesive strategy used (n = 55): selective-etch strategy, etch-and-rinse strategy, Universal self-etch adhesives strategy, and Single Bond Universal strategy. Using nano-filled resin composite (Filtek Ultimate) for all restorations	Three restorations were unsuccessful, one from each group The difference between self-etch, and selective etch and etch-rinse groups was significant The groups of self-etch and etch-and-rinse were significantly different regarding their final adaptation values after 36 months compared with their initial values There was no secondary decay

		Evaluation of restorations at the beginning and after 6, 12, 18, 24 and 36 months based on the modified USPHS criteria.	
Dutra-Correa et al, 2019 (33) **Randomized clinical trial**	Evaluation of the performance of four dentin adhesive systems for the restorative treatment of NCCL during 42-month used	129 lesions of NCCLs in 39 patients NCCLs were divide into four groups: (1) Scotch bond multipurpose (MP), (2) Single bond plus (SB) (3) Scotch bond SE (SE) (4) Easy bond (EB) Using a nano filled Resin Composite Evaluation over 18-36-42 months using USPHS criteria	There is a base rate and a 42-month retention of 100/100% for MP, 94/74/100% for SB, 100/87/5 for SE and 100/100 for EB. Survival of restorations was not dependent to the he type of adhesive used Marginal compliance was similar in all groups, but there was significant marginal deterioration in EB After 42 months, wear was observed in 3-step etch and rinse restorations (MP)
Manarte-Monteiro et al, 2019 (34) **Prospective, double-blind RCT**	Comparing clinical performance and success/retention rate of two multi-mode (MM) adhesives used in self-etch (SE) or etch-and-rinse (ER) modes with self-etching-all-in-one (SE/SE) adhesive with enamel etching in NCCL restorations at one-year follow-up	38 participants with 210 restorations in 6 groups Control Futura bond VRDC_SE (G1), Control Futura bond with enamel etching (G2) (VRDC_SE), Futura bond VRU_ER (G3), Futura bond VRU_SE (G4), Adhese VR Universal _ER (G5) and Adhese VR Universal _SE (G6) Evaluation of restorations at the beginning and after one year using FDI criteria	5 restorations were lost (G1 n = 2; G2, G3, G4 n = 1) due to retention Marginal compatibility was less available in G1 compared to G2 and and (multi-mode) MM adhesive groups, especially G6. Overall success rate for G1 was 93.9%, for G2, G3, and G4 was 97% and for G5 and G6 was 100%.
Matos et al, 2019 (35) **Double-blind, randomized controlled trial**	18-month clinical evaluation of a copper-containing universal adhesive in NCCLs lesions	Evaluating 216 restorations in 36 people by random Treatment groups including; ERcu = etching and rinsing with 0.1% CuNp, ERct = etching and rinsing without CuNp, SEcu = self-etching with 0.1% CuNp, SEct = self-etch without CuNp. Using composite resin Evaluation of restorations at the beginning and after 6, 12, and 18 months using FDI and USPHS criteria	Clinical performance (FDI / USPHS) of universal adhesive was tested after 18 months and no increase was observed in its clinical performance in ER mode with the addition of CuNp There was a significant increase in durability of SE restorations when CuNp was added Significant increase in durability of SE restorations with the addition of CuNp and reduction of marginal differences after 18 months
Zanatta et al, 2019 (36) **A Double-blind Randomized Clinical Trial**	Evaluation of the bonding performance of a universal adhesive used based on self-etch or etch and rinse protocols in NCCLs and comparing these two protocols with the corresponding gold standard techniques.	Evaluation of 152 restorations in 34 participants Using one of three adhesives (Scotch bond, Adper Single Bond 2, or Clearfil SE Bond) and one of two tested bonding techniques Reconstruction of NCCLs with nanocomposite resin (Filtek Supreme)	There was not a significant difference in aesthetics or functional and biological evaluation criteria among the investigated adhesive systems and techniques.

		Evaluation of restorations using FDI criteria at the beginning (seven days after restoration), and after 6, 12, and 24 months.	
Cruz et al, 2020 (37) **Double-blind, randomized clinical trial**	Evaluation of the 6-month clinical performance of Adhese Universal with two different application strategies (self-etching vs. etching and rinsing method) during reconstruction NCCL lesions.	117 NCCL lesions were evaluated in 26 patients belonging into two groups as follow: - Adhese Universal in etching and rinsing mode - Adhese Universal in self-etching mode Using composite resin (Tetric Evo Ceram) for all restorations Evaluation of restorations at the beginning and after 6 months using the World Dental Federation criteria	There was no significant difference in restorations performance between the beginning and the end of the 6-month period in self-etch mode There was a significant difference in etch ans rinse conditions for fracture/retention and margin consistency There were significant differences between groups after 6 months for fracture/retention and marginal compliance Restorations lost after 6 months in etch and rinsing group
Lührs et al, 2020 (38) **Prospective randomized clinical study**	Evaluation of the clinical performance of restorations done in NCCLs lesions using different cavity preparation designs	Evaluation of 85 NCCLs in 24 patients Treatment groups including; Cleaning the dentin surface, roughening the dentin surface filled with smooth composite with a round bur, roughening dentin surface/dentin surface roughening/preparation of NCCL cavity with a round bur, surface roughness/preparation of NCCL cavity with round bur along with smooth composite Restoration of defects after shaving of enamel and selective enamel etching with composite (with phosphoric acid) Evaluation of restorations using modified USPHS criteria in the follow-up period of 7.7 years	Total durability was 82.8%. There was no significant difference between the groups regarding aesthetic appearance, marginal consistency, anatomical form and marginal discoloration Suitability of composites as long-term stable materials for restoration of NCCLs
Perdigão et al, 2020 (39) randomized clinical trial	Evaluating the effect of a hydrophobic bonding resin on the 36-month performance of a universal adhesive	Using Universal adhesive (SBU, 3M Oral Care) in NCCLs of 39 people The studied groups are including; (1) three-step ER (etch-and-rinse), (2) two-step ER, (3) two-step SE (self-etch) and (4) one-step SE. Applying an additional layer of a hydrophobic bonding resin for three-step ER and two-step SE strategies Using composite resin (Filtek Supreme XTE, 3M Oral Care)	There was a 36-month retention rate of 100% for 3-ER and 2-ER, 76% for 2-SE and 86.2% for 1-SE. Retention rate for two-stage SE was lower after 36 months compared to both three-ER and two-ER Evaluation of the same retention rate for the two SE groups Marginal discoloration worsen significantly for restorations made with 3-ER, 2-SE and 1-SE at 18-month follow-up

		Evaluation of restorations at the beginning and after 18 and 36 months using modified United States Public Health Service (USPHS) criteria.	
Peumans et al, 2021 (40)	Evaluating clinical performance of a medium-strength 2SEa compared to a 3-stage E&Ra after 6 years	239 NCCL lesions in 50 patients nanohybrid composite Herculite XRV (Kerr) Restoration using nanohybrid composite Herculite XRV (Kerr) and random bond with 2SEa Opti bond XTR ('O-XTR', Kerr) or gold-standard control 3E&Ra Opti bond FL ('O-FL', Kerr). Evaluation of restorations after 1, 2 and 6 years using FDI criteria	Overall rate of clinical success: 81.9% and 80.9% for O-XTR and O-FL respectively Failure in 42 restoration (21 O-XTR, 21 O-FL) Retention rate of O-XTR and O-FL were 92.9% and 88.9% respectively In 37% of O-XTR and 30.2% of O-FL restorations surface marginal discoloration was observed wich was clinically acceptable Caries were available at the restoration margin in six O-XTR and 4 O-FL restorations None of both studied groups were significantly different regarding any of the evaluated parameters

The data presented in table (1) indicated that in 33.33% of the reviewed articles, there was no difference between various bonding methods in terms of performance or durability and preservation. Besides, the data also revealed that in 29.62% of these articles, the self-etch adhesive techniques used yielded weaker results in terms of performance, survival and durability, marginal staining and decay. However, in 18.51% of the reviewed studies, self-etch techniques (single or two-step) had a better performance, and in 40.7% of them, the performance of etching and washing technique was better.

Discussion

NCCL is a dental disease that affects up to 60% of the population which has a global prevalence of 46.7%. NCCL may lead to dentin hypersensitivity, pulpal disorders, and compromise esthetics (8). Considering the importance of this disease, it is important to pay attention to treatment methods and their effectiveness. In the present study, it was observed that in 33.33% of the reviewed articles, there was no difference between various bonding techniques regarding their performance or durability and preservation. Besides, the data revealed that in 29.62% of these articles, the self-etch adhesive techniques applied yielded weaker results in terms of performance, survival and durability, marginal staining and decay. It's while in 18.51% of the reviewed studies, self-etch techniques (single or two-step) performed better than the other ones, and in 40.7% of them, the performance of etching and rinsing technique was better.

The formation of NCCL is associated with occlusal factors and biologically induced corrosion processes that alter the morphology and structure of dentin that directly affect the adhesion and thus the survival rate of these restorations (41). NCCLs are usually found in anterior teeth and premolars that have poor long-term prognosis while are accessible easily. These lesions are usually happen due to the lack of micromechanical retention, the need for bonding to enamel and dentin (25). The longevity of restoration depends on various factors such

as patient characteristics, preparation design, type of restorative material and adhesive system (4). The success of restoration of cavities without additional mechanical retention, such as NCCL, is directly related to the used adhesion strategy (36). It has been reported that the invasion of acidic resin monomers used in simplified adhesive or self-etching systems, whic is determined by their pH, is directly associated with their capacity to bond to enamel edges (21). In this regard, Brackett et al reported that although the overall clinical performance was not different between the two examined adhesives, the restorations were lost mainly in the self-etch adhesive group in teeth with sclerotic dentin surfaces. It indicates that a mild pH of 2.7, is not capable of decalcifying sclerotic dentin optimally to form hybrid layers. Inappropriate air drying of self-etched resins leads to excessive residual solvent in the adhesive and hybrid layers under resin composite restorations and makes them prone to hydrolysis and reduced bond durability (17). The results of this systematic study also revealed that the self-etching techniques and adhesives used yielded weaker results regarding their performance, survival and durability, marginal staining and decay.

Perdigao et al (22) also stated that, similar to many other one-steps self-etch adhesives, EB contains phosphoric acid 2-hydroxyethyl methacrylate ester as functional monomers. While SE is a strong self-etch adhesive with pH = 1, EB is considered an extremely mild self-etch adhesive as its pH is relatively high (2.4). This high pH may explain the significant deterioration of marginal adaptation from the beginning to 18 months after applying EB. Self-etching adhesives do not cause enamel etching to the depth of phosphoric acid. Both self-etch adhesives used in this study increased marginal surface staining around the enamel margins from baseline to 18 months significantly. This increment in staining may be due to a shallow pattern of enamel etching, as surface staining is associated with poor enamel etching ability in self-etch adhesives, even for those considered strong self-etch adhesives such as SE. The results of another study in this regard indicated that self-etch adhesives have simpler application techniques compared to the etching and rinsing methods, which can be divided into one-step self-etching and two-step self-etching subgroups. These adhesives require fewer steps, are less sensitive to technical problems, and do not need using phosphoric acid and rinsing steps. One-step self-etching adhesives act as permeable membranes after photopolymerization and allows diffusion of water to the surface of the adhesive. This may be clinically associated with the low survival rate of self-etch adhesives. Besides, there is no surface etching methods, especially on tooth enamel, that can be considered to reduce the durability of the self-etching adhesives. In this study, GLUMA Universal and All-Bond Universal adhesives had higher durability loss rate in their self-etch mode compared to the acceptable rates considered by the ADA (31).

The results of the study by Lopes et al (28) indicated that after 6 months of clinical service, a total of 15 restorations failed due to bonding, 11 restorations with the SE approach and 4 bonding with the ER approach (ER-M and ER-D), specified a weak performance link of Xeno Select When used in the SE strategy. This poor bonding ability may be associated with the type of chemical bonding created by this adhesive with dental substrates. Generally, SE adhesives are different from each other in many ways, particularly in resin monomer composition, water content, and acidity. However, the findings of another research indicated that both total etch

adhesive, Admira Bond, and two-step self-etch adhesive, Clearfil SE Bond were effective in repairing NCCL class V lesions after 2 years (25). Clearfil SE Bond Acid Primer contains 10-MDP water-soluble, with a pH close to 2. This causes gentle etching of the dentine surface and consequently creates a stable uniform thin hybrid layer. In addition, an interaction occurs between 10-MDP and hydroxyapatite (HA) crystals around and inside the collagen fibers of the hybrid layer. Another factor that contributes to the satisfactory performance of Clearfil SE Bond is utilizing a separate hydrophobic filled adhesive layer. This layer may also help the resistance to the stresses created at the composite/dentin interface during polymerization.

XENO V+ contains a penta-acrylate phosphate (PENTA) ester modified monomer that decreases curing time and aroma to a mildly alcoholic odor (29). Cruz et al. (37) reported that enamel etching before applying the universal adhesive improves the bond strength, as etching creates micropores that are easily penetrated by the adhesive. In the research done by Ritter et al. (17), it was revealed that the excellent clinical performance of group 1 restorations for all criteria proves that the three-step etch-prime-bond adhesive acts sufficiently in NCCLs in a non-retentive way. The good retention rates for groups 2 and 3 indicate that whenever the simplified adhesive is used based on the directions, the retention rate remains high for at least a three-year evaluation period. Marginal compliance and marginal discoloration were the criteria that had the biggest drop in alpha scores from the beginning to evaluation periods, particularly in groups 2, 3 and 4. Although the Bravo score shows a problem, the restoration is clinically acceptable.

The results of a systematic review study also indicated that compared to the self-etch approach, the etch-and-rinse approach for universal adhesives provides improved clinical achievements regarding their durability, marginal compatibility, and marginal staining.

Etching is an important step to improve the adhesion strength of adhesives. In etching and rinsing strategy, phosphoric acid etching dissolves hydroxyapatite and creates macro and micro pores on the enamel surface. This process increases the total surface area of the substrate and allows the resin monomers to penetrate the enamel and form “prism-like” resin tags. In self-etch strategy, dental cavities are prepared and primed simultaneously.

Self-etching strategies cannot etch enamel to the same depth as phosphoric acid. This issue explains the main reason why the etch and rinse strategy used for universal adhesives leads to better clinical achievements in comparison with self-etch strategy. Time-dependent hydrolytic degradation caused by water is another impressive factor in the degradation process. Destruction of the adhesive/dentin interface may lead to several problems such as loss of retention, marginal staining, and secondary caries (40).

Conclusion

The evidence achieved from this study indicates that compared to the self-etch method, other methods such as etch and rinse can yield better clinical achievements in terms of durability, marginal consistency and marginal staining.

Providing clinical trial studies with appropriate data and long-term follow-up period can be effective in specifying the best role of the evaluated methods. It is hoped that the findings of this study will be productive in the treatment of NCCLs and providing the best solution for prevention of NCCLs.

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