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SYSTEMATIC REVIEW

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Etching time and bonding of adhesive systems to dentin of primary teeth: A systematic review and meta-analysis

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Abstract

Background: Due to the chemical and morphological differences between primary vs. permanent teeth, the time reduction of the acid etching or acidic primer can result in higher values of bond strength.

Aim: To assess through a systematic review and meta-analysis the influence of the reducing etching (acid etching or acidic primer) time on the bond strength of adhesive systems to primary dentin.

Design: A systematic search was carried out in 3 databases: PubMed, Web of Science and Scopus. Studies that evaluated the effect of reducing the etching time on the bond strength of adhesive systems to primary dentin were included. Meta-analyses were performed using a random-effects model, with subgroups for etch-and-rinse and self-etching adhesives, with a significance level of $P < .05$. The risk of bias and heterogeneity between studies (Cochrane and I2 tests) were assessed.

Results: Eight studies were included in the systematic review and seven in the meta-analyses. The shortening etching time did not influence the immediate dentin bond strength for etch-and-rinse ($Z = 0.07$, $P = .95$) and self-etching adhesives ($Z = 0.41$, $P = .69$). After ageing, however, the shorting etching time improved the bond strength for etch-and-rinse adhesives ($Z = 2.01$, $P = .04$). All studies presented high bias risk.

Conclusions: Reducing the acid-etching time to primary dentin improves the long-term bond strength to this substrate.

KEYWORDS

adhesive system, bond strength, dental etching, primary dentin

1 | INTRODUCTION

Aesthetic and conservative restorations render adhesive systems essential for Pediatric Dentistry. There are, however, no protocols firmly established by manufacturers for using it in primary teeth, as the same adhesive protocol is assigned to permanent and primary teeth, disregarding the chemical and morphological differences between these dentin substrates.[1,2] Primary dentin has a higher tubular density, with a larger diameter in peritubular and intertubular dentin and the lower mineral content,[2,3] turning this substrate more reactive to acid conditioners.[4] Therefore, an increased demineralization occurs in primary dentin, producing a thicker hybrid layer and lower bond strength values[4-6] when submitted to the same etching time used for dentin in permanent teeth.[4]

The deeper demineralization of primary dentin jeopardizes the adhesion by the collapse of collagen fibrils and calcium phosphate crystal precipitation, and thus, less penetration of resin monomers occurs into the demineralized dentin.[7,8] The unprotected collagen fibril zone formed at the base of the hybrid layer is considered the weakest area within the adhesive interface,[8,9] which is highly susceptible to both hydrolytic and enzymatic long-term deterioration.[8]

To improve the adhesion to primary dentin, some authors have proposed the reduction of the etching time.[1,4,5] A reduced etching time for primary dentin would yield the formation of a more homogeneous hybrid layer[5,6] and increase the bond strength values. The results of the studies that proposed a reduction in etching time, however, are not unanimous. Higher bond strength values are found when the acid-etching agent is applied for shorter times than indicated by the manufacturers,[10,11] but these findings were not found in studies with the same scope,[12,13] neither for self-etching adhesives systems.[14] So, there is a need to appraise and systematically review the existing literature. Although randomized controlled trials are traditionally the gold standards for judging the benefits of treatments,[15] laboratory studies evaluating the bond strength values may be considered useful as screening tools for new adhesive approaches, as reducing the etching time for primary dentin.[16] Similarly, a systematic review synthesizing the evidence on the outcome 'bond strength' may also promote evidence-based achievements to predict the clinical effectiveness of adhesive systems.

This systematic review and meta-analysis aimed to investigate the influence of reducing the etching (acid etching or acidic primer) time on the bonding of etch-and-rinse and self-etching adhesive systems to dentin of primary teeth. The tested null hypothesis was that the bond strength of adhesive systems to primary dentin was not affected by reduced acid-etching time.

Why this paper is important to paediatric dentists

- The reduction in the conditioning time of primary dentin for etch-and-rinse and self-etch adhesives did not jeopardize immediate adhesion.
- The reduction of acid-etching time contributed to resin-dentin bonding stability over time.
- It is necessary to develop specific adhesive protocols for primary teeth.

2 | MATERIALS AND METHODS

This systematic review was conducted following the recommendations of the Cochrane Handbook and structured according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[17] The addressed focused question was: 'Does the reduced acid-etching time impact on the bond strength between adhesive systems and primary dentin?' The research question was developed based on the acronym PICO (participant, intervention, comparator and outcome), in which, primary dentin was the 'participant'; the reduced acid-etching time was the 'intervention'; acid-etching time according to manufacturers' instructions was the 'control', and the 'outcome' was the bond strength.

2.1 | Search strategy

A comprehensive literature search was undertaken through the PubMed/MEDLINE, Scopus and Web of Science databases for identification of studies published by 25 May 2020. The search was conducted with no publication time or language restrictions. The search strategy for the PubMed/MEDLINE database was formulated with the combination of MeSH terms and free terms as follows: ((((((((((((tooth, deciduous[MeSH Terms]) OR tooth, deciduous) OR deciduous tooth) OR deciduous dentition*) OR primary dentition*) OR milk tooth) OR milk teeth) OR deciduous teeth) OR primary teeth) OR primary tooth) OR baby tooth) OR baby teeth)) AND ((((((dentin bonding agents[MeSH Terms]) OR dentin bonding agents) OR dental bonding[MeSH Terms]) OR dental bonding) OR adhesive system*) OR bond*). This strategy was adapted to search the Scopus as follows: (TITLE-ABS-KEY ("adhesive systems") AND TITLE-ABS-KEY ("deciduous teeth") OR TITLE-ABS-KEY ("primary teeth")) and Web of Science - TOPIC: (ADHESIVE SYSTEM) AND TÓPICO: (DECIDUOUS TEETH) OR TOPIC: (PRIMARY TEETH) AND TOPIC: (BOND STRENGTH) databases. The results of searches of various databases were cross-checked to locate and eliminate duplicates.

2.2 | Study selection

In the first phase, titles and abstracts were screened independently by two authors (CRR and LDG) to identify potentially eligible studies. The inclusion criteria were as follows: (a) laboratory studies that have evaluated the bond strength of adhesive systems to primary dentin and (b) have included reducing the etching time before using adhesive systems. The studies selected in the first phase were subjected to a full-text reading for the definitive inclusion in the systematic review, and two exclusion criteria were considered: (a) bond strength values within 24 hours not presented and (b) absence of a control group (acid-etching time according to manufacturers' instructions). Disagreements between the two authors regarding eligibility were resolved by a consensus with a third reviewer (ROR). The reference lists of all included studies were hand-searched to retrieve all potentially relevant studies.

2.3 | Data extraction

Extracted data from included studies were registered by one researcher (ROR) in a standardized form (Microsoft Office Excel 2016, Microsoft Corporation, Redmond, WA, USA). For each study, the publication's data (title, authors, year of publication and the first author origin), methodology details (the type of primary teeth, number of teeth per group, adhesive systems, mechanical test and storage time), intervention (acid-etching time according to manufacturers' instruction and reduced time) and the outcome (bond strength values) were recorded. For studies that did not clearly report the bond strength values or had presented the results in graphs or figures, corresponding authors were contacted by email (at least twice). If no information was provided, the study was not included in the meta-analysis.

2.4 | Assessment of risk of bias

The risk of bias in each study was assessed based on the criteria described in a previous systematic review[18] and adapted for the present review, considering the items: sample size calculation, the same number of teeth in all experimental groups, a random sequence of performance of the adhesive procedures, evaluation of the failure mode, adhesive procedures performed by a single operator and blinding of the responsible operator for performing the mechanical test. For each identified item, a 'YES' was assigned, and for each missing information, a 'NO' was assigned. The risk of bias was classified according to the sum of the number of items that received 'YES' as follows: 1 to 3 = high risk of bias; 4 to 5 = medium risk of bias; and 6 to 7 = low risk of bias.

2.5 | Data analysis

Standardized mean differences were evaluated, through a random-effects model, between experimental (reduced acid-etching time) and control groups (acid-etching time according to the manufacturers). Subgroup meta-analysis was conducted considering the etching strategy (etch-and-rinse adhesive systems and self-etching adhesive systems). Moreover, meta-analyses were performed considering the ageing (water storage time) on the bond performance (including studies that had a storage time for at least 6 months). For studies that evaluated more than one adhesive system, the bond strength means (standard deviations) were combined to one mean (standard deviation) using a predefined formula (Cochrane Statistical Guidelines).[19] Statistical heterogeneity among studies was considered using the Cochran Q test and the inconsistency I^2 test (>50% indicates high heterogeneity).[19] Meta-analyses were conducted using Review Manager (RevMan version 5.3; Cochrane Collaboration, London, UK) with the significance level at 5%.

3 | RESULTS

3.1 | Study selection

The study selection process is presented in a PRISMA flowchart (Figure 1).[17] A total of 1625 potentially eligible studies were found in the researched databases. After excluding duplicates, 1330 studies were evaluated regarding the inclusion criteria. Most of these studies (1323 studies) did not perform a bond strength test and/or did not include a reduced acid-etching time. Seven studies were selected for full-text screening. Another study was identified from the reference list of selected studies, so eight studies were included in the qualitative analysis. One study could not be included in the meta-analysis because the standard deviation values were not provided, even after requesting the authors. So, seven studies were considered in the quantitative analysis. An inter-examiner agreement was obtained during study selection (Cohen's Kappa, 0.84).

3.2 | Descriptive analysis

The main descriptive data are summarized in Table 1. All studies were conducted by researchers from Brazil[11,12,14,20,21] and Spain.[10,13,22] All studies were published in English, and their publication years ranged from 2006 through 2014.

The microtensile test was applied in all studies for bond strength assessment. Six studies considered sound dentin[10-13,21,22] as a bonding substrate, and two studies also considered caries-affected dentin.[14,20] Three studies evaluated the reduced acid-etching time,[13,20,21] and five evaluated both the reduction of acid-etching time and primer application time.[10-12,14,22] In only two studies,[12,14] the bond strength was also evaluated after water storage of 12 months.

Among the etch-and-rinse adhesive systems, most of the studies used Single Bond/Adper Single Bond 2 (3M ESPE).[10-12,14,21,22] The adhesives Excite (Ivoclar/Vivadent)[13] and Prime & Bond NT (Dentsply Sirona)[20] were used by one study each. All studies that evaluated the bond strength using self-etching adhesive system used Clearfil SE Bond (Kuraray Noritake),[10-12,14,22] and two studies also included the adhesive One-Up Bond F (Tokuyama)[10,22]

3.3 | Meta-analysis

According to the overall meta-analysis (Figure 2), reduced time of acid etching or primer application did not impact

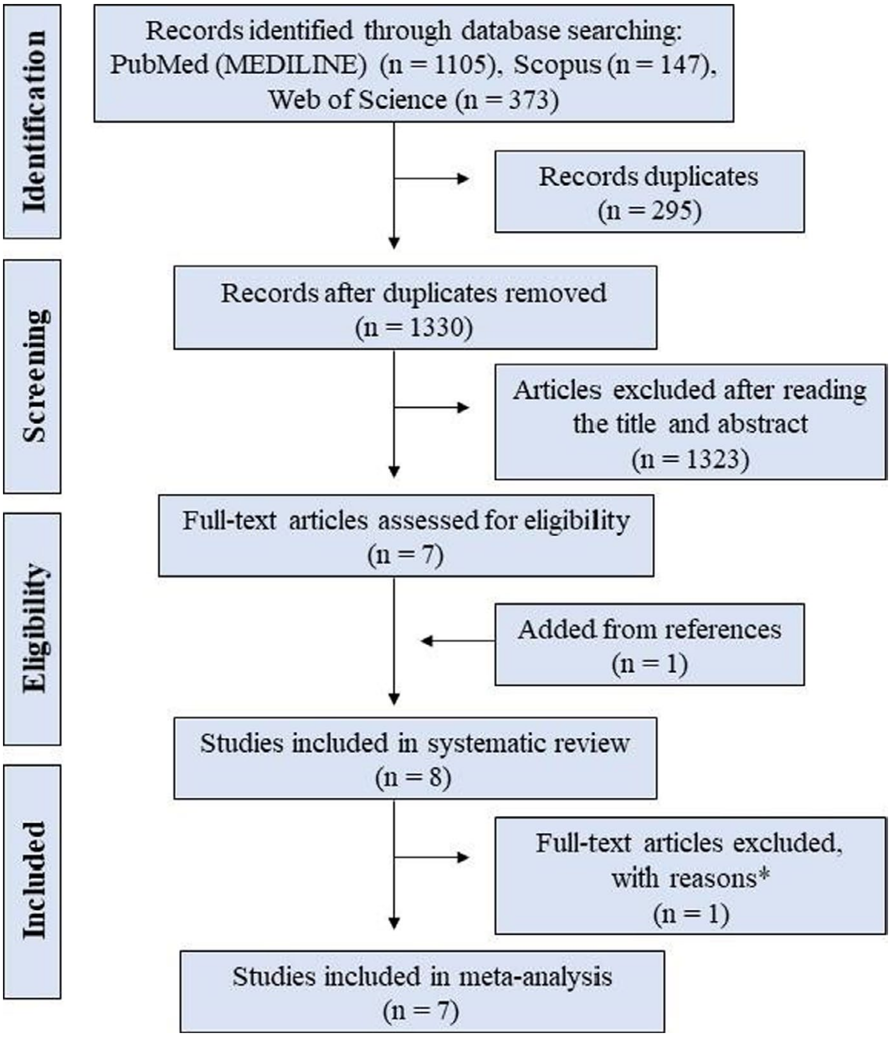

FIGURE 1 Flow chart diagram of study selection according to PRISMA statement

on the immediate bond strength values, as no significant differences were found between experimental (reduced time) and control (acid etching or primer application time according to manufacturers) groups (Z = 0.33, P = .74), as well as the subgroup meta-analysis considering etch-and-rinse adhesive systems (Z = 0.07, P = .95) or self-etching adhesives (Z = 0.41, P = .69), separately. The data were not heterogeneous (I^2 = 0; Chi^2 P = .80). The reduced acid-etching time resulted in greater bond strength values (Z = 2.01, P = .04) when specimens were tested after 12 months of water storage. The overall meta-analysis of long-term bond strength values, however, revealed no significant differences between control and experimental groups (Z = 0.76; P = .45), as the subgroup meta-analysis considering only self-etching adhesives (Z = 0.63; P = .53), as depicted in Figure 3. No significant heterogeneity was observed in overall (I^2 = 44%, Chi^2 P = .15,) and subgroup meta-analysis (I^2 = 6%, Chi^2 P = .30, and I^2 = 0%, Chi^2 P = .46, respectively, for etch-and-rinse and self-etch adhesive systems).

3.4 | Quality and risk of bias of the studies

All included studies have a high risk of bias (Table 2). No study informed the sample size calculation, if a single operator performed all adhesive procedures, and if the operator of test machine was blinded to experimental groups.

4 | DISCUSSION

This systematic review is the first to compile data from laboratory studies that evaluated the reduced time of acid etching or acidic primer for the use of adhesive systems applied to primary teeth. The concern with the performance of adhesive systems on primary teeth has long been described, justified by the histological and mineral content differences compared to permanent teeth and which result in lower bond strength values.[5,6] Besides, commercially available adhesives do not recommend a specific protocol for their use on primary teeth, considering the particularities of this substrate.

TABLE 1 Descriptive data and bond strength values of the included studies

Study	Country	Type of teeth	N[a]	Mechanical test	Adhesive system[b]	Etching time (seconds)	Immediate bond strength (24 hours)	Long-term bond strength (12 months)
Aguilera et al, 2013	Spain	Molars	n = 6	Microtensile	Single Bond (3M ESPE)	15	29.4 (11.5)[d]	-
						7[c]	42.0 (17.1)[d]	
					Clearfil SE Bond (Kuraray)	20	29.3 (10.1)[d]	
						10[c]	27.4 (7.3)[d]	
					One-Up Bond F (Tokuyama)	20	10.7 (3.7)[d]	
						10[c]	18.0 (7.4)[d]	
Bolanos-Carmona et al, 2006	Spain	Molars	n = 3	Microtensile	Excite (Ivoclar/Vivadent)	15	3.8 (1.3)[d]	-
						5[c]	3.3 (1.2)[d]	
Lenzi et al, 2013	Brazil	Molars	n = 6	Microtensile	Adper Single Bond 2 (3M ESPE)	15	44.2 (6.8)[d]	21.6 (6.1)[d]
						7[c]	40.9 (3.2)[d]	30.1 (5.5)[d]
					Clearfil SE Bond (Kuraray)	20	41.0 (6,5)[d]	36.4 (4.6)[d]
						10[c]	41.2 (5.1)[d]	33.6 (4.3)[d]
Osorio et al, 2010	Spain	NI	n = 2	Microtensile	Adper Single Bond (3M ESPE)	15	29.3 (11.5)[d] 42.0(17.1)[d]	-
						7[c]		
					Clearfil SE Bond (Kuraray)	20	29.3 (13.1)[d]	
						10[c]	27.4 (15.3)[d]	
					One-Up Bond F (Tokuyama)	20	11.7 (3.7)[d]	
						10[c]	17.8 (13.4)[d]	
Sanabe at al., 2009	Brazil	Molars	n = 10	Microtensile	Adper Single Bond (3M ESPE)	15	49.0 (12.9)[d]	30.4 (5.6)[d]
						7[c]	46.9 (15.1)[d]	36.0 (13.6)[d]
					Clearfil SE Bond (Kuraray)	20	52.9 (13.1)[d]	42.4 (16.6)[d]
						10[c]	51.7 (12.9)[d]	41.9 (18.6)[d]
Sardella et al, 2005	Brazil	Molars	n = 4	Microtensile	Adper Single Bond (3M ESPE)	15	47.5 (14.4)[d]	-
						7[c]	59.4 (13.1)[d]	
					Clearfil Se Bond (Kuraray)	20	30.2 (8.6)[d]	
						10[c]	31.6 (6.6)[d]	
Scheffel et al, 2013	Brazil	Molars	n = 4	Microtensile	Prime & Bond NT (Dentsply Sirona)	15	25.7 (15.3-36.3)[e]	-
						10[c]	30.5 (24.3-37.5)[e]	
						5[c]	30.3 (25.8-0.34.7)[e]	
Torres et al, 2007	Brazil	Molars	N = 10	Microtensile	Single Bond (3M ESPE)	15	8.8 (3.0)[d]	-
						10[c]	7.8 (4.5) [d]	
						5[c]	10.0 (3.3)[d]	

[a]Number of teeth per group. NI: not informed or unclearly described in the study.
[b]According to that described in the study.
[c]Reduced acid etching or acidic primer application time.
[d]Mean and standard deviation (MPa).
[e]Median and percentile (MPa).

Study or Subgroup	Manufactures´ time Mean	SD	Total	Reduced time Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Etch-and-rinse								
Aguilera et al., 2012	29.38	11.5	6	42	17.1	6	7.0%	−0.80 [−2.00, 0.40]
Bolaños-Carmona et al., 2006	13.43	5.91	3	6.2	2.81	3	2.5%	1.25 [−0.75, 3.25]
Lenzi et al., 2014	44.2	6.8	6	40.9	3.2	6	7.4%	0.57 [−0.59, 1.74]
Osorio et al., 2010	29.38	11.5	2	42	17.1	2	0.9%	−0.49 [−3.91, 2.92]
Sanabe et al., 2009	49	12.9	10	46.9	15.1	10	13.1%	0.14 [−0.73, 1.02]
Sardella et al., 2005	47.5	14.4	4	59.4	13.1	4	4.6%	−0.75 [−2.23, 0.73]
Torres et al., 2007	8.72	2.96	10	8.91	7.01	20	17.5%	−0.03 [−0.79, 0.73]
Subtotal (95% CI)			**41**			**51**	**53.0%**	**−0.01 [−0.45, 0.42]**
Heterogeneity: Tau² = 0.00; Chi² = 5.31, df = 6 (P = 0.50); I² = 0%								
Test for overall effect: Z = 0.07 (P = 0.95)								
1.1.2 Self-etching								
Aguilera et al., 2012	20.01	12.1	12	22.67	8.55	12	15.6%	−0.25 [−1.05, 0.56]
Lenzi et al., 2014	41	6.5	6	41.2	5.1	6	7.9%	−0.03 [−1.16, 1.10]
Osorio et al., 2010	20.51	12.82	4	22.67	12.93	4	5.2%	−0.15 [−1.54, 1.24]
Sanabe et al., 2009	52.9	13.1	10	51.7	12.9	10	13.1%	0.09 [−0.79, 0.97]
Sardella et al., 2005	30.2	8.6	4	31.6	6.6	4	5.2%	−0.16 [−1.55, 1.23]
Subtotal (95% CI)			**36**			**36**	**47.0%**	**−0.10 [−0.56, 0.37]**
Heterogeneity: Tau² = 0.00; Chi² = 0.33, df = 4 (P = 0.99); I² = 0%								
Test for overall effect: Z = 0.41 (P = 0.69)								
Total (95% CI)			**77**			**87**	**100.0%**	**−0.05 [−0.37, 0.26]**
Heterogeneity: Tau² = 0.00; Chi² = 5.70, df = 11 (P = 0.89); I² = 0%								
Test for overall effect: Z = 0.33 (P = 0.74)								
Test for subgroup differences: Chi² = 0.06, df = 1 (P = 0.80), I² = 0%								

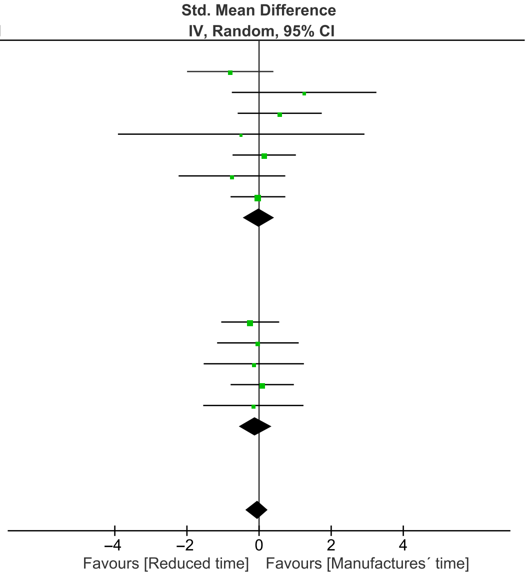

FIGURE 2 Results of reducing etching time meta-analyses, using random-effects model

Study or Subgroup	Manufactures´ time Mean	SD	Total	Reduced time Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Etch-and-rinse								
Lenzi et al., 2014	21.6	6.1	6	30.1	5.5	6	18.9%	−1.35 [−2.66, −0.04]
Sanabe et al., 2009	30.4	5.6	10	36	13.6	10	29.3%	−0.52 [−1.41, 0.38]
Subtotal (95% CI)			**16**			**16**	**48.2%**	**−0.79 [−1.56, −0.02]**
Heterogeneity: Tau² = 0.02; Chi² = 1.07, df = 1 (P = 0.30); I² = 6%								
Test for overall effect: Z = 2.01 (P = 0.04)								
1.1.2 Self-Etching								
Lenzi et al., 2014	36.4	4.6	6	33.6	4.3	6	21.9%	0.58 [−0.59, 1.75]
Sanabe et al., 2009	42.4	16.6	10	41.9	18.6	10	29.9%	0.03 [−0.85, 0.90]
Subtotal (95% CI)			**16**			**16**	**51.8%**	**0.23 [−0.47, 0.93]**
Heterogeneity: Tau² = 0.00; Chi² = 0.55, df = 1 (P = 0.46); I² = 0%								
Test for overall effect: Z = 0.63 (P = 0.53)								
Total (95% CI)			**32**			**32**	**100.0%**	**−0.27 [−0.97, 0.43]**
Heterogeneity: Tau² = 0.22; Chi² = 5.38, df = 3 (P = 0.15); I² = 44%								
Test for overall effect: Z = 0.76 (P = 0.45)								
Test for subgroup differences: Chi² = 3.67, df = 1 (P = 0.06), I² = 72.8%								

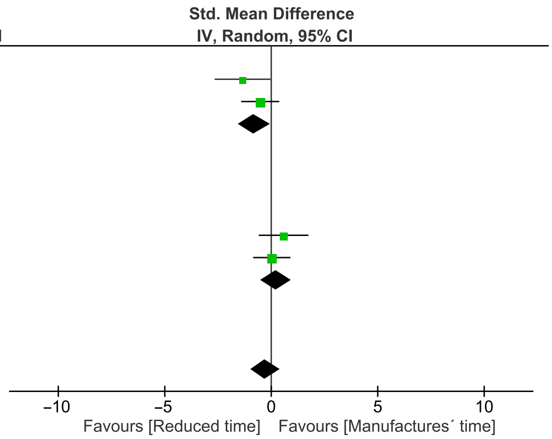

FIGURE 3 Results of reducing etching time meta-analyses after ageing, using random-effects model

The hypothesis tested in this review—the reduction of acid etching or acidic primer time influences the bond strength to dentin of primary teeth—can be partially accepted, because the reduced time of acid etching increased the dentin bond strength of adhesive systems to primary dentin only after ageing. The reduced time of the primer application of self-etching adhesives, however, did not influence the bond strength, regardless of the water storage time. The reduction of the acid-etching time seems to decrease the degradation that occurred during water storage. Water degradation is more pronounced for etch-and-rinse systems, as previously pointed by a systematic review and meta-analysis of in vitro studies[23]; a superior immediate performance was observed for etch-and-rinse adhesives; however, after ageing, the bond strength values were similar, regarding the etching strategy.

The lowest mineral content of primary dentin and the highest density and tubular diameter[2,3,6] appear to be responsible for thicker hybrid layers[4] and lower bond strength values obtained in primary dentin.[6] Thick demineralized dentin layers impair the complete infiltration by resin monomers, especially at their base.[8,9] The hybrid layers with poorly or non-infiltrated demineralized dentin zones offer a pathway for nanoleakage and interface degradation over time.[7,12] The etch-and-rinse adhesives appear to be less resistant to degradation than self-etching,[12,24] probably because of the higher demineralization ability of phosphoric acid than acidic primers. The reduction of the acid-etching time results in thinner,[10,11,14,22] and a more infiltrated hybrid layers.[10,22] More homogeneous hybrid layers seem not to influence the immediate bond strength; however, it may be related to bond stability, represented by

TABLE 2 Risk of bias

Study	Random sequence	Sample size calculation	Same number of teeth per group	Failure mode evaluation	Single operator	Blinded operator	Risk of bias
Aguilera et al, 2013	No	No	?	No	No	No	High
Bolanos-Carmona et al, 2006	Yes	No	No	Yes	No	No	High
Lenzi et al, 2013	Yes	No	Yes	Yes	No	No	High
Osorio et al, 2010	No	No	?	Yes	No	No	High
Sanabe at al., 2009	Yes	No	Yes	Yes	No	No	High
Sardella et al, 2005	No	No	Yes	Yes	No	No	High
Scheffel et al, 2013	No	No	Yes	Yes	No	No	High
Torres et al, 2007	Yes	No	Yes	Yes	No	No	High

Note: ?: Unclearly described in the study.

the higher bond strength values in the group that reduced the acid-etching time.

The acid primer application for shorter times than that recommended by the self-etching system manufacturers, however, did not impact the bond strength values,[2,4,11,12,14] regardless of evaluation time (immediate or after ageing). The demineralization ability of acidic monomers is lighter compared to phosphoric acid etch as a separate step, preventing the excessive dentin mineral loss. The simultaneous demineralization and monomer infiltration decrease the collapse of the demineralized dentin; therefore, fewer potential discrepancies and gap formations may be observed.[4,25] Irrespective of the application time (10 or 20 seconds), the acidic primers were able to partially dissolve the smear layer and leaving hydroxyapatite remnants available for chemical interaction with the adhesive monomers.[7,8,14] Sanabe et al[12] observed in SEM analysis hybrid layers with indistinguishable morphological characteristics when the primer was applied for the time recommended by the manufacturer or by half the time. Laboratory studies also demonstrate the stability of self-etching adhesives over time.[7,24,26] Both studies[12,14] that evaluated the bond strength over time used the adhesive Clearfil SE Bond, which is considered a 'gold standard' for self-etching adhesives.[27] This adhesive system contains MDP (10-methacryloxydecyl dihydrogen phosphate) as an acidic polymerizable monomer. Due to its mild aggressiveness, MDP causes minimal dissolution of the smear plugs and limited opening of tubules,[28] leaving hydroxyapatite remnants available for chemical interaction with a functional monomer.[12] These precipitates prevent the loss of calcium from the dentinal matrix.[26] The less defective hybrid layers and intense chemical adhesion to hydroxyapatite[29] may contribute to the stability of bonded interfaces over time.[12,14]

The dentin condition (sound or caries-affected) impacts on the bonding performance of adhesive systems. Caries-affected dentin (CAD) presents less of mineral content and higher intertubular porosity, which results in a deeper demineralized layer.[30] The intratubular mineral obliteration decreases the monomer infiltration and resin tag formation,[31] with lower bond strength values to CAD than sound dentin.[30-32] Additionally, selective caries removal has been strongly recommended, based on minimal intervention concept[33]; therefore, CAD is a clinically relevant substrate. Only one study[14] presents the necessary data for CAD quantitative analysis; thus, a meta-analysis comparing the reduced etching time on CAD cannot be performed, and this is a limitation of this systematic review. Future studies evaluating the immediate and long-term bond strength are necessary to prove the effects of the reduced etching time on caries-affected dentin. The electronic search of our systematic review included only the databases PubMed/MEDLINE, Web of Science and Scopus, which is also a limitation. The inclusion of other databases, however, could not add to the present outcome, and grey literature can result in a higher number of incomplete data, having an unclear impact on meta-analysis results in medical research.

All included studies were classified as having a high risk of bias. The absence or incomplete description of the parameters as sample size calculation, random sequence of specimen preparation and blinding of the operator responsible for carrying out the mechanical test should be considered in future studies. Nevertheless, all meta-analyses did not present heterogeneity. This result is uncommon, as, in general, meta-analyses of laboratory studies show high heterogeneity[23,34,35] primarily due to the methodological variations, as the use of specific guidelines for conducting and reporting in vitro studies is not widespread. Some factors may be associated with non-heterogeneity, as the single mechanical test used in all studies (microtensile bond strength test); besides, the included studies were carried out either in Brazil or in Spain, even by the same research group, contributing for similar methodologies.

The methodological limitations of this in vitro study do not permit a direct extrapolation to the clinical situation, because the relation between the bond strength evaluations with the clinical performance is hard to establish.[36] The adhesive ability of a material is an indicator of the longevity of restorations; superior laboratory performance is indicative of better clinical performance, however.[37] The main reasons for restoration failures are secondary caries and fracture, so achieving higher values of bond strength, especially in the long-term, to predict the clinical performance of this material/technique.[36] Therefore, conducting laboratory studies is necessary even before clinical studies.

The reduction of the acid-etching time to primary dentin improved the long-term bond strength of etch-and-rinse adhesives; however, this result should be interpreted with caution, because only two studies could be included in the meta-analysis. Ideally, our results should be confirmed by randomized clinical trials. Currently, there is one randomized clinical trial evaluating the reduction of acid-etching time of primary dentin, showing a trend, not statistically significant, but clinically relevant, of better clinical outcome, after 18 months, with reduced acid-etching time for etch-and-rinse adhesive systems.[38] For self-etching adhesive system, there is no literature with clinical methodology. So, our findings encourage future randomized clinical trials with sufficiently long follow-up time.

The present systematic review and meta-analysis showed that the reduction in the acid etching and acidic primer application time did not jeopardize the immediate bond strength to primary dentin. Moreover, reduced acid-etching time promoted higher bond strength values after ageing, even if only two studies were included.[12,14] The reduced application time of self-etching primers did not impact the dentin bond strength. These results are valuable, considering the reduction in clinical time, without affecting the performance of the adhesive system or improving it.

5 | CONCLUSION

Based on the findings of this systematic review, it can be concluded that reducing the acid-etching time to primary dentin improves the long-term bond strength of etch-and-rinse adhesives to this substrate.

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

AUTHORS' CONTRIBUTIONS

ROR conceived the idea and study design. LDG and CRR performed the literature search. ROR performed the extraction of data. TTF performed the meta-analysis. LDG wrote the manuscript. ROR, TTF and CCR contributed substantially to the discussion and proofread the manuscript before its submission.

ETHICS STATEMENT

No ethical approval will be needed because data from previously published studies in which ethical consent was obtained by primary investigators will be retrieved and analysed.

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