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Literature Review

Influence of Surface Treatment on Composite Adhesion in Noncarious Cervical Lesions: Systematic Review and Meta-analysis

AC Rocha • WLO Da Rosa • AR Cocco • AF Da Silva • E Piva • R-G Lund

Clinical Relevance

Although the meta-analysis demonstrated a positive effect of dentin surface treatment, further clinical trials are needed to determine the best treatment option for improving the retention of resin composite in NCCLs.

SUMMARY

The purpose of this study was to analyze the influence of dentin surface treatments on the retention rate of resin composite restorations in non-carious cervical lesions (NCCLs). Seven randomized clinical trials were included in this review. Data regarding retention rate, type of surface treatment, and the main characteristics of studies were analyzed. Two reviewers performed a literature search up to December 2016 in eight databases: PubMed (Medline), Lilacs, Ibecs, Web of Science, BBO, Scopus, Scielo and The Cochrane Library. Only clinical trials evaluating dentin surface treatments in resin composite restoration in NCCLs were included. Noncontrolled clinical trials, reviews, editorial letters, case reports, case series and studies published in a language other than English, Portuguese, or Spanish were not included. The included studies evaluated different surface treatments, such as using an adhesive system with a frictional technique, drying the dentin, and removing sclerotic dentin by using a bur and applying EDTA before primer use. The analysis considering the mechanical removal of dentin surface with a bur and the application of an adhesive system in a frictional mode showed

Analice da Cunha Rocha, DDS, MSc, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

Wellington Luiz de Oliveira da Rosa, DDS, MSc, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

Alexandra Rubin Cocco, DDS, MSc, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

Adriana Fernandes da Silva, DDS, MSc, PhD, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

Evandro Piva, DDS, MSc, PhD, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

*Rafael Guerra Lund, DDS, MSc, PhD, Graduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas/RS, Brazil

*Corresponding author: Gonçalves Chaves, 457 Room 503, Pelotas, RS 96015-560, Brazil; e-mail: rafael.lund@gmail.com

DOI: 10.2341/17-086-L

these treatments improved retention rates of the resin composite restorations in NCCLs ($p<0.05$). There is evidence in the literature suggesting that the mechanical removal of dentin surface with a bur and the application of an adhesive system in a frictional mode could improve the retention rates of resin composite restorations in NCCLs. However, the studies showed high heterogeneity, and additional clinical trials are needed to determine the best dentin treatment option in NCCLs.

INTRODUCTION

The prevalence of noncarious cervical lesions (NCCLs) varies from 5% to 85% and has been increasing in recent years due to an aging population, especially in premolars.[1-5] Among the main dental materials used for the treatment of NCCLs are resin composites. They are used to protect the affected teeth against the loss of a healthy tooth structure, to improve esthetics, and to treat dental hypersensitivity, as well as when the affected tooth is used as lateral support for a removable partial denture.[6,7]

Treatment of NCCLs remains a major challenge for dentists, and studies have reported that the retention loss of NCCLs can vary from 0% to 50%.[8] Restoration loss especially occurs because of the difficulty of dental material adhesion;[9] a high degree of sclerosis can exist, and a high amount of minerals can impair the adequate establishment of a hybrid layer.[6,8] Besides, many studies have reported the loss of retention and marginal discoloration after cervical restorations with resin composites.[8,10] To minimize these problems, tooth surface treatment has been suggested to improve resin composite adhesion in NCCLs.[11-13]

The surface treatment techniques that were proposed include surface irrigation with EDTA, adhesive application with a frictional technique, and drying the dentin before adhesive application.[11,13-15] Some studies have already evaluated the effects of surface treatment on NCCL treatment, but a question still remains about whether clinicians should consider using these approaches to improve the adhesion of resin composites. Therefore, the aim of this study was to analyze the influence of dentin surface treatments on the retention rate of resin composite restorations in NCCLs. Our hypothesis evaluated whether surface treatments could improve resin composite retention.

METHODS AND MATERIALS

The protocol of this review was registered in the PROSPERO international database for systematic reviews (CRD42014010018). This systematic review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA Statement).[16] To formulate the question from evidence-based practice, the following PICO (Population, Intervention, Comparison and Outcomes) was established: the population was patients who present with NCCLs; the intervention was dentin surface treatment (any nonconventional procedure performed prior to resin composite restoration, such as surface irrigation with EDTA, adhesive application with a frictional technique, drying the dentin before adhesive application); the comparison was teeth without dentin surface treatment; and the outcome was retention rate (complete or partial loss of the restoration). The research question was as follows: Does dentin surface treatment improve the retention rate of resin composite restorations in NCCLs?

Search Strategies

The literature search was carried out by two independent reviewers of studies published from 1940 to December 2016. Eight databases were screened, including PubMed (Medline), Lilacs, Ibecs, Web of Science, BBO, Scopus, Scielo, and The Cochrane Library, using the search strategy developed for PubMed (Medline) and adapted for other databases (Table 1). The references cited in the included papers were also checked to identify other potentially relevant articles. After the identification of articles in the databases, the articles were imported into Endnote X7 software (Thompson Reuters, Philadelphia, PA, USA) to remove duplicates.

Study Selection

Two authors independently assessed the titles and abstracts of all the documents. The studies were analyzed according to the selection criteria described in Table 2. Full copies of all the potentially relevant studies were identified. Those appearing to meet the inclusion criteria or for which there were insufficient data in the title and abstract to make a clear decision were selected for full analysis. The full-text papers were assessed independently and in duplicate by two authors. Any disagreement regarding the eligibility of the included studies was resolved through discussion and consensus or by a third reviewer. Only

Table 1: *Search Strategy Used in PubMed (MedLine)*

Search	Search Terms
#3	Search #1 AND #2
#2	"Non-carious cervical lesions" OR "Non-carious cervical lesion" OR "non-carious, cervical lesion" OR "non-carious cervical lesions" OR "Tooth Wear"[Mesh] OR "tooth wear" OR "Tooth Wears" OR "Wear, Tooth" OR "Wears, Tooth" OR "Dental Wear" OR "Dental Wears" OR "Wear, Dental" OR "Wears, Dental" OR "Tooth Loss"[Mesh] OR "tooth loss" OR "Loss, Tooth" OR "Tooth Cervix"[Mesh] OR "Cervix, Tooth" OR "Cementoenamel Junction" OR "Cementoenamel Junctions" OR "Junction, Cementoenamel" OR "Junctions, Cementoenamel" OR "Cervix Dentin" OR "CEJ" OR "Tooth Abrasion"[Mesh] OR "Abrasion, Tooth" OR "Abrasion, Dental" OR "Dental Abrasion" OR "Tooth Erosion"[Mesh] OR "Erosion, Tooth" OR "Erosions, Tooth" OR "Tooth Erosions" OR "class V restorations" OR "composite class V"
#1	"Clinical Trial" [Publication Type] or clinical trial or ""Study Characteristics" [Publication Type] or study characteristics or randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR random*[tw] OR research design[mh:noexp] OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control*[tw] OR prospectiv*[tw] OR volunteer*[tw])

papers that fulfilled all eligibility criteria were included.

Data Extraction

The data were extracted using a standardized form. If there was some information missing, the authors of the included papers were contacted via e-mail to retrieve any missing data. The following data were tabulated: study design, publication year, country, number of patients, gender, age, evaluation criteria, follow-up (months), and number of teeth evaluated (Table 3). The characteristics of the included studies, such as selection criteria, surface treatment, control group, and restoration characteristics (brand, company and country), were also analyzed (Table 4).

Assessment of Risk of Bias

The methodologic quality was assessed by the two reviewers. Studies were evaluated and classified according to Cochrane guidelines[17] for the following items: selection bias (sequence generation, allocation concealment), performance and detection bias (blinding of operators or participants and personnel), bias due to incomplete data, reporting bias (selective reporting, unclear withdrawals, and missing outcomes), and other bias (including industry sponsorship bias).

Statistical Analysis

The analyses were performed using Review Manager Software version 5.2 (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). The global analysis was carried out using a random-effects model, and pooled-effect estimates were obtained by comparing the risk difference of each dentin surface treatment group with the conventional protocol (control); $p<0.05$ was considered statistically significant. Multiple groups from the same study were analyzed according to Cochrane guidelines for combining groups.[18] Subgroup analyses were also performed considering the mechanical removal of dentin surface with a bur, the application of an adhesive system in a frictional mode, or in dry dentin. Statistical heterogeneity of the treatment effects among studies were assessed using the Cochran's Q test and the inconsistency I^2 test, in

Table 2: *Inclusion and Exclusion Criteria*

PICO	Inclusion Criteria	Exclusion Criteria
Population	Studies of participants with: ■ Noncarious cervical lesions	
Intervention	Studies with subjects who have undergone to the following procedures: ■ Pretreatment of dentin surface before resin composite restoration in noncarious cervical lesions	Studies with subjects who have undergone to the following procedures: ■ Used restorative dental materials different than resin composite (such as glass-ionomer cements) in noncarious cervical lesions
Outcomes	Studies investigating: ■ Retention rate	
Study design	■ Prospective or retrospective clinical trials	■ Noncontrolled clinical trials, reviews, editorial letters, case reports, case series ■ Studies published in a language other than English, Portuguese, or Spanish

Table 3: *Description of Demographic Data, Study Design, and Main Objectives of Included Studies*

Study (Authors)	Year	Country	Study Design	Number of Patients	Sex (Number)		Age (years)	Evaluation Criteria	Follow-Up (Months)	Number of teeth
					Women	Men				
Van Dijken[13]	2010	Sweden	RCT	72	42	30	42-84	USPHS	6, 12, 18, 24, 36, 48, 60, 72, 84, and 96 months	112
Loguercio and others[26]	2011	Brazil	RCT	40	63	57	20->49	USPHS	6, 12, and 24 months	120
Dalkiliç and Omurlu[14]	2012	Turkey	RCT	29	13	16	30-70	Modified USPHS	3, 12, and 24 months	158
Luque-Martinez and others[11]	2015	Chile	RCT	48	22	26	40-48	FDI	6, 12, and 18 months	77
Zander-Grande and others[12]	2014	Brazil	RCT	31	19	12	20->49	FDI	6, 12, and 24 months	124
Zander-Grande and others[35]	2011	Brazil	RCT	40	29	11	20->49	USPHS	6, 12, and 24 months	160
Perdigão and others[15]	2014	United States	RCT	39	15	24	20->49	FDI; USPHS	6 and 18 months	196

FDI, World Dental Federation; RCT, randomized clinical trial; USPHS, United States Public Health Service.

which values greater than 50% were considered indicative of substantial heterogeneity.[17]

RESULTS

Search Strategy

A total of 4040 potentially relevant records were identified from all the databases, of which 1046 were duplicates. No additional studies were identified as relevant after a search of the reference lists. Figure 1 is a flowchart that summarizes the article selection process according to the PRISMA Statement.[12] After the title and abstract examination, 2971 studies were excluded because they did not meet the eligibility criteria. Of the 23 studies retained for detailed review, 16 studies were not included because 11 evaluated the restoration material without surface treatment[19-29] and five papers were *in vitro* studies.[30-34] A total of seven studies fulfilled all of the selection criteria and were included in the qualitative analysis.

Descriptive Analysis

The studies were published between 2010 and 2015. All studies were randomized clinical trials. The sample size ranged from 29 to 72 subjects. A total of 947 teeth were evaluated in this review for all the included clinical trials. The ages of the patients ranged from 20 to 84 years old. All clinical studies had a minimum of 18 months of follow-up. Five studies evaluated the restorations according to United States Public Health Service (USPHS) criteria, and three used World Dental Federation (FDI) criteria.

Two studies evaluated the application of the adhesive system with the frictional technique,[12,15] and two others analyzed the effects of dry and moist dentin.[12,19] Additionally, one study investigated the removal of sclerotic dentin through the use of a bur,[14] and in another, only the roughness of the tooth surface with a bur was investigated.[36] Moreover, only one study applied EDTA before primer use in NCCLs.[11]

Risk of Bias of Included Studies

Concerning the quality assessment (Figure 2), these studies presented a low risk of bias for most of the biases that were analyzed. Only two studies[13,14] did not report blinding the participants and personnel, as well as blinding the outcome assessments.

Meta-Analysis

A meta-analysis was performed for the six randomized clinical trials. Considerable heterogeneity was observed in this analysis (I^2=55%). The analysis considering the mechanical removal of dentin surface with a bur (Figure 3A) and the application of an adhesive system in a frictional mode (Figure 3B) showed these treatments improved retention rates of the resin composite restorations in NCCLs ($p<0.05$). However, when considering only the application of an adhesive system in dry dentin compared with a control, no statistically significant differences were observed (Figure 3C).

DISCUSSION

The hypothesis that was evaluated was accepted once our meta-analysis demonstrated that dentin surface treatments could improve resin composite retention in NCCLs. All studies were randomized, and in general, they presented a low risk of bias because the evidence obtained from them had high quality. Among the surface treatments suggested to

Table 4: *Main Characteristics of the Included Studies*

Study	Selection Criteria	Surface Treatment	Control Group
Van Dijken[13]	Healthy subjects; treatment of NCCL	Surface roughened by a diamond bur followed by application of an etch-and-rinse or self-etch adhesive	Surface not roughened before adhesive application
Loguercio and others[26]	Healthy subjects; no dentin hypersensitivity; treatment of NCCL	Slight rubbing action: adhesive lightly spread on the surface for approximately 10 seconds (pressure was equivalent to approximately 4.0±1.0*g*). An air stream was applied for 10 seconds at a distance of 20 cm. Vigorous rubbing action: adhesive rigorously agitated on the surface for approximately 10 seconds (pressure equivalent to approximately 34.5±6.9*g*). An air stream was applied for 10 seconds at a distance of 20 cm	No rubbing action: adhesive only spread over the entire surface for approximately 3 seconds and left undisturbed for 7 seconds. An air stream was applied for 10 seconds at a distance of 20 cm.
Dalkiliç and Omurlu[14]	Healthy subjects; treatment of NCCL	Outer surface of the sclerotic dentin was removed by roughening with a diamond bur, then etch-and-rinse or self-etch adhesive was applied.	Adhesive application without prior removal of sclerotic dentin
Luque-Martinez and others[11]	Healthy subjects; treatment of NCCL	Surfaces were treated with 17% EDTA for 2 minutes, copiously rinsed with water for 30 seconds, and slightly dried with an air stream for five to 10 seconds while keeping the dentin surface slightly moist before the adhesive was applied.	Adhesive application without surface treatment with EDTA
Zander-Grande and others[12]	Healthy subjects; treatment of NCCL	Adhesive was rigorously agitated on the entire dentin surface for approximately 15-20 seconds. A microbrush was used to scrub the dentin surface under manual pressure (equivalent of approximately 34.5±6.9*g*). An airstream was applied for 10 seconds at a distance of 20 cm. The air-dry pressure used was 40 psi.	Adhesive only spread over the entire surface for approximately three to five seconds and was left undisturbed for 15 to 20 seconds. An airstream was applied for 10 seconds at a distance of 20 cm.
Zander-Grande and others[35]	Healthy subjects; not included teeth with dentin sclerosis; treatment of NCCL	Adhesive application with dry dentin	Adhesive application with moist dentin
Perdigão and others[15]	Healthy subjects; treatment of NCCL	Adhesive application with dry dentin	Adhesive application with moist dentin

Table 4: *Main Characteristics of the Included Studies (ext.)*

Study	Restoration	Dropouts	Failures
Van Dijken[13]	*Adhesive System:* Clearfil SE Bond (Kuraray Co. Ltd., Osaka, Japan) in self-etch mode PQ 1 (Ultradent, South Jordan, Utah, United States) in etch-and-rinse mode *Composite Resin:* Tetric Ceram (Ivoclar/Vivadent, Schaan, Liechtenstein) Point 4 (Kerr Corp., Orange, United States)	Seven restorations	Retention
Loguercio and others[26]	*Adhesive System:* Prime & Bond NT (Dentsply DeTrey, Konstanz, Germany) in etch-and-rinse mode *Composite Resin*: Esthet-X (Dentsply DeTrey, Konstanz, Germany)	None	Retention
Dalkiliç and Omurlu[14]	*Adhesive System:* Single Bond (3M ESPE, St. Paul, Minnesota, United States) in etch-and-rinse mode Clearfil SE Bond (Kuraray Medical, Tokyo, Japan) in self-etch mode XENO III (Dentsply/DeTrey, Konstanz, Germany) in self-etch mode *Composite Resin:* Filtek Supreme (3M ESPE, St. Paul, Minnesota, United States)	Six patients (94 restorations)	Retention
Luque-Martinez and others[11]	*Adhesive System:* Adper Easy One (3M ESPE, St. Paul, Minnesota, United States) in self-etch mode *Composite Resin:* Filtek Z350XT (3M ESPE, St. Paul, Minnesota, United States)	Six patients	Retention
Zander-Grande and others[12]	*Adhesive System:* Adper Prompt L-Pop (3M ESPE, St. Paul, Minnesota, United States) in self-etch mode XENO III (Dentsply Caulk, Milford, DE, United States) in self-etch mode *Composite Resin:* Filtek Z250 (3M ESPE, St. Paul, Minnesota, United States) Esthet X (Dentsply Caulk, Milford, DE, United States)	None	Retention
Zander-Grande and others[35]	*Adhesive System:* One-Step Universal Dental Adhesive System (Bisco, Schaumburg, Illinois, United States) in etch-and-rinse mode Adper Single Bond Plus Adhesive (3M ESPE, St. Paul, Minnesota, United States) in etch-and-rinse mode *Composite Resin:* Filtek Z250 (3M ESPE, St. Paul, Minnesota, United States)	None	Retention
Perdigão and others[15]	*Adhesive System:* Scotchbond Universal Adhesive (3M ESPE, St. Paul, Minnesota, United States) in etch-and-rinse, self-etch and selective etching mode *Composite Resin:* Filtek Supreme Ultra (3M ESPE, St. Paul, Minnesota, United States)	1 patient	Retention, marginal staining and postoperative sensitivity

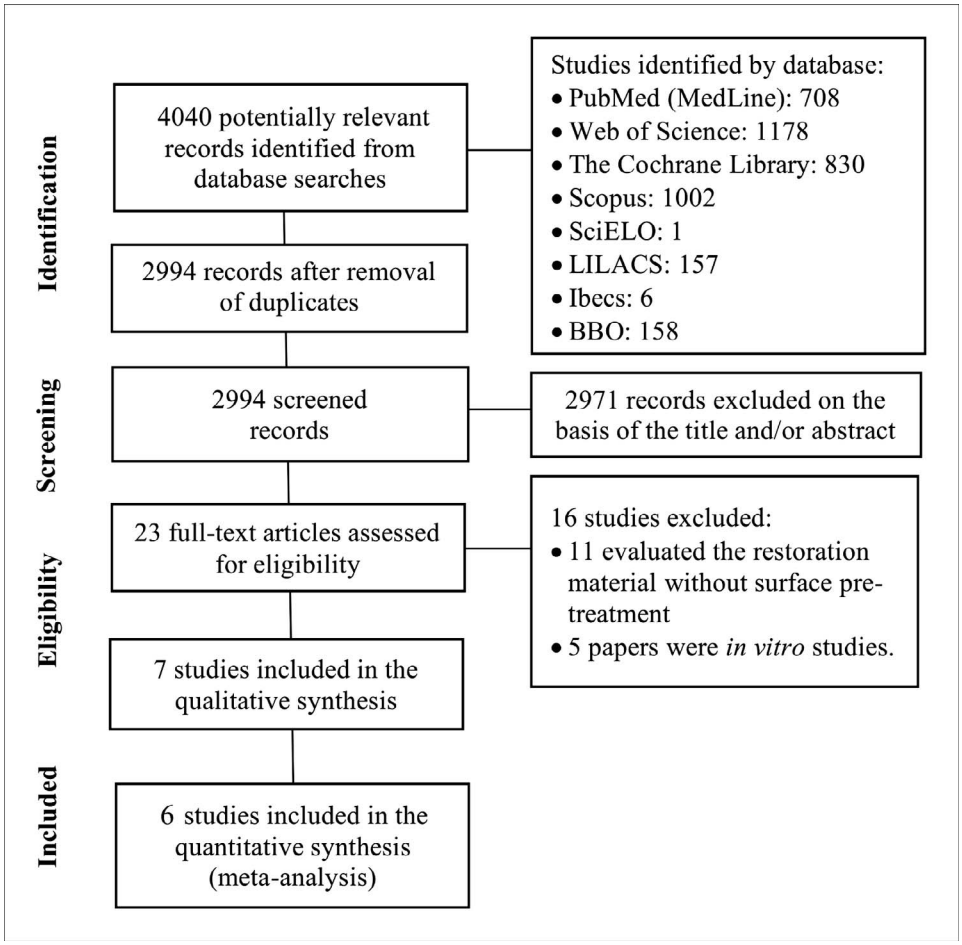

Figure 1. *Search flow (as described in the PRISMA statement).*

improve resin composite retention, two studies evaluated the application of an adhesive system in a frictional mode.[12,26] Both studies reported that vigorous application of the adhesive system improved the retention of restorations in NCCLs. One of the studies compared two different frictional techniques, including a slight rubbing action and the vigorous application of adhesives, and the researchers concluded that the vigorous application could be a clinical approach to improve the retention of resin composite in NCCLs.[26] It was reported that this approach improved the bond strength of self-etch adhesives to enamel[37,38] and to dentin.[38–41] In dentin, the active adhesive system application may have improved smear layer dissolution, micromechanical interlocking and chemical interactions.[42]

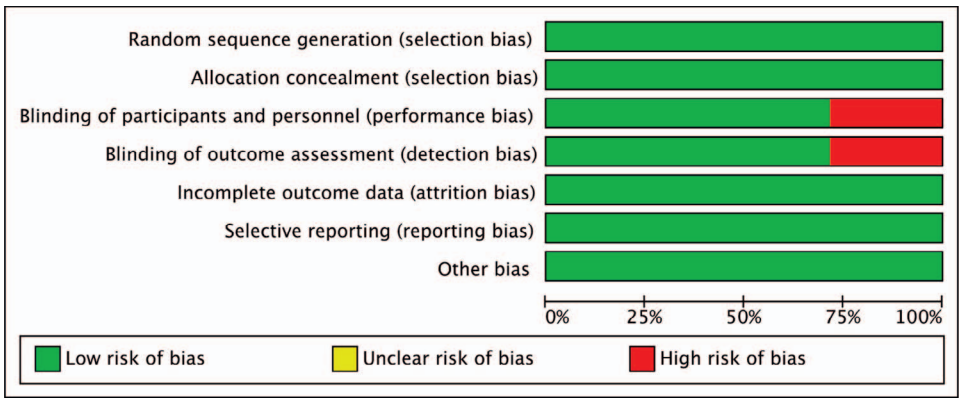

Figure 2. *Risk of bias graph: authors' judgments about each risk of bias item presented as percentages across all included studies.*

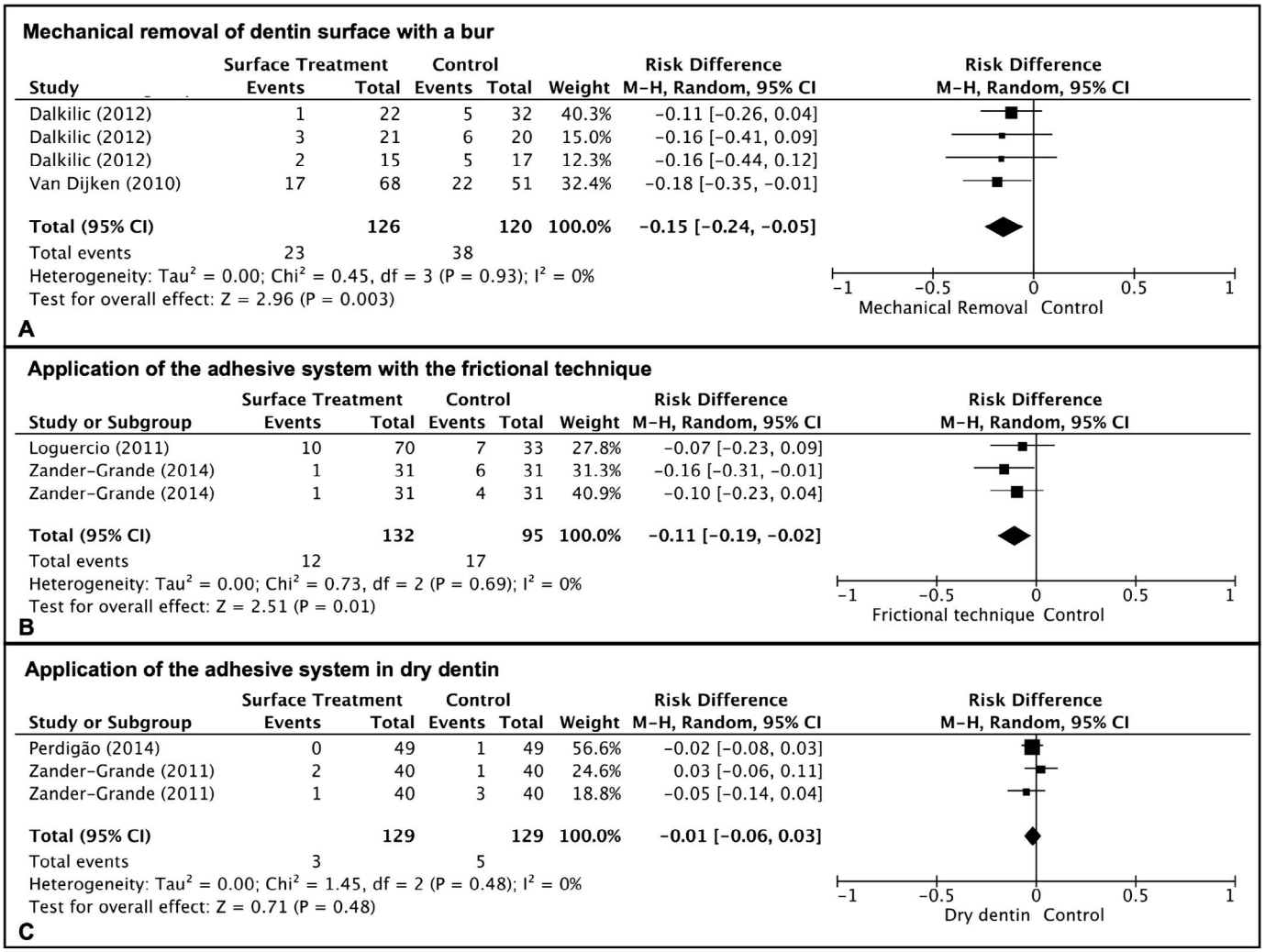

Figure 3. *Meta-analysis considering (A) the mechanical removal of dentin surface with a bur, (B) the application of an adhesive system in a frictional mode or (C) in dry dentin.*

Although clinical trials evaluating this approach are limited,[14] the available literature suggests that adhesive application in a frictional mode could improve the retention rates of resin composite.

One of the factors that could compromise adhesion in NCCLs is the presence of dentin sclerosis, which consists of a hypermineralized dentin that has difficult resin composite adhesion.[6,43] It was reported that 54%, 22%, and 2% of NCCL presented mild, moderate, and heavy dentin sclerosis, respectively.[2] Alternative strategies for adhesion to sclerotic dentin have been recommended by previous researchers.[6] It was observed that lesions were slightly roughened before adhesive system application showed lower loss rates of restoration compared with unroughened adhesives.[13,14] This difference probably occurred because these lesions had a high degree of sclerosis. In the present review, one study investigated the removal of the surface layer of sclerotic dentin through the use of a bur[14] and showed no improvement in the retention and marginal staining after 24 months. On the other hand, one clinical trial showed that roughening the tooth surface with a bur prior to an etch-and-rinse or self-etch adhesive application improved retention rates after 8 years for adhesives used in both sclerotic and nonsclerotic dentin.[13]

Furthermore, many failures of restoration are due to the technique sensitivity of the adhesive systems, and some studies have questioned the technique of using moist dentin. It is necessary to preserve demineralized dentin to allow adequate resin monomer infiltration, and this sensitivity technique is a major challenge for students or inexperienced dentists.[44–46] Due to these disadvantages, other dentin surface treatments that were

evaluated included the application of an adhesive system over dry and moist dentin.[15,35] It was suggested that the maintenance of demineralized dentin in a dry state could minimize the negative effects of water on hybrid layer formation.[15] Additionally, universal adhesives were evaluated in two studies, and they were applied in self-etch, etch-and-rinse, and selective enamel etching modes, which allowed the clinician to decide on a specific adhesive protocol that was best suited for the cavity that was being prepared.[46] Studies that evaluated the application of these adhesives in etch-and-rinse or self-etch modes,[15,35] both in moist and dry dentin, demonstrated that the behavior of the adhesive was not dependent on the bonding strategy that was used after 18[15] and 24 months.[35] Further studies with longer follow-up periods are needed to evaluate if dry dentin can increase the retention rate of resin composite in NCCLs.

Another method that was evaluated was the application of EDTA, which could dissolve the smear layer and permit a chemical bond between the primer/bond and the dentinal collagen and calcium.[47,48] As a consequence, better interaction of the adhesive with the sclerotic dentin might occur, which would improve the etching pattern and the interaction between self-etch adhesives and sclerotic dentin.[11,49,50] EDTA is widely recognized as an effective inhibitor of endogenous metalloproteinases (MMPs),[51] and the application of 17% EDTA for two minutes could significantly reduce the activity of dentin MMPs.[52] EDTA also chelates zinc and calcium ions that are essential for MMP activity.[53,54] *In vitro* studies have reported promising results after preliminary conditioning with EDTA, which produced a shallow demineralization of the dentin.[49,50] In this review, one study evaluated the application of 17% EDTA for two minutes prior to adhesive application and showed a significant increase in the retention rates of composite restorations in NCCLs after 18 months.[11] It is reported that EDTA could improve adhesion of the self-etch adhesives to sclerotic dentin[49,50,55] by producing selective dissolution of hydroxyapatite and "kidnapping" the metallic ions presented in dentin,[56,57] enhancing the interaction of the self-etch adhesive with the tissue.[49,50,55]

The studies also varied in terms of the evaluation methods used for clinical assessment of the restorations of NCCLs. Most studies used the USPHS and FDI criteria.[58] The USPHS mainly evaluated marginal adaptation staining, retention, fracture, marginal discoloration, postoperative sensitivity and recurrence of caries,[13,26,35] whereas FDI evaluated esthetic properties (staining margin), functional properties (fractures and retention, marginal adaptation), and biological properties (postoperative sensitivity, secondary caries).[11,12] We used the outcome "retention rate" that both criteria analyzed, which allowed the comparisons. A recent study[15] that compared both methods concluded that the FDI criteria were more sensitive to small variations in the clinical outcomes than were the USPHS criteria when evaluating restorations of NCCLs.

One limitation of our review is that the included studies presented substantial heterogeneity, which was probably due to the different surface treatments that were evaluated, follow-up periods, evaluation criteria, materials that were tested and outcomes that were assessed. This high heterogeneity and the small amount of studies regarding surface treatment in NCCLs made other comparisons difficult. Furthermore, an important factor that influences retention of NCCL restoration is the kind of adhesive system (etch-and-rinse or self-etch) used. However, due to the small number of included studies, the results of this study could not be controlled for this confounder. Further studies comparing different dentin surface treatments need to be performed to determine the best treatment option that can improve the longevity of resin composite in NCCLs.

In summary, the influence of dentin surface treatment in the retention rates of resin composite restorations in NCCLs was dependent on the strategy that was used. The application of an adhesive system in a frictional mode and the mechanical removal of dentin surfaces with a bur improved retention rates of resin composite restorations in NCCLs. Although the meta-analysis demonstrated a positive effect of treatment, only a few studies were already available in the literature, and further clinical trials are needed to determine the best treatment option. Additionally, there was not enough evidence to support this conclusion over longer-term follow-up, as the majority of included studies evaluated the outcomes for up to 24 months.

CONCLUSIONS

There is evidence in the literature suggesting that the mechanical removal of dentin surfaces with a bur and the application of an adhesive system in a frictional mode may improve the retention rates of resin composite restorations in NCCLs. However, the studies showed high heterogeneity, and addi-

tional clinical trials are needed to compare different strategies in longer-term follow-ups and determine the best treatment option for resin composite in NCCLs.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the PROSPERO International Database for systematic reviews. The approval code for this study is CRD42014010018.

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.

(Accepted 14 December 2017)

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