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Clinical Performance of Adhesive Systems and Composite Resins in Restoration of Noncarious Cervical Lesions: Systematic Review of Randomized Clinical Trials from 2004 to 2014

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Abstract

The aim of the present study was to compile a systematic review of the best available evidence on the clinical performance adhesives and composites used for the restoration of noncarious cervical lesions.

Several electronic databases such as Cochrane Oral Health Group Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL), Medline and Embase were interviewed. In addition, some studies were identified by hand searching. Thus randomized controlled trials comparing at least two adhesives or two composite resins with at least 12 months follow-up were selected. Criteria for quality assessment included: random sequence generation; allocation concealment; blinding of outcome assessment; and information on withdrawals.

Two hundred and fifty eight writings were found by the search strategy, but only 8 articles were finally selected. These studies demonstrated a good clinical performance for the four accession strategies and evaluated the different composite resins. However, they showed great variation between the adhesives of the same category.

Thus, subject to the design and the quality of studies included in this systematic review, we can conclude that there is not enough evidence to support the superiority of an adhesive or a composite resin to another for the restoration of non-carious cervical lesions.

Keywords: Noncarious cervical lesions; Restorations; Composite resin; Adhesive system; Systematic review

Introduction

Noncarious cervical lesions (NCCLs) (including erosion, abrasion, and abfraction) are types of chronic tooth surface destruction that are not bacterial in origin [1,2]. With increases in the aged population and therefore the number of people who retain their teeth for long periods of time, the prevalence of NCCLs is increasing [2]. Non-carious cervical lesions can cause dentinal sensitivity if the affected teeth are exposed to irritation. Non-carious cervical lesions are among the most frequent situations requiring adhesive techniques in today's operative dentistry [3].

Furthermore, many clinical studies in conservative dentistry have focused on the treatment of NCCLs because of their increased prevalence and aesthetic implications.

Treating these lesions is complicated by the fact that the dry operative field needed during the restorative procedure is often hard to obtain.

Adhesive techniques have been developed to such an extent that they are now involved in most clinical procedures.

Advances in enamel/dentin bonding research over the past decade have led to the refinement of two distinctly different adhesion strategies: the etch-and-rinse approach; and the self-etch approach [4]. Conventional three-step etch-and-rinse adhesives have been reported to bond relatively effectively to enamel and dentin *in vitro* [5,6] and *in vivo* [7]. To date, they have been considered as the golden standard with which new-generation adhesives should be compared.

Current trends in adhesive dentistry are directed towards the development and use of adhesives with a simple and fast application procedure. The one-step self-etch adhesives or so-called all-in-one adhesives can be considered a significant improvement in terms of ease of use, as compared with the three-step etch-and-rinse adhesives [8].

The performance of several adhesive systems has been tested, and the retention of etch-&-rinse adhesive systems has clearly improved over earlier systems [4]. However, the retention rates of these etch-&-rinse adhesive systems still vary significantly over a period of 1 to 3 years [9].

Nevertheless, premature failure of the restoration is partially due to the restorative material. There is a widespread theory that high modulus restorative materials are unable to flex in the cervical region when tooth structure is deformed under load and, therefore, the restorative materials can be displaced from the cavity [10]. As a result, materials with low elastic modulus, such as microfilled composites [10], flowable resins [11] and glass ionomer cements [12,13] have been indicated for the restoration of cervical lesions, with the aim of absorbing the stresses generated during the polymerization shrinkage of composites and the mechanical loading in which the teeth are subjected during function.

Many controlled studies have shown the clinical performance of different adhesives systems. To date, however, there has been little clinical

evidence that reports on the outcome of direct composite restorations placed on NCCL, and a few rigorous systematic evaluation of existing studies has available. Yet, controlled data on the efficacy of adhesives and composites treatment are essential to guide both dental practice and further research in the treatment of NCCL. Thus, our objective was to perform a systematic review of the best available evidence on the clinical performance adhesives and composites used for the restoration of non-carious cervical lesions.

Methods

A search strategy was created using the designed PICO question (Patient-Intervention-Comparison-Outcome), is the following: Patients with or at risk of having non-carious lesions who underwent restorative treatment of non-carious lesions they retain stable therapeutic results over time?.

- Participants: Humans with non-carious cervical lesions
- Intervention: restoration or rehabilitation.
- Comparison: two or many dentin adhesive systems, two or many resin composites.
- Outcomes: retention, marginal adaptation, marginal discoloration, caries occurrence, preservation of tooth vitality and post-operative sensitivity.
- Studies: randomized controlled trial (RCT).

Study selection criteria

In vitro studies and those using non-human enamel such as bovine teeth were excluded.

The search was further restricted to Systematic reviews (SRs) of randomized controlled trials (RCTs) and individual RCTs that reported at least one year of follow-up of restoration of non carious cervical lesions.

Search methods to identify studies

After the development of a protocol, article citations were obtained through an electronic search of databases (2004 to 2014) and hand-searching of bibliographic reference listings of published primary and review studies.

Electronic databases were searched including: Cochrane Oral Health Group Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE and EMBASE. In addition, studies were identified by hand searching of selected journals.

The search on databases included the following key words and their respective MESH terms which included: "Tooth Wear/prevention and control"[Mesh] OR "Tooth Wear/rehabilitation"[Mesh] OR «Tooth Wear/therapy"[Mesh].

No language restrictions were imposed.

The titles and abstracts of the articles were screened using the exclusion and inclusion criteria above leaving a total of eligible studies for critical appraisal.

To implement, two methods were used: consultation of HINARI (Health Inter Network Access to Research Initiative) and that of the Interuniversity Library of Medicine of Paris (France).

Two reviewers independently performed study description and risk-of-bias assessments; disagreements were resolved by discussion among the two reviewers and a third reviewer.

Where needed, authors of studies were contacted for additional information to resolve ambiguities.

Risk-of-bias was assessed by the Cochrane Collaboration tool (Higgins and Green, 2009)

Results

Study selection

The electronic and manual searches resulted in 258 articles, including 97 in MEDLINE, 139 in the Cochrane Central Register of Controlled Trials, 0 in Embase and 22 in manual researches.

In total, 209 articles were excluded based on evaluation of the title and abstract (Table 2). Of the 49 articles assessed for eligibility, 24 were excluded for not satisfying one or more inclusion criteria; it was essentially randomized clinical trials or not but the methodology was inconclusive for inclusion in this systematic review, and 17 articles were excluded for meeting one or more exclusion criteria.

Finally the twenty five remaining articles, seventeen were finally excluded because it is in situ studies on human enamel and related only to the prevention of dental erosion, and one randomized clinical trial with a follow-up period was short (less than 1 year).

The remaining eight articles were eligible for assessment of their quality. Data were extracted independently by a specialist in operative Dentistry on an Excel spreadsheet.

Quality assessment

The quality assessment of the methodology of all of the included studies (Table 1) was performed independently by two blinded reviewers according to the revised recommendation of the CONSORT statement. After the scores had been determined, an overall estimation of plausible risk of bias (low, moderate, or high) was performed for each selected study. Low risk of bias was estimated when all of the criteria were met, a moderate risk was estimated when one or more criteria were partly met, and a high risk of bias was estimated when one or more criteria were not met (Higgins and Green, 2011).

Study description

The results of the CONSORT-based quality analysis are illustrated in Table III. All of the studies [14-20] were considered to be at high risk of bias. Only one study remaining [21] was at low risk of bias. The most frequent unsatisfactory criteria were the lack of a sample size calculation (Criterion A) and the Completeness of follow-up (specified reasons for withdrawals and dropouts in each study group) (Criterion D). All studies except one [14] satisfied Criterion G.

Among the eight studies included in this systematic review, 5 [14,16,17,20,21] evaluated the effectiveness of self-etch adhesives on non-carious lesions, one study investigated the clinical effectiveness of three adhesives and the use of retention form in Class V resin composite restorations of the non-carious cervical lesion (NCCL) [19] and two [15,18] evaluated the effectiveness of different resins composite on non-carious lesions.

Effects of intervention

In this review, study [14] evaluated the clinical effectiveness of a one-step self-etch adhesive and a "gold-standard" three-step etch-and-rinse adhesive in non-carious Class-V lesions, showed regarding the clinical success rate, there was no significant difference between the two groups at the 2-year recall (p>0,05).

The overall clinical success rate in the Clearfil S3 Bond and the Optibond FL group after 2 years was 98.7% and 100%, respectively.

A remarkable observation in this clinical study was a progressive deterioration of marginal integrity in both groups during the 2-year study period. However, all marginal defects were small and remained clinically acceptable, as they actually do not require clinical intervention.

In a second study [16] lower scores for marginal discoloration and adaptation were noted when an all-in-one self etching adhesive was applied to non-carious cervical lesions and compared to a three-step total etch adhesive.

There were differences between the clinical performance of the all-in-one adhesive and that of the three-step etch-prime-bond adhesive when applied to NCCL with different degrees of dentin sclerosis..

The study of Loguercio [17] evaluated the performance of All Bond Self-Etch used as a one-(SE-1) or two-step self-etch system (SE-2), showed good results with respect to the anatomical criteria, marginal adaptation and postoperative sensitivity throughout the 6 and 12-month evaluation.

The retention rates for SE-1 and SE-2 were 84.8% and 90.9%, respectively, after 24 months. Compared to baseline, the retention rate for SE-1 was statistically lower.

Two studies [20,21] evaluated the effectiveness of self-etch adhesive with or without beforehand enamel phosphoric-acid-etching to restore non-carious cervical lesions.

The effectiveness of this adhesive (SE-1) was very good after 2 years of clinical service. More minor defects and restoration staining at the enamel margin were noticed when enamel had not been selectively acid-etched [21].

The clinical performance of the two-step self-etch adhesive (SE-2), Clearfil SE, remained excellent after 3 yr of clinical functioning. Additional etching of the enamel cavity margins was not critical for its clinical performance [20].

Comparison of the 3-year clinical performance of a hybrid (Clearfil AP-X; AP) and a flowable (Clearfil Flow FX; FX) resin composite in non-carious cervical lesions [15] showed that there were no significant differences between the two types of resin composite for each variable. One hundred percent retention was recorded for AP, whereas three out of 50 restorations were lost for FX.

Category	Description	Grading
A	Sample size calculation, estimating the minimum number of participants required to detect a significant difference among compared groups	0=did not exist/not mentioned/ not clear 1=reported but not confirmed 2= reported and confirmed
B	Randomization and allocation concealment methods	0=clearly inadequate 1=possibly adequate 2=clearly adequate
C	Clear definition of inclusion and/or exclusion criteria	0=no 1=yes
D	Completeness of follow-up (specified reasons for withdrawals and dropouts in each study group)	0=no/not mentioned/not clear 1=yes/no withdrawals or dropouts occurred
E	Experimental and control groups comparable at study baseline for important prognostic factors	0=no 1=unclear/possibly not comparable for one or more important prognostic factors 2=clearly adequate
F	Presence of masking	0=no 1=unclear/not complete 2=yes
G	Appropriate statistical analysis	0=no 1=unclear/possibly not the best method applied 2=yes

Table 1: Categories for Assessing the Quality of Selected Studies

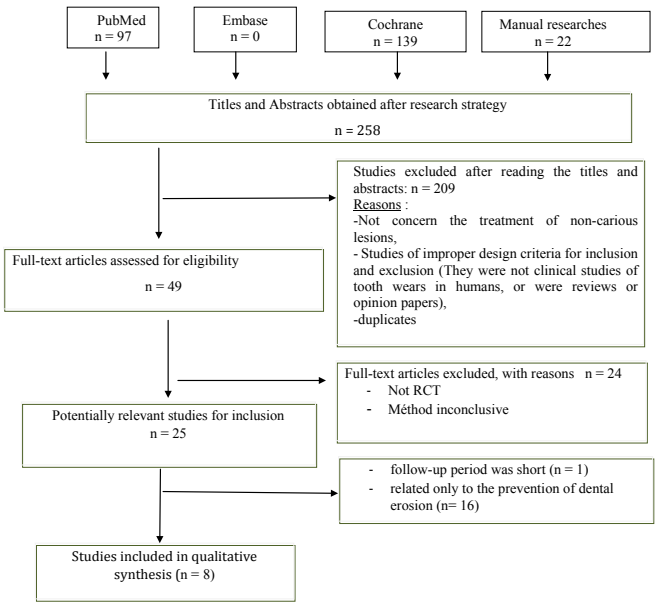

Table 2: PRISMA flowchart of the search strategy.

Comparison of the clinical performance of a hybrid composite (Clearfil AP-X, Kuraray, Tokyo) and a nanocomposite (Filtek Z350, 3M ESPE, St. Paul, MN) over a period of 2 years in non-carious class V lesions [18] showed no significant differences in the clinical performances between the materials.

No surface texture changes or secondary caries were detected in association with any restorations. The retention rates for Clearfil AP-X (100 %) and for Filtek Z350 (91.38%) did not differ significantly (P>0.05). Two Z350 restorations were completely lost after 2 years. No significant differences were observed in the color match, marginal discolouration, marginal adaptation or anatomic form.

Discussion

Risk-of-bias assessment

The results of the CONSORT-based quality analysis are illustrated in Table 3. One study [21] was at low risk of bias; all of the remaining studies [14-20] were considered to be at high risk of bias. The most frequent unsatisfactory criteria were the lack of a sample size calculation (Criterion A), which may contribute to the low statistical power of studies at high risk of bias. The second most often dissatisfied criterion was the Completeness of follow-up (specified reasons for withdrawals and dropouts in each study group) (Criterion D).

We also noted a lack of information on randomization (Criterion B) for some articles [14-16,19,20].

Three-step etch-and-rinse adhesives versus one-step self-etch adhesives

Current trends in adhesive dentistry are directed towards the development and use of adhesives with a simple and fast application procedure. The one-step self-etch adhesives or so-called all-in-one adhesives can be considered a significant improvement in terms of ease of

N°	Study	A	B	C	D	E	F	G	Risk of bias
1	Helene F. et al. 2011	2	2	1	1	2	2	2	low
2	Banu Ermis et al. 2011	0	1	1	0	2	0	1	high
3	Shisei Kubo, et al. 2010	0	1	0	0	2	2	2	high
4	Ritter et al. 2008	0	1	1	0	2	1	2	high
5	Loguercio et al. 2010	0	1	1	0	2	0	2	high
6	Wei Qin et al. 2012	0	2	1	0	2	0	2	high
7	Peumans M et al. 2005	0	1	1	0	0	0	2	high
8	Kim et al. 2009	0	1	1	1	0	2	2	high

Table 3: CONSORT-based Quality Analysis of the Included Studies

use, as compared with the three-step etch-and-rinse adhesives [22].

Indeed, an *in vitro* study by Van Landuyt et al. [22] recorded application times of 44 s for Clearfil S3 Bond and 113 s for Optibond FL.

Regarding the bonding effectiveness of the one-step self etch adhesive Clearfil S3 Bond, some *in vitro* studies [22-25] measured micro-tensile bond strengths to dentin and enamel similar as those recorded for some two-step self-etch adhesives (Clearfil SE Bond, Kuraray; Optibond Solo Plus Self-Etch, Kerr; Clearfil Protect Bond, Kuraray), as well as for the three-step etch-and-rinse adhesive Optibond FL (Kerr), which can be considered as a "gold standard."

The clinical study of Banu Ermis et al. [14] is the first one comparing the 2-year clinical performance of Clearfil S3 Bond with the three-step etch-and-rinse adhesive and so considered gold-standard Optibond FL.

The overall clinical success rate in the Clearfil S3 Bond and the Optibond FL group after 2 years was 98.7% and 100%, respectively. Only one Clearfil S3 Bond restoration was clinically unacceptable due to restoration loss (retention rate=98.7%).

Similar excellent success rates of 97-100% were reported in most short-term clinical trials evaluating Clearfil S3 Bond [26,27].

In second study [16] lower scores for marginal discoloration and adaptation were noted when an all-in-one selfetching adhesive was applied to non-carious cervical lesions and compared to a three-step total etch adhesive.

In the clinical trial of Brackett et al. [28], an obviously lower success rate of 81% was recorded for Clearfil S3 Bond after 2 years. According to the authors, this lower success rate was likely due to the inexperience of the operators in adhesive dentistry research and due to the fact that the enamel was left unprepared.

A systematic review combining all clinical studies published on 5 years showed that three-step etch-and-rinse adhesives remain today the most powerful adhesives and less sensitive to the implementation [29].

Comparison one- step self-etch system (SE-1) and two-step self-etch system (SE-2)

The study of Loguercio [17] evaluated the performance of All Bond Self-Etch used as a one-(SE-1) or two-step self-etch system (SE-2), showed good results with respect to the anatomical criteria, marginal adaptation and postoperative sensitivity throughout the 6 and 12-month evaluation.

The retention rates for SE-1 and SE-2 were 84.8% and 90.9%, respectively, after 24 months. Compared to baseline, the retention rate for SE-1 was statistically lower.

Although similar microtensile bond strength values could be found for one- and two-step All-Bond SE [30], they differed slightly under this clinical evaluation.

Regarding the comparison of self-etch adhesive with and without selective enamel acid-etching before application of adhesive in the restoration of non-carious cervical lesions, in this systematic review no significant difference between the two groups was shown after two years [21] and three years [20] of clinical service, but significant differences in favor of the selective acid-etching procedure were recorded for two of the secondary endpoints: marginal staining at the enamel and minor marginal defects.

Self-etch adhesives provide a user-friendly solution of low technique-sensitivity to the treatment of class V noncarious lesions, although their bonding properties to enamel are discussed.

These results reinforce the initial authors' assumption.

In terms of the retention primary endpoint, this new adhesive showed a very good clinical performance given the context in which it was evaluated. Self-etch adhesives are known to promote excellent adhesion to dentin [31], and the observed 98% retention rate is an excellent result for cervical restorations realized in a private practice clinical setting under time constraints.

Actually, the American Dental Association requires a 90% retention rate after 18 months. Kubo et al. [32], observed a 97% retention rate at 3 years concerning class V restorations treated using a one-step self-etch adhesive in a dental university hospital setting, whereas van Dijken and Pallesen reported an average 2.8% annual failure rate for class V restorations treated with various adhesive systems in a recent review [33].

Retention form on the adhesion of different adhesive systems

Previous studies have concluded that three-step etch&rinse adhesives had a superior clinical performance over simplified adhesives that have shown inconsistent clinical performances [34-36].

In the current study, without retention form, the two-step etch&rinse type showed a marked decreased retention rate (71.4%) at two years, suggesting its long-term durability may be poor.

In the current study, One-step self-etch showed a completely favorable retention rate (100%), regardless of the presence of retention form. Other studies, in which retention form was not used, have reported various retention rates of One-step self-etch. Brackett et al. [37] reported a 24% loss of retention after six months and 35% after one year.

Van Dijken [38] reported a loss of retention of 3.9%, 13.5%, 15.4% and 21.2% after 6, 12, 18 and 24 months, respectively.

Considering that long-term leakage-free margins of non carious cervical lesions (NCCL) Class V resin composite restorations cannot be guaranteed by contemporary adhesive systems [31], it is noteworthy that preparing the retention form on the NCCL can provide a clinical performance of less marginal discoloration in adhesive restorations.

In the current study, it is difficult to determine which retention form is necessary for the higher retention rate of adhesive restorations, because only two-step etch&rinse showed an improved retention rate with retention form; the other adhesive groups, Three-step etch&rinse and One-step self-etch, showed a high retention rate, irrespective of retention form. Longer-term clinical evaluations are needed to confirm the effectiveness of the retention form on the retention rate of NCCL composite resin restorations.

Comparison of different composite resins

Recently, resin-based composites have been increasingly used as restorative materials because the increasing demand for aesthetic restorative dentistry has stimulated the development of adhesive techniques and composites.

Comparison of the 3-year clinical performance of a hybrid (Clearfil AP-X; AP) and a flowable (Clearfil Flow FX; FX) resin composite in non-carious cervical lesions [15] showed that there were no significant differences between the two types of resin composite for each variable. One hundred percent retention was recorded for AP, whereas three out of 50 restorations were lost for FX.

Comparison of the clinical performance of a hybrid composite (Clearfil AP-X, Kuraray, Tokyo) and a nanocomposite (Filtek Z350, 3M ESPE, St. Paul, MN) over a period of 2 years in non-carious class V lesions showed no significant differences in the clinical performances between the materials[18].

No surface texture changes or secondary caries were detected in association with any restorations. The retention rates for Clearfil AP-X (100%) and for Filtek Z350 (91.38 %) did not differ significantly (P>0.05). Two Z350 restorations were completely lost after 2 years. No significant differences were observed in the colour match, marginal discolouration, marginal adaptation or anatomic form.

This finding is supported by the results of a recent clinical study [39]. This inconsistency may be due to the improvement of dentin adhesive systems, though the magnitude of dentin bond strength to prevent retention failure of a resin composite in NCCLs is still unclear.

Many studies reported that retention rates decreased with time [39,40]. This is probably due to fatigue failure of adhesives. Although three restorations had been lost at 6 months recall, no further retention failures occurred up to 3 years in the present study.

A possible explanation for this is technical error rather than poor bond strength or durability of the adhesive system. Early loss of restorations may no longer be the main cause of clinical failure when reliable adhesives are used [26,41-43].

Conclusion

The studies included in this present systematic review described good clinical performance of resin composites and dentin adhesive systems for restoration of non-carious cervical lesions.

However this systematic review highlighted the need for additional, well-planned RCTs to examine the efficacy of resin composites and dentin adhesive systems in noncarious cervical lesions. Such RCTs should have an adequate sample size calculation, clearly describe the randomization process, and adopt a continuous scale (retention, marginal staining, restoration staining, and post-operative sensitivity) to record changes.

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