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Do Tooth- and Cavity-related Aspects of Noncarious Cervical Lesions Affect the Retention of Resin Composite Restorations in Adults? A Systematic Review and Meta-analysis

AMO Correia • E Bresciani • AB Borges • DM Pereira • LC Maia • TMF Caneppele

Clinical Relevance

Recognizing the effects related to the teeth and cavities of NCCLs that are relevant to the success of the restoration is important, as clinicians must be aware of them during the procedure and follow-up of the patients.

SUMMARY

Purpose: The purpose was to perform a systematic review and meta-analysis based on the following research question: do tooth- and cavity-related aspects of noncarious cervical lesions (NCCLs) affect the retention of composite restorations?

Methods: Randomized clinical trials (RCTs) that evaluated the retention rate of resin restorations in NCCLs were included for the identification and comparison of their characteristics. The search was conducted in PubMed and adapted for Scopus, Web of Science, Latin

Ayla Macyelle de Oliveira Correia, PhD student, Department of Restorative Dentistry, São Paulo State University (Unesp), Institute of Science and Technology, São José dos Campos, São Paulo, Brazil

Eduardo Bresciani, associate professor, Department of Restorative Dentistry, São Paulo State University (Unesp), Institute of Science and Technology, São José dos Campos, São Paulo, Brazil

Alessanda Buhler Borges, associate professor, Department of Restorative Dentistry, São Paulo State University (Unesp), Institute of Science and Technology, São José dos Campos, São Paulo, Brazil

Daniele Masterson Pereira, librarian, Centro de Ciências da Saúde, Federal University of Rio de Janeiro–UFRJ, Rio de Janeiro, Brazil

Lucianne Cople Maia, professor, Department of Pediatric Dentistry and Orthodontic, Federal University of Rio de Janeiro–UFRJ, Rio de Janeiro, Brazil

*Taciana Marco Ferraz Caneppele, associate professor, Department of Restorative Dentistry, São Paulo State University (Unesp), Institute of Science and Technology, São José dos Campos, São Paulo, Brazil

*Corresponding author: Av Eng Francisco José Longo, 777 Jardim São Dimas, São José dos Campos/SP 12245-000, Brazil; e-mail: taciana.caneppele@unesp.br

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American and Caribbean Health Sciences Literature database (LILACS), Brazilian Library in Dentistry (BBO), Cochrane Library, and System for Information on Grey Literature in Europe (SIGLE) without restrictions until July 2018. Unpublished and ongoing trial registries were also searched. The Cochrane Collaboration tool was used for assessing risk of bias. The quality of the evidence was graded using the Grading of Recommendations: Assessment, Development and Evaluation. Using the random effects model, a meta-analysis was conducted for each aspect (arch distribution, tooth location, wear facets, dentin sclerosis, shape, size, depth, occluso-gingival distance, and margin location).

Results: We retrieved 6738 articles. After removal of duplicates and nonrelevant articles, 24 RCTs remained. The anterior tooth location favored the retention rates of restoration of NCCLs (relative risk [RR], 1.08; 95% confidence interval [CI], 1.00-1.16). The presence of wear facets is a risk factor for the retention of restorations (RR, 0.91; 95% CI, 0.83-0.99). The evidence was moderate for arch distribution and low or very low for all other factors because of heterogeneity, imprecision, and inconsistency.

Conclusion: The tooth location and the presence of wear facets can affect the retention of composite resins in NCCLs.

INTRODUCTION

Noncarious cervical lesions (NCCLs) are commonly observed in clinical dental practice and are characterized by the cervical loss of hard dental tissue, with no occurrence of dental caries or trauma. They may be superficial or deep and can present as extensive defects with various shapes.[1] The etiology of NCCLs has been described as multifactorial, resulting from the combination of different processes, including stress (abfraction), friction (abrasion), and biocorrosion (chemical, biochemical, and electrochemical degradation).[2-4] Initially, NCCLs develop in enamel with slow progression into dentin, leading to gradual dentin sclerosis.[1,5] Sclerosis occurs as a response to low intensity and chronic stimuli from physiologic aging, which is a characteristic consistent with the more frequent occurrence of NCCLs in an elderly population.[6-8]

NCCLs are often restored to treat dental hypersensitivity, to improve esthetics, and to prevent further loss of dental tissues.[9,10] However, NCCL restorations have a high index of failure, resulting from loss of retention, secondary caries, marginal discoloration, and marginal adaptation, compromising the longevity of the restorative treatment.[5,11] Problems with NCCL restorations include nonretentive characteristics and the location of lesion margins in dentin or cementum, as well as the presence of dentin sclerosis, which compromises the adhesive process.[10,12-14]

Approaches to improving the clinical performance of NCCL restorations, focusing mainly on restorative materials and dentin substrate treatment, have been described.[1,14-21] Although these findings are promising, cavity geometry (shape and size) has been reported to play an important role in the longevity of NCCL restorations.[5,22-25] Also, dentin sclerosis,[25] tooth location,[26,27] and the presence of wear facets[26] have been reported to be relevant to the retention of NCCL restorations. Others[28,29] have reported that these factors do not influence retention. Therefore, because of the inconsistent results available, a systematic review was conducted with the focused question: Do tooth- and cavity-related aspects of NCCLs affect the retention of resin composite restorations in adults?

METHODS

Protocol and Registration

The study protocol was registered at the PROSPERO database (www.crd.york.ac.uk/PROSPERO) under the number CRD42016039569 and followed the recommendations of the PRISMA statement for reporting the present systematic review.[30]

Eligibility Criteria

The research question was as follows: do tooth- and cavity-related aspects of noncarious cervical lesions affect the retention of resin composite restorations? Randomized clinical trials (RCTs) that evaluated the retention rate (follow-up period of at least two years) of resin composite restorations in participants with NCCLs were included for the identification and comparison of their characteristics. Eligible studies reported one or more of the following factors in relation to restoration retention rate: 1) arch distribution; 2) tooth location; 3) wear facets; 4) dentin sclerosis; 5) shape; 6) size; 7) depth; 8) occluso-gingival distance; and 9) margin location. Non-RCTs, observational studies, case reports, reviews, and *in vitro* studies were excluded.

Table 1: *Electronic Database and Search Strategy (5 December 2016, Updated in July 2018)*

PUBMED
((((((((((((Dental Restoration, Permanent[MeSH Terms]) OR Restoration*[Title/Abstract]) OR Dental Filling*[Title/Abstract]) OR Composite Resins[MeSH Terms]) OR Composite Resin*[Title/Abstract]) OR Resin composite*[Title/Abstract])))))) AND ((((((((((((((((Tooth abrasion[Title/Abstract]) OR Tooth Cervix[MeSH Terms]) OR Cementoenamel Junction*[Title/Abstract]) OR CEJ[Title/Abstract]) OR Tooth Erosion*[Title/Abstract]) OR Dental Erosion[Title/Abstract]) OR Tooth Wear[MeSH Terms]) OR Tooth Wear[Title/Abstract]) OR Cervical lesion*[Title/Abstract]) OR Class V [Title/Abstract]))))
Scopus
TITLE-ABS-KEY (“Tooth abrasion” OR “Tooth Cervix” OR “Cementoenamel Junction” OR CEJ OR “Tooth Erosion” OR “Dental Erosion” OR “Tooth Wear” OR “Dental Wear” OR “Cervical lesion” OR “Class V”) AND (restoration OR “Dental Filling” OR “Composite Resin” OR “Resin composite”) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “re”)) AND (LIMIT-TO (SUBJAREA, “DENT”))
Web of Science
#1 TS= (“Tooth abrasion” OR “Tooth Cervix” OR “Cementoenamel Junction” OR CEJ OR “Tooth Erosion” OR “Dental Erosion” OR “Tooth Wear” OR “Dental Wear” OR “Cervical lesion” OR “Class V”) #2 TS= (restoration OR “Dental Filling” OR “Composite Resin” OR “Resin composite”) #1 AND #2
LILACS and BBO
(MH:” tooth abrasion” or MH: “Tooth cervix” or MH: “tooth erosion” or “erosão dentária” or MH: “tooth wear” or “desgaste dentário”) and (MH: “Dental Restoration, permanent” or MH: “Composite resins” or “resinas compostas” or compósitos)
Cochrane Library
#1 “Tooth abrasion" #2 MeSH descriptor: [Tooth Cervix] explode all trees #3 “Cementoenamel Junction” or CEJ #4 #2 or #3 #5 “Tooth Erosion" #6 “Cervical lesion” or “cervical lesions” or “Noncarious lesions” or “Class V” or NCCL #7 #1 or #4 or #5 or #6 #8 MeSH descriptor: [Dental Restoration, Permanent] explode all trees #9 Restoration* or “Dental Fillings" #10 #8 or #9 #11 MeSH descriptor: [Composite Resins] explode all trees #12 “Composite Resin” or “Composite Resins” or “Resin composite” or “Resin composites" #13 #11 or #12 #14 #10 or #13 #15 #7 and #14

Information Sources and Search Strategy

To define the search strategy, a preliminary search for studies was conducted using some specific keywords on the characteristics of NCCLs (shape, depth). However, the search did not retrieve relevant results. Therefore, we decided to use terms related to lesions in general and restoration with resin composite. Information on aspects of interest was only determined during the full-text reading of the studies.

The search strategy was conducted using multiple combinations of MeSH terms and free keywords (Table 1). An electronic search was performed in MEDLINE via PubMed, citation databases (Scopus and Web of Science), Latin American and Caribbean Health Sciences Literature database (LILACS), Brazilian Library in Dentistry (BBO), Cochrane Library, and ongoing trial databases, including ClinicalTrials.gov (www.clinicaltrials.gov) and ReBEC (The Brazilian Clinical Trials Registry; www.rebec.gov.br). The non–peer-reviewed literature was searched using the database System for Information on Grey Literature in Europe (SIGLE). Additionally, the reference lists of the included studies were checked to identify possible relevant studies. An expert librarian (DM) supervised the search strategy. No restrictions were placed on the publication date or language. The search strategy was appropriately modified for each database to identify eligible studies.

A “Search Alert” with the search strategy in the PubMed, Scopus, Web of Science databases, and Cochrane Library was created, and the search was updated weekly until July 2018.

Study Selection and Data Collection Process

The studies were selected by title and abstract according to the described search strategy (Table 1). Articles that appeared in more than one database were considered only once. Full-text articles were

also obtained when the title and abstract contained insufficient information for a clear decision. The search in the Cochrane Library retrieved some abstracts from conferences. The authors were contacted for further information about the publication of the entire study. Subsequently, two reviewers classified those that met the inclusion criteria. Each eligible article received a study identification number, which combined the first author name and year of publication.

Relevant information about the study design, participants, number of treated teeth, follow-up time, dropouts, and factors reported were extracted independently using customized extraction forms by two authors (Table 2); in cases of disagreement, a decision was reached by consensus.

When multiple reports of the same study (eg, reports with different follow-up times) were found, the study with the highest long-term follow-up time was included for data extraction. When more than one resin composite or adhesive was included in the study, their values were combined to make a single entry. Three attempts to contact the authors by e-mail were made when data not described in the articles were necessary.

Regarding the retention rate, we collected data from the studies and grouped them according to the factors reported: arch distribution, tooth location, wear facets, dentin sclerosis, shape, size, depth, occluso-gingival distance, and margin location.

Risk of Bias in Individual Studies

Two independent reviewers performed the quality assessment of the included studies using the Cochrane Collaboration tool for assessing risk of bias in randomized trials.[47] During data selection and quality assessment, any disagreements between the reviewers were solved through discussion and, if needed, consultation with a third reviewer (LCM).

The risk of bias of each domain was classified following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions 5.1.0 (http://handbook.cochrane.org). The criteria for judging risk of bias covers six items: selection bias (sequence generation and allocation concealment), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other sources of bias.[47] The studies were classified as having low, high, or unclear risk of bias.[47]

Data Synthesis and Statistical Analysis

According to tooth- and cavity-related aspects of NCCLs, the data analyzed were dichotomized, as shown in Table 3. The extracted data were analyzed using the R statistical language R Studio (version 3.4.4; Studio Team, Boston, MA, USA).

Differences observed between the groups were expressed as pooled relative risk (RR), with 95% confidence interval (CI). The retention rate for each tooth- and cavity-related aspect of NCCLs was evaluated with an intention-to-treat protocol. When not reported in the article, the retention rate was calculated according to intention-to-treat. The factor effect on the defined outcome measurement was calculated from the study data using the random-effects model. Statistical heterogeneity of the treatment effects among studies was assessed using the Cochran Q test and the inconsistency I^2 test, in which values greater than 50% were considered indicative of substantial heterogeneity.[47] No subgroup analyses were performed.

Publication Bias

We assessed publication bias using funnel plot techniques and, given the known limitations of these methods, the Egger regression test as appropriate.[52,53]

Certainty of Evidence

The quality of the evidence was graded for each outcome across studies (certainty of evidence) using the Grading of Recommendations: Assessment, Development and Evaluation (GRADE; http://www.gradeworkinggroup.org/) to determine the overall strength of the evidence for each meta-analysis.[52] For RCTs, the GRADE approach addresses five possible reasons (risk of bias, imprecision, inconsistency, indirectness of evidence, and publication bias) to downgrade the quality of the evidence (one or two levels). Each domain was assessed as having no limitation, serious limitations, or very serious limitations to categorize the quality of the evidence as high, moderate, low, or very low. The GRADEpro Guideline Development Tool, available online (https://gradepro.org/), was used to create a Summary of Findings table.

RESULTS

Study Selection

The search in the databases led to 6738 articles (Figure 1). After the removal of duplicates, 3715 results remained. By screening title and abstract, articles not related to the topic of this systematic

Table 2: *Data Extraction From Selected Studies*

Study ID	Evaluation Criteria	Split-Mouth	Number of Subjects	Subjects' Age Mean [range] (y)	Number of Teeth
Abdalla and Sayed 2008[16]	Modified USPHS	Yes	42	n.r. [35-65]	125
Aw and others 2005[31]	Modified USPHS	Yes	57	51 [29-75]	171
Çelik and others 2007[15]	Modified USPHS	No	37	n.r. [29-67]	252
Dall'Orologio and others 2010[32]	Modified USPHS	No	50	46 [30-52]	150
Dall'Orologio and Lorenzi 2014[33]	Modified USPHS	No	50	n.r. [21-66]	150
Fagundes and others 2014[19]	Modified USPHS	No	30	n.r. [18-50]	35
Häfer and others 2015[18]	FDI	Yes	40	46.7 [18-66]	110
Hörsted-Bindslev and others 1996[34]	USPHS	Yes	26	47 [n.r.]	80
Karaman and others 2012[20]	Modified USPHS	Yes	21	60 [48-70]	134
Kubo and others 2006[35]	Modified USPHS	Yes	8	61.3 [45-78]	72
Kubo and others 2010[36]	Modified USPHS	No	22	61.9 [29-78]	98
Loguercio and others 2015[37]	Modified USPHS and FDI	No	39	n.r. [20-n.r.]	200
Oginni and Adelek 2014[26]	Modified USPHS	No	89	46 [29-76]	287
Özgünaltay and Onen 2002[38]	Modified USPHS	Yes	24	n.r. [40-65]	48
Sartori and others 2013[39]	Modified USPHS	Yes	20	46.7 [33-64]	70
Torres and others 2014[40]	Modified USPHS	Yes	30	40.70 [21-60]	138
Tuncer and others 2013[41]	Modified USPHS	No	24	58 [38-73]	123
Tuncer and others 2017[42]	Modified USPHS	Yes	20	58.9 [27-83]	97
van Dijken 2004[43]	Modified USPHS	No	90	58 [46-72]	144
van Dijken 2005[44]	Modified USPHS	Yes	35	58 [34-84]	73
van Dijken 2010[45]	Modified USPHS	Yes	72	60.1 [42-84]	119
van Dijken 2013[17]	Modified USPHS	Yes	67	64.7 [39-84]	169
Van Meerbeek and others 1993[27]	Vanherlemethod	No	35	n.r. [n.r.]	132
Zanatta and others 2019[46]	FDI	No	34	n.r. [21-n.r.]	152

Abbreviations: ER, etch-and-rinse adhesive; FC, flowable compomer; FO: flowable ormocer; ID, identification; n.r., not reported; PAMR, poly-acid modified resin composite; RMGI, resin-modified glass-ionomer adhesive; SE, self-etch adhesive.

Table 2: *Data Extraction From Selected Studies (ext.)*

Study ID	Mechanical Preparation	Adhesive systems/Composite Resin	Follow-up Time (y)	Aspect	Dropouts at Follow-up (%)
Abdalla and Sayed 2008[16]	Dentin walls were roughened	SE/microhybrid	2	Arch distribution; tooth location	15
Aw and others 2005[31]	Enamel beveling (0.5-1 mm)	ER/microhybrid and microfill	3	Arch distribution; tooth location; wear facets; dentin sclerosis; depth	15
Çelik and others 2007[15]	No	ER/FO, FC, flowable and microhybrid	2	Arch distribution; tooth location	31.75
Dall'Orologio and others 2010[32]	Dentin roughening and enamel beveling (1 mm)	SE and ER/microhybrid	7	Dentin sclerosis; depth; margin location	16
Dall'Orologio and Lorenzi 2014[33]	Dentin roughening and enamel beveling (1 mm)	ER/nano-ceramic and microhybrid	8	Dentin sclerosis; shape; margin location	20
Fagundes and others 2014[19]	No	ER/hybrid	7	Arch distribution; tooth location	28.57
Häfer and others 2015[18]	Hypermineralized dentin and the marginal enamel were prepared	SE and ER/nano-hybrid	3	Arch distribution; tooth location; depth	25.45
Hörsted-Bindslev and others 1996[34]	No	ER/hybrid	3	Arch distribution; tooth location	12.5
Karaman and others 2012[20]	No	SE/nano-hybrid	2	Arch distribution; tooth location	0
Kubo and others 2006[35]	Most of the enamel and dentin walls were lightly roughened + enamel beveling (n.r.)	SE and ER/microhybrid	5	Arch distribution; tooth location	0
Kubo and others 2010[36]	Dentin roughening and enamel beveling (1 mm)	SE/flowable and microhybrid	3	Arch distribution; depth; size	0
Loguercio and others 2015[37]	No	SE and ER/nanofilled	3	Arch distribution; tooth location; wear facets; dentin sclerosis; shape; occluso-gingival distance	12.82
Oginni and Adelek 2014[26]	No	ER/microhybrid	2	Arch distribution; tooth location; wear facets	34.14
Özgünaltay and Onen 2002[38]	Enamel beveling (1 mm)	ER/microhybrid	3	Arch distribution	16.67
Sartori and others 2013[39]	n.r.	ER/Nanofilled	3	Tooth location; wear facets; dentin sclerosis; shape; occluso-gingival distance	28.57
Torres and others 2014[40]	n.r.	ER/microfilled	5	Arch distribution; tooth location; wear facets; dentin sclerosis; shape; depth; occluso-gingival distance	23.1
Tuncer and others 2013[41]	No	SE and ER/nanohybrid	2	Arch distribution; tooth location	0
Tuncer and others 2017[42]	No	ER/microhybrid	2	Arch distribution; tooth location	12.37
van Dijken 2004[43]	Part of the lesions were lightly roughened	SE and ER/microhybrid and hybrid	2	Depth; dentin sclerosis	1.4
van Dijken 2005[44]	Part of the lesions were slightly roughened	RMGI/hybrid and PAMR	6	Dentin sclerosis; depth	8.2
van Dijken 2010[45]	Part of the lesions were roughened	SE and ER/hybrid	8	Dentin sclerosis; depth; size	5.88
van Dijken 2013[17]	Lesions were slightly roughened	SE and ER/microhybrid	5	Arch distribution; tooth location; dentin sclerosis; depth; size	5.92
Van Meerbeek and others 1993[27]	Part of the lesions had the bevelled enamel	SE and ER/hybrid	2	Arch distribution; toth location	3.78
Zanatta and others 2019[46]	No	SE and ER/nanofilled	2	Arch distribution; tooth location; dentin sclerosis; occluso-gingival distance	12.5

Table 3: *Dichotomy of Results According to the Evaluation Criteria of the Studies*

Study	Aspect	
	Arch Distribution	
	Maxillary	**Mandibular**
Abdalla and Sayed 2008[16]; Aw and others 2005[31]; Çelik and others 2007[15]; Özgünaltay and Önen 2002[38]	Maxillary	Mandibular
Häfer and others 2015[18]; Karaman and others 2012[20]; Kubo and others 2006[35]; Kubo and others 2010[36]; Oginni and Adelek 2014[26]; Tuncer and others 2013[41]; Tuncer and others 2017[42]; van Dijken 2013[17]	Maxilla	Mandible
Fagundes and others 2014[19]; Hörsted-Bindslev and others 1996[34]	Upper	Lower
	Tooth Location	
	Anterior	**Posterior**
Abdalla and Sayed 2008[16]	Anterior	Premolar
Aw and others 2005[31]	Central incisors; lateral incisors; canines	First premolars; second premolars; first molars
Çelik and others 2007[15]; Karaman and others 2012[20]	Anterior	Posterior
van Dijken 2013[17]	Incisor/cuspidate	Premolar; molar
Fagundes and others 2014[19]; Kubo and others 2006[35]; Van Meerbeek and others 1993[27]	Incisor; canine	Premolar; molar
Oginni and Adelek 2014[26]	Anterior	Premolars; molars
Tuncer and others 2013[41]; Tuncer and others 2017[42]	Anterior (central, lateral and canine)	Posterior (premolar and molar)
	Wear Facets	
	With Wear Facets	**Without Wear facets**
Aw and others 2005[31]	Present	Absent
Oginni and Adeleke 2014[26]	With	Without
	Dentin Sclerosis	
	Dentin Sclerosis	**No Dentin Sclerosis**
Aw and others 2005[31*a*]	Mild; moderate; heavy	None
Zanatta and others 2019[46]; Dall'Orologio and others 2010[32]; Loguercio and others 2015[37]; Sartori and others 2013[39*b*]	2; 3; 4	1
Dall'Orologio and Lorenzi 2014[33]	Moderate; severe	No evidence
van Dijken 2004[43]; van Dijken 2005[44]; van Dijken 2010[45]; van Dijken 2013[17*c*]	<50%; >50%	None
Torres and others 2014[40*d*]	Slightly; moderately; severely	No
	Shape	
	Wedge	**Saucer**
Aw and others 2005[31]	<45; 45-90	90-135; >135
Zanatta and others 2019[46]	<90	90-135; >135
Sartori and others 2013[39]	V shaped	U shaped
	Size	
	Small/Moderate	**Large**
van Dijken 2010[45]	Small; moderate	Deep
van Dijken 2013[17]	Small; medium	Large

review were excluded. Thus, 235 articles were assessed to verify their eligibility. Among them, 211 were excluded for the following reasons: 1) the study did not report factors related to NCCLs; 2) the study did not compare the factors in the results; 3) they were conference meeting abstracts without full-text publication; 4) the study tested resin composite and other material, but the factors related to NCCLs were not presented for each material; 5) the study reported on lesions with the same characteristics; and 6) a study with longer-term follow-up was selected.

Study Characteristics

The characteristics of the 24 selected studies are listed in Table 2. The split-mouth study design was used in most of the studies. The number of

Table 3: *Dichotomy of Results According to the Evaluation Criteria of the Studies (cont.)*

Study	Depth	
	Shallow/Moderate	**Deep**
Aw and others 2005[31]	1-2 mm	2-3; 3-4; >4 mm
Zanatta and others 2019[46]	Flat (1-1.5 mm); medium (1.5-2 mm)	Deep (> 2 mm)
Dall'Orologio and others 2010[32]	1-2 mm	>2 <3; 3 mm
van Dijken 2010[45]	Shallow; moderate	Deep
van Dijken 2013[17]	Superficial; medium	Deep
Häfer and others 2015[18]	Shallow (<1 mm); medium (1-2 mm)	Deep (>2 mm)
Sartori and others 2013[39]	≤1.5 mm	>1.5 mm
	Occluso-gingival Distance	
	Short	**Long**
Aw and others 2005[31]	1-2; 2-3	3-4; >4 mm
Zanatta and others 2019[46]	<1.5; 1.5-2.5 mm	2.6-4; >4 mm
	Margin Location	
	Above/Aligned	**Intrasulcus**
Dall'Orologio and others 2010[32]	>1-2; > 2 mm	Intrasulcus
Dall'Orologio and Lorenzi 2014[33]	Above/aligned	1 mm below

[a] *Scale of Duke and others.*[48]
[b] *According to the criteria described by Swift and others.*[49]
[c] *Scale of Heymann and Bayne.*[50d] *According to the criteria described by Van Landuyt and others.*[51]

participants ranged from 8 to 90, with 35 to 287 treated teeth in these studies. Considerable variability was found in the age of the participants, with ages ranging from about 18 to 84 years old.

Mechanical preparation of the cervical lesions was common. Dentin roughening, removal of sclerotic dentin, enamel beveling, or their combination was reported in more than half of the studies.

Risk of Bias Within Studies

The results of the risk of bias assessment of the 24 included studies are presented in Figures 2 and 3. All the judgments in a cross-tabulation of the study by entry are presented in Figure 2. All the items in four studies were judged as low risk of bias.[33,37,41,46] Figure 3 illustrates the proportion of studies with each of the judgments for each entry. The risk of bias of selective reporting was judged as low, whereas blinding of outcome assessment was judged as unclear. The risk of bias of random sequence generation, allocation concealment, and incomplete outcome data were judged as high; however, the proportion was so small that it would not seriously weaken confidence in the results.

Meta-analysis and Summary of Findings

For the meta-analysis, studies were grouped according to the factors related to NCCLs (Figures 4 and 5). All studies for each tooth- and cavity-related aspect were included, despite their risk of bias. The impact of this decision was evaluated in a sensitivity analysis, where only studies with low risk of bias were included. No change in the overall significance was shown (data not shown).

Arch Distribution—For arch distribution (maxillary vs mandibular), 14 studies were included.[15-20,26,31,34-36,38,41,42] The overall results were RR, 1.01; 95% CI, 0.98-1.05; $I^2 = 23\%$, suggesting that the arch distribution of the NCCL does not affect the success rate of the resin composite restoration (Figure 4A).

Tooth Location—The forest plot of the meta-analysis for tooth location can be seen in Figure 4B. Eleven studies were included.[15-17,19,20,26,27,31,35,41,42] The overall results were RR, 1.08; 95% CI, 1.00-1.16. The heterogeneity was high ($I^2 = 82\%$, $p<0.001$). Therefore, anterior tooth location favors the retention rates of resin restoration of NCCLs by a factor of 1.08.

Wear Facets—For wear facets, only two studies were included.[26,31] The results were RR, 0.91; 95% CI, 0.83-0.099; $I^2 = 0\%$ (Figure 4C). The presence of wear facets is a risk factor for the retention rate of resin composite restorations.

Dentin Sclerosis—For dentin sclerosis (with vs without), 11 studies were included.[17,31-33,37,39,40,43-46] The overall results were RR, 0.99; 95% CI, 0.93-1.05

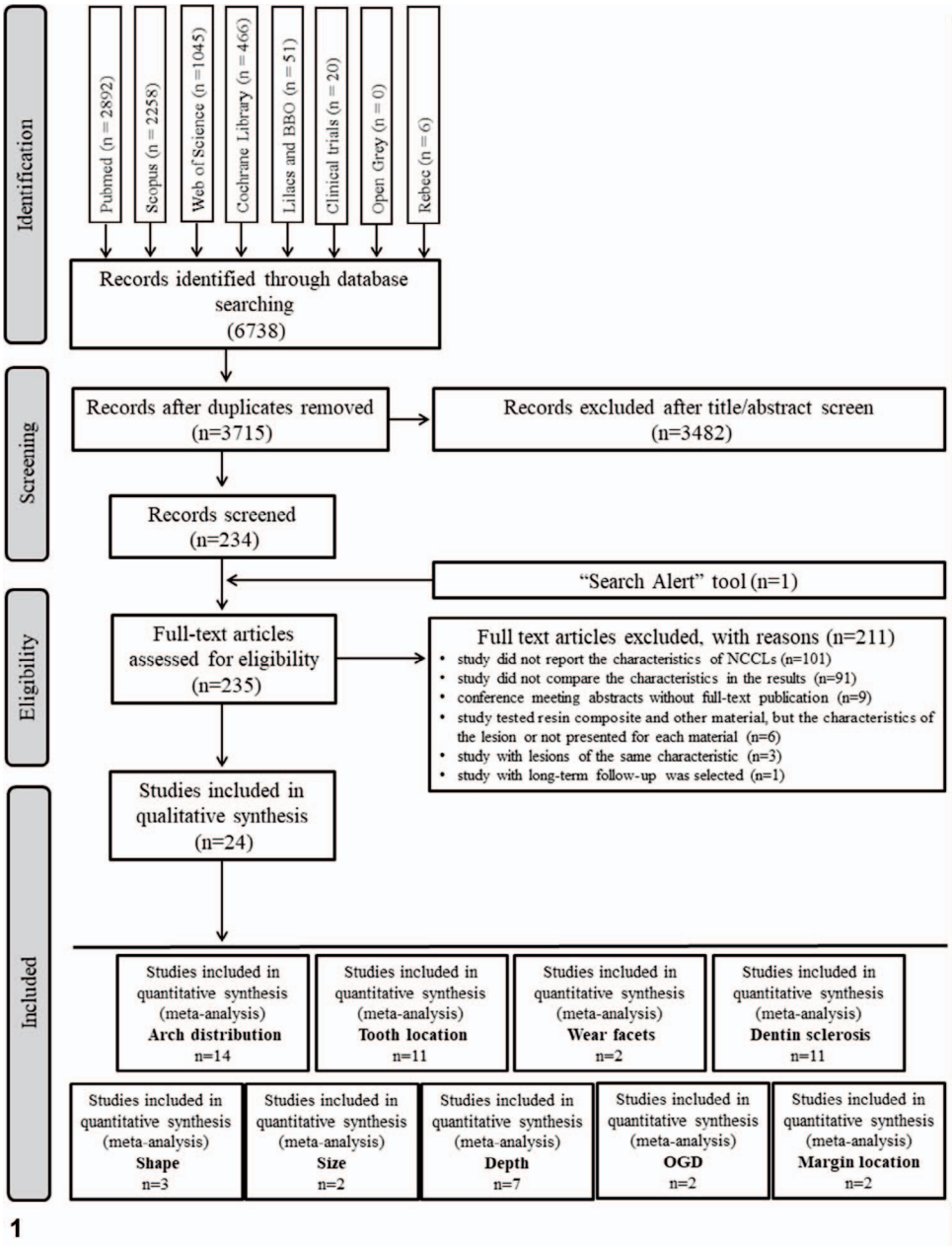

Figure 1. *Flow diagram of the study identification.*

Figure 2. *Risk of bias summary: review authors' judgments about each risk of bias item for each included study.*

(Figure 4D). The heterogeneity was 60%, suggesting dentin sclerosis does not affect the success rate of the resin composite restoration of NCCLs.

Shape—The forest plot of the meta-analysis for shape can be seen in Figure 5A. Three studies were included.[31,39,46] The overall results were RR, 1.03; 95% CI, 0.91-1.18. The heterogeneity was 51% (p=0.13), suggesting the shape of NCCL does not affect the success rate of resin composite restorations.

Size—For the size of lesions, two studies by the same author were included.[17,45] The size of NCCL does not affect the retention rate of the composite restorations (RR, 0.97; 95% CI, 0.88-1.08; I^2 = 0%; p=0.44; Figure 5B).

Depth—For the depth (shallow/moderate vs deep) of NCCL, seven studies were included,[17,18,31,32,39,45,46] and this characteristic does not seem to affect the retention rate of composite

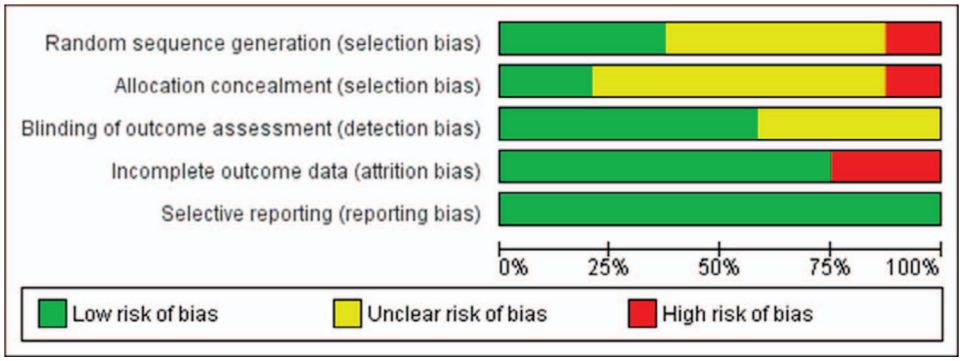

Figure 3. *Risk of bias graph: authors' judgments about each risk of bias item presented as percentages across all included studies.*

restorations (RR, 0.98; 95% CI, 0.92-1.04; I^2 = 0%; Figure 5C).

Occluso-gingival Distance—Two studies[31,46] reported the occluso-gingival distance of lesions and its influence on the retention rate of restorations (Figure 5D). The results of the meta-analysis for this characteristic showed no effect on the retention rate of restorations (RR, 1.03; 95% CI, 0.93-1.13; I^2 = 0%).

Margin Location—For margin location (above/aligned vs intrasulcus), only two studies were included.[32,33] High heterogeneity was detected (I^2=83%; p=0.02). With an RR, 4.14; 95% CI, 0.17-99.76, the margin location of the NCCL did not influence the retention rate of the resin composite restorations (Figure 5E).

Publication Bias

For the factors arch distribution, tooth location, and dentin sclerosis, it was possible to assess publication bias using funnel plot techniques and the Egger regression test. No statistical signs of publication bias (arch distribution: p=0.693; tooth location: p=0.489; dentin sclerosis: p=0.174 Egger) were found; this was confirmed using funnel plot inspection (data not shown). For other characteristics, publication bias was not assessed because there were inadequate numbers of included trials to properly assess with a funnel plot or more advanced regression-based measures.

Grading the Body of Evidence

Table 4 displays a summary of the various aspects used to rate the quality of the evidence according to the GRADE working group.[52]

The indirect evidence was responsible for downgrading the quality of the evidence by one level for all factors related to NCCLs. For some characteristics (wear facets, shape, size, and occluso-gingival distance), the strength of evidence was also downgraded one level due to imprecision (the optimal information size criterion was not met). Moreover, the inconsistency in the data due to high and nonexplained heterogeneity was responsible for downgrading the results for tooth location, dentin sclerosis, shape, depth, and margin location.

DISCUSSION

To the best of our knowledge, this is the first systematic review to synthesize the influence of tooth and cavity-related aspects of NCCLs on the retention rate of resin composite restorations.

The results of the review suggest that the location of the tooth in the dental arch and the presence of wear facets interfere with the retention rate of resin restorations in NCCLs. In contrast, other aspects such as dentin sclerosis, shape, size, depth, occluso-gingival distance, and margin location of the cavity showed no influence on the retention rate. We set out to identify the best clinical evidence available to answer the focused question and performed an extensive search with careful quality assessment. However, as we could not find primary studies that answered our specific research question, we drew indirect conclusions by using randomized clinical trials testing different adhesive approaches for the resin restoration of NCCLs.

This type of lesion may be present in different shapes and sizes and may affect any tooth (anterior or posterior).[1,2,8,54-56] Moreover, they are considered a significant restorative challenge because they are in general nonretentive and the cervical area concentrates high stresses caused by masticatory forces.[10,57-60]

Several clinical trials have attempted to study the longevity of resin restoration of NCCLs. Participants were recruited with different types of NCCLs, and the researchers usually reported the charac-

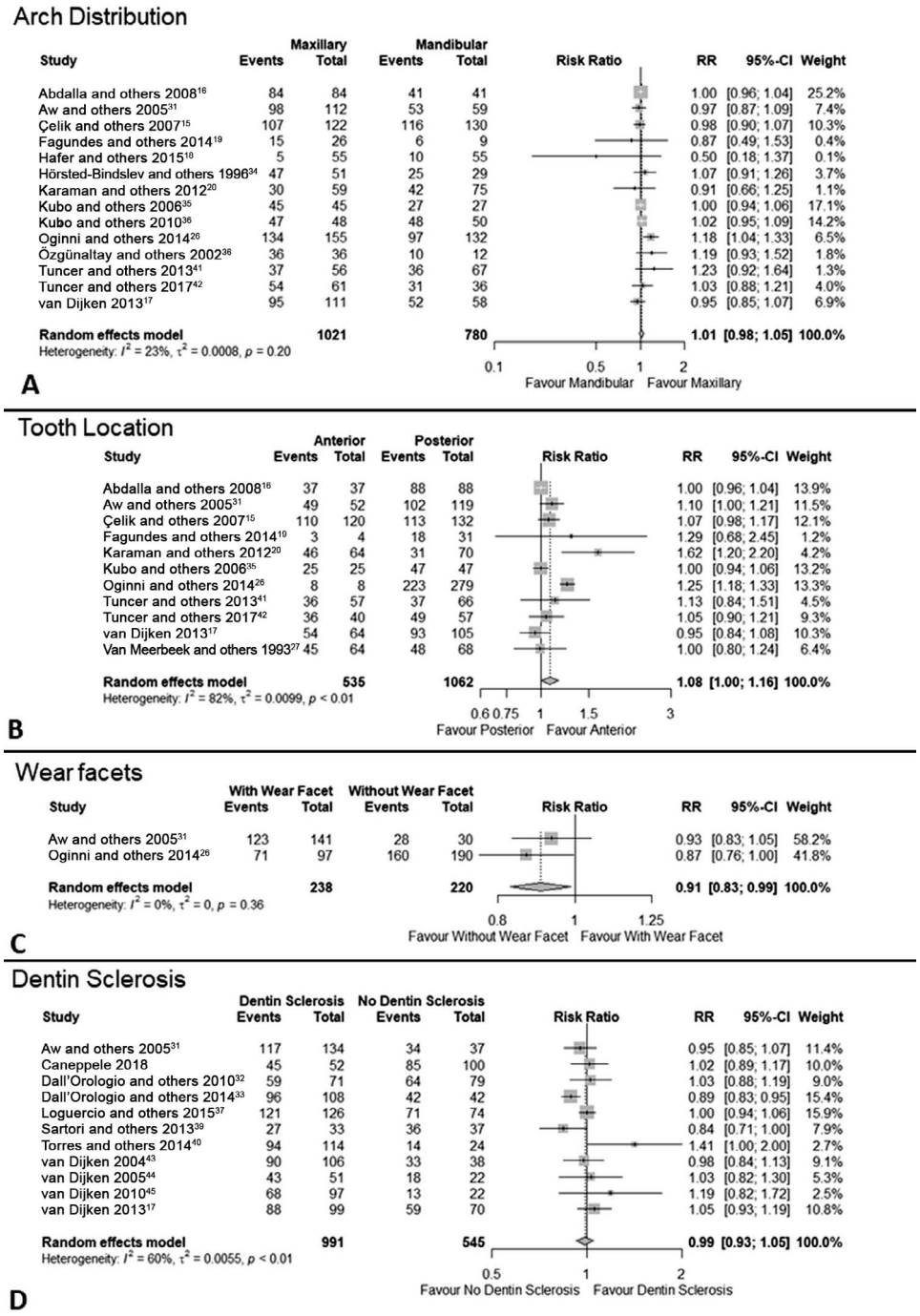

Figure 4. *Meta-analysis considering (A) arch distribution, (B) tooth location, (C) wear facets, and (D) dentin sclerosis.*

teristics of the lesions that would be restored. However, they infrequently related restorative success with the aspect of the lesion. In our search strategy, we found 91 studies that reported the characteristics of the lesions but that did not correlate the success rate with the observed characteristics. Although this would be only a complementary analysis, without statistical power in individual studies, grouping the results in a systematic review such as the current one could provide important findings.

We found only 24 manuscripts that related some aspects with the success rate of the restorations. Although we found reports for nine different aspects, not all included articles reported all of them, making some aspects meta-analyzed with minimal data. In addition, the variability in reporting the character-

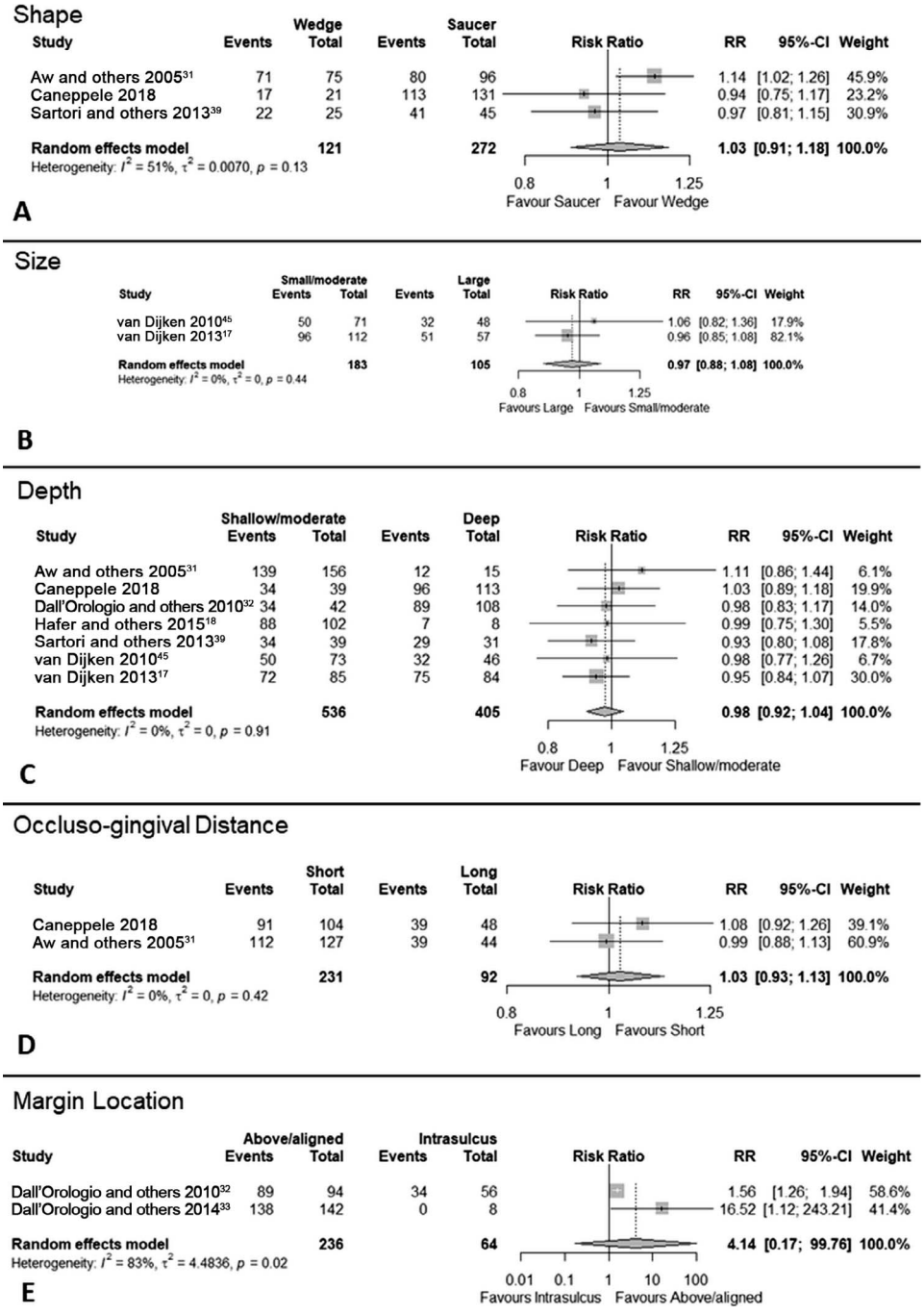

Figure 5. *Meta-analysis considering (A) shape, (B) size, (C) depth, (D) occluso-gingival distance, and (E) margin location.*

istics made it difficult to group the data, and, as a result, the information was dichotomized to allow the meta-analysis. Some aspects already had a dichotomous nature, such as arch distribution (maxillary vs mandibular), tooth location (anterior vs posterior), wear facets (with vs without). However, other characteristics had more than two data possibilities, and for that, we created cutoff points to dichotomize and group the studies (Table 3).

A critical point to be considered in this systematic review is that the findings were derived from indirect evidence. The primary objective of the included studies was to compare different adhesive strategies or different resin composites for NCCL restoration, and this may have contributed to the heterogeneity found in some meta-analyses. An important factor that influences retention of NCCL restoration is the kind of adhesive system (etch &

Table 4: *Summary of Finding and Quality of the Evidence*

Factor	Anticipated Absolute Effects[a] (95% CI)		Relative Effect, RR (95% CI)	No. of Participants (Studies)	Certainty of the Evidence (GRADE)[b]
Arch distribution	Mandibular	Maxillary	1.01 (0.98-1.05)	1801 (14 RCTs)	⊕⊕⊕○ Moderate[c]
	76 per 100	77 per 100 (75 to 80)			
Tooth location	Posterior	Anterior	1.08 (1.00-1.16)	1597 (11 RCTs)	⊕⊕○○ Low[c,d]
	80 per 100	86 per 100 (80 to 93)			
Wear facet	Without wear facet	With wear facet	0.91 (0.83-0.99)	458 (2 RCTs)	⊕⊕○○ Low[c,e]
	85 per 100	78 per 100 (71 to 85)			
Dentin sclerosis	No dentin sclerosis	Dentin sclerosis	0.99 (0.93-1.05)	1536 (11 RCTs)	⊕⊕○○ Low[c,d]
	86 per 100	85 per 100 (80 to 90)			
Shape	Saucer	Wedge	1.03 (0.91-1.18)	393 (3 RCTs)	⊕○○○ Very low[c,d,e]
	86 per 100	89 per 100 (78 to 100)			
Size	Large	Small/moderate	0.97 (0.88-1.08)	288 (2 RCTs)	⊕⊕○○ Low[c,e]
	79 per 100	77 per 100 (70 to 85)			
Depth	Deep	Shallow/moderate	0.98 (0.92-1.04)	941 (7 RCTs)	⊕⊕○○ Low[c,d]
	84 per 100	82 per 100 (77 to 87)			
Occluso-gingival distance	Long	Short	1.03 (0.93-1.13)	323 (2 RCTs)	⊕⊕○○ Low[c,e]
	85 per 100	87 per 100 (79 to 96)			
Margin location	Intrasulcus	Above/aligned	4.14 (0.17-99.76)	300 (2 RCTs)	⊕⊕○○ Low[c,d]
	53 per 100	100 per 100 (9 to 100)			

[a] *The risk in the intervention group (and its 95% CI) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).*
[b] *GRADE Working Group guidelines for evidence.*
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.
Very low certainty: We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.
[c] *Indirect evidence (the main objectives of the included studies were not compare the characteristics of the lesions and relate it with the success rate of the restorations.*
[d] *Inconsistency in the data due to high and non-explained heterogeneity.*
[e] *The optimal information size criterion was not met.*

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. This limits the external validity and generalizability of findings.

In the analysis of risk of bias using the Cochrane tool,[47] some studies were categorized as high risk of bias in the selection bias domains. Although this domain is fundamental for the analysis of the RCTs, for this study, we do not consider it to be of primary importance, because the groups compared in the meta-analysis were not those being randomized.

Some studies[8,60-62] showed a higher prevalence of NCCLs in maxillary teeth. Those teeth seem more prone to NCCLs, possibly due to their lingual inclination.[8] In our study, 14 studies were included, totaling 1021 restored teeth in the maxilla vs 780 restored teeth in the mandible. Although the distribution in the arch influenced the development of NCCLs, this factor did not seem to affect the restorative success of these lesions.

Regarding the tooth location in the arch, posterior teeth are more likely to present NCCLs, possibly because occlusal and nonaxial forces are exerted on that group of teeth.[8] The referred forces could also stress the adhesive area, decreasing the longevity of the adhesive restorations, because from this meta-analysis, we found an RR of 1.08, favoring the success rate of restoration in anterior teeth. However, the meta-analysis of these data showed high heterogeneity; thus, the results should be considered with caution. Then, the quality of the evidence was downgraded due to the inconsistency.

The presence of wear facets also influenced restorative success and is strongly related to the development of NCCLs.[26,57,63-65] In a three-dimensional finite element model, some authors observed in malocclusion scenarios that tensile stresses generated on the cervical areas were higher compared with stresses generated under normal occlusion conditions, those possibly being capable of producing NCCLs.[7] Moreover, in patients with untreated malocclusion, restoration success might also be affected, because the stress in the cervical

area could be higher than the adhesive resistance of the restorations, possibly leading to restoration displacement. Therefore, the treatment of these lesions should go beyond their restoration, because if the causes of lesions persist, premature failure of the restoration might ensue.[66] The meta-analysis of this characteristic included only two articles, and despite the low heterogeneity, the quality of the evidence was downgraded as the Optimal Information Size (OIS) criterion was not met, that is, only a very small sample supported the evidence.

Different classifications for the shape of the lesions have been reported, with some formats relating to more specific causes of lesions.[2,3,8,54-56,67] The studies included in this meta-analysis used different methods to classify the format of the lesions, which may have contributed to the heterogeneity of the data. We dichotomized in wedge and saucer formats and used an internal angle of 90° as the division between the two formats. The wedge format may be more related to occlusal stress, and, considering that occlusal stress indirectly observed on the wear facets influenced restorative success, one might suppose similar observations would be detected for the present characteristics; however, the influence of cavity format was not observed to influence restoration success. The quality of this evidence was considered very low because, in addition to the indirectness of evidence and the inconsistency (due to high heterogeneity), the reduced number of articles included with a small sample size meant the OIS criterion was not met.

As the development of NCCLs tends to be a slow and chronic process, dentin sclerosis is commonly found on the surface of the lesions.[1,5,8] Secondary dentin, the occlusion of open dentinal tubules, pulpal retreat, and other tooth protective measures slowly take place in the presence of noxious stimuli, thereby minimizing clinical symptoms and maintaining pulpal integrity. As for the shape characteristic, the different criteria for and methods of measuring dentin sclerosis are fraught with subjectivity and susceptible to inter- and intraexaminer variation with regard to features such as discoloration, smoothness, and translucency. In restorative procedures, sclerotic dentin is a substrate that can lead to adhesion difficulties, because, with some types of adhesives, hypermineralization can prevent the formation of a hybrid layer.[10,68] In this meta-analysis, there was great variability in the types of adhesives studied, which might have contributed to the high heterogeneity and lack of influence of this characteristic on restorative success.

The characteristics of size, depth, and occluso-gingival distance are all related to the dimension of the lesion. To allow the grouping of studies, we dichotomized some points. All these characteristics were shown not to affect restorative success. Evidence was downgraded to low for the three characteristics.

Only two articles reported the margin location and related it to restorative success. The high heterogeneity found allowed a wide confidence interval, overlapping the no effect line of this characteristic in restorative success. Despite the greater difficulty in isolating the operative field for subgingival lesions, this seems not to affect restorative success.[66,69,70]

To minimize bias, we followed the guidelines provided in the Cochrane Handbook for Systematic Reviews of Interventions.[47] However, our findings and interpretations are limited by the quality and quantity of the available indirect evidence on the effects of tooth- and cavity-related aspects of NCCLs on the success rate of resin restorations. We assessed the risk of bias of the included trials by using the published data, which ultimately may not reflect the actual situation and may lead to publication bias. Also, to minimize publication bias, we did not restrict our search to the English language. For three aspects, we were able to evaluate publication bias by inspecting funnel plots and the Egger analysis, and no problem was detected. However, publication bias could not be determined for other studied aspects, as there was an insufficient number of studies to allow this inspection through a funnel plot. This would reflect on any conclusions drawn from this review.

A knowledge of tooth- and cavity-related aspects of NCCLs that could affect restorative success could help clinicians understand the prognosis of restorations. For future research, investigators are encouraged to collect information from RCTs regarding the tooth- and cavity-related aspects of NCCLs and relate them to success rates. In addition, future RCTs should follow the CONSORT guidelines to improve evidence quality and transparency in reporting.[71]

CONCLUSION

The results of the meta-analysis suggest that NCCLs restored in anterior teeth are more likely to succeed than in posterior teeth. The presence of wear facets can reduce the retention rate of resin restoration in NCCLs. Arch distribution, dentin sclerosis, shape, size, depth, occluso-gingival distance, and margin

location did not affect the restorative success of resin restorations. However, the quality of evidence of the outcomes ranged from moderate to very low.

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Conflict of Interest

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

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