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Caroline Sala Gallina

O TEMPO DE CONDICIONAMENTO ÁCIDO INFLUENCIA A ADESÃO AO ESMALTE DE DENTES DECÍDUOS? REVISÃO SISTEMÁTICA E META-ANÁLISE

Santa Maria, RS
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Dissertação apresentada ao Programa de Pós-Graduação em Ciências Odontológicas, Área de Concentração em Odontologia, ênfase em Odontopediatria, da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para obtenção do título de **Mestre em Ciências Odontológicas**.

Orientadora: Profa. Dra. Rachel de Oliveira Rocha

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Aprovado em 22 de julho de 2021:

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Rachel de Oliveira Rocha, Dra. (UFSM)
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Débora Martini Dalpian, Dra. (UFN)

_____

Graziela Botton, Dra. (CEOM)

Santa Maria, RS
2021

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RESUMO

O TEMPO DE CONDICIONAMENTO ÁCIDO INFLUENCIA A ADESÃO AO ESMALTE DE DENTES DECÍDUOS? REVISÃO SISTEMÁTICA E META-ANÁLISE

AUTORA: Caroline Sala Gallina
ORIENTADORA: Rachel de Oliveira Rocha

As diferenças na composição e morfologia do esmalte de dentes decíduos fez com que, durante muito tempo, tempos superiores de condicionamento tenham sido sugeridos na tentativa de favorecer a adesão a esse substrato. No entanto, embora atualmente o tempo de 15 segundos seja comum, não há uniformidade na literatura de que este seja suficiente para a obtenção de padrões adequados de condicionamento e, consequentemente, permitir adesão suficiente e duradoura. Em Odontopediatria, a busca constante pela redução do tempo clínico a fim de favorecer o controle do comportamento infantil e a necessidade de evidências para guiar o processo de tomada de decisão, justificam a realização deste estudo, que tem como objetivo revisar sistematicamente a literatura para estudos laboratoriais que avaliaram a influência de diferentes tempos de condicionamento ácido do esmalte de dentes decíduos na resistência de união de sistemas adesivos. A busca por estudos laboratoriais foi realizada nas bases de dados eletrônicas (PubMed, Scopus e ISI Web of Science) a partir da estratégia criada pela combinação de termos específicos (MeSH) e livres, sem restrição de data ou idioma. Dois revisores, de forma independente selecionaram os estudos seguindo os critérios de elegibilidade de forma que, estudos que tenham comparado ao menos dois tempos de condicionamento ácido e avaliado a resistência de união de sistemas adesivos ao esmalte de dentes decíduos foram selecionados. Estudos que não apresentaram valores de resistência de união como médias e desvio-padrão, que não compararam tempos de condicionamento ácido diferentes para o mesmo sistema adesivo foram excluídos, assim como os que avaliaram a adesão de cimentos de ionômero de vidro, selantes ou braquetes ortodônticos. Dois revisores selecionaram os estudos, extraíram os dados e avaliaram o risco de viés. Os valores de resistência de união foram meta-analisados usando um modelo de efeitos aleatórios, com nível de significância de $p < 0,05$. A Heterogeneidade (I2) foi avaliada pelo teste Q da Cochran. De 219 estudos potencialmente elegíveis, 6 foram selecionados para análise integral do texto e 5 estudos foram incluídos na revisão sistemática e 4 na meta-análise. Tempos de condicionamento ácido superiores a 15 segundos não influenciam a resistência de união dos sistemas adesivos ao esmalte decíduo ($Z=0,02$; $p=0,98$). A heterogeneidade foi moderada ($I2=49\%$; $p=0,10$). Todos os estudos apresentaram um alto risco de viés. Com base nos resultados obtidos, pode-se concluir que o tempo de condicionamento ácido de 15 segundos parece suficiente para promover valores de resistência de união de sistemas adesivos ao esmalte de dentes decíduos similares a tempos mais longos.

Palavras-chave: Esmalte dentário. Condicionamento ácido do dente. Adesivos dentinários. Dente decíduo.

ABSTRACT

DOES ACID ETCHING TIME INFLUENCE ON ENAMEL BONDING OF PRIMARY TEETH? A SYSTEMATIC REVIEW AND META-ANALYSIS

AUTHOR: Caroline Sala Gallina
ADVISOR: Rachel de Oliveira Rocha

The differences in composition and morphology of primary enamel have meant that higher etching times have been suggested in an attempt to favor adhesion to this substrate for a long time. However, although 15 seconds is now standard, there is no uniformity in the literature that this is sufficient to obtain adequate conditioning standards and, consequently, to allow sufficient and lasting adhesion. In pediatric dentistry, the constant search for the reduction of clinical time in order to favor the control of children's behavior and the need for evidence to guide the decision-making process justify this study, which aims to systematically review the literature for laboratory studies that evaluated the influence of different acid etching times on the bond strength of adhesive systems to enamel of primary teeth. The search for laboratory studies was performed in electronic databases (PubMed, Scopus, and ISI Web of Science) using a strategy created by combining specific (MeSH) and free terms without date or language restrictions. Two reviewers independently selected the studies following the eligibility criteria: studies that compared at least two acid etching times and evaluated the bond strength of adhesive systems to primary enamel were selected. Studies that did not present bond strength values as means and standard deviation, did not compare different etching times for the same adhesive system were excluded, as well as those that evaluated the bonding of glass ionomer cement, sealants, or orthodontic brackets. Two reviewers selected the studies, extracted the data, and assessed the risk of bias. The bond strength values were meta-analyzed using a random-effects model, with a significance level of $p < 0.05$. Heterogeneity (I^2) was assessed by Cochran's Q test. Of 219 potentially eligible studies, 6 were selected for full-text analysis and 5 studies were included in the systematic review and 4 in the meta-analysis. Acid etching times longer than 15 seconds did not influence the bond strength of adhesive systems to deciduous enamel ($Z=0.02$; $p=0.98$). Heterogeneity was moderate ($I^2=49\%$; $p=0.10$). All studies presented a high risk of bias. Based on the results obtained, it can be concluded that the acid etching time of 15 seconds seems sufficient to promote bond strength values of adhesive systems to the enamel or primary teeth similar to longer times.

Keywords: Dental enamel. Acid-etching. Dentin-bonding agents. Deciduous tooth.

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1 INTRODUÇÃO

A partir da proposta do condicionamento ácido do esmalte, de Michael Gabriel Buonocore (1955), a adesão passou a fazer parte da prática odontológica nas diversas especialidades, possibilitando procedimentos restauradores mais conservadores, e estéticos, colagens ortodônticas, além de técnicas preventivas de lesões de cárie.

Desde então, a adesão ao esmalte tem sido considerada previsível, dado a efetiva e duradoura união obtida a esse substrato (BUONOCORE, 1955). Isso se deve, em parte, às características do substrato altamente mineralizado (aproximadamente 96% de conteúdo inorgânico, em peso), com baixa concentração de água e conteúdo orgânico (aproximadamente 4%, em peso) (BUONOCORE, 1955). Assim, o emprego do agente condicionador ácido possibilita o aumento da energia de superfície e molhabilidade do substrato (RETIEF; MIDDLETON; JAMISON, 1985; TSUJIMOTO *et al*., 2010), com a criação de microporosidades que permitirão a união micro-mecânica com o sistema adesivo (BARKMEIER *et al*., 2009).

O agente condicionador mais empregado é o ácido fosfórico, em concentrações próximas de 37% aplicado por tempos que variam de 15 a 120 segundos (BOJ *et al*., 2004; FAVA *et al*., 2003; GARCIA-GODOY; GWINNETT, 1991; HOSOYA, 1991). A variação no tempo de aplicação, em especial no esmalte de dentes decíduos, tem sido justificada em parte pela presença de uma camada aprismática (GWINNETT,1966; RIPA; GWINNETT; BUONOCORE, 1966), que parece influenciar negativamente a adesão a esse substrato (GWINNETT, 1973; SHEYKHOLESLAM; BUONOCORE, 1972), sugerindo assim, tempos mais longos de condicionamento ácido. Muito embora seja descrita mais comumente em dentes decíduos, a camada aprismática, mesmo em dentes permanentes, apresenta prismas em arranjos de cristais de hidroxiapatita paralelos entre si e perpendiculares na superfície, o que resultando em padrões de condicionamento diferentes daqueles encontrados em áreas com prismas orientados perpendicularmente (HOBSON; RUGG-GUNN; BOOTH, 2002; RISNES; LI, 2019).Em contrapartida, o esmalte de dentes decíduos, comparado ao de dentes permanentes, é menos mineralizado (HUNTER *et al*., 2000b; LIPPERT; PARKER; JANDT, 2004; LUSSI *et al*., 2000), com maior concentração de carbonato e menor de fosfato de cálcio (CORRER *et al*., 2007; HUNTER *et al*., 2000), o que pode resultar em uma ação mais acentuada do condicionamento ácido.

Alguns estudos mostram que não são necessários tempos de condicionamento ácido mais longos para o esmalte de dentes decíduos, pois o tempo de 15 segundos parece ser

suficiente para a obtenção de padrões de condicionamento suficientes para promover adequada adesão (BOJ *et al.*, 2004; GWINNETT; GARCIA-GODOY, 1992). No entanto, outros apontam tempos superiores como necessários para adequados padrões de condicionamento (HOSOYA, 1991; HOSOYA; GOTO, 1992; MEOLA; PAPACCIO, 1986).

Considerando que o tempos clínicos reduzidos são atrativos em Odontopediatria, que inexiste um protocolo único no que se refere ao tempo de condicionamento ácido do esmalte de dentes decíduos e que revisões sistemáticas são ferramentas fundamentais no processo de tomada de decisão, este estudo tem como objetivo revisar sistematicamente a literatura para estudos laboratoriais que avaliaram a resistência de união, considerando os diferentes tempos de condicionamento ácido do esmalte de dentes decíduos.

2 ARTIGO - ACID-ETCHING TIME ON ENAMEL BONDING OF PRIMARY TEETH: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Acid-etching time on enamel bonding of primary teeth: a Systematic Review and Meta-Analysis

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Author contributions:

ROR conceived the idea and study design. CSG and ROR performed the literature search. ROR performed the extraction of data and the meta-analysis. CSG wrote the manuscript. ROR and FZMS contributed substantially to discussion and proofread the manuscript before its submission.

Running title: Primary enamel acid-etching

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Acid-etching time on enamel bonding of primary teeth: a Systematic Review and Meta-Analysis

ABSTRACT

Background: Longer enamel acid-etching times may not be necessary to promote adequate bonding in primary teeth, even the presence of a thicker prismless layer.

Aim: To systematically review the literature of in vitro studies regarding the influence of acid-etching time on enamel bonding of primary teeth.

Design: Literature searching was carried out in PubMed, Web of Science, and Scopus databases selecting studies comparing the acid-etching time on the bond strength of adhesive systems to the enamel of primary teeth. Two reviewers independently selected the studies, one extracted the data, and evaluated the risk of bias. The bond strength data were meta-analyzed using a random-effects model, with a significance level of $p < 0.05$. Heterogeneity (I2) was assessed by the Cochran Q test.

Results: From 219 screened studies, 6 reports were assessed for eligibility, 5 were included in the systematic review, and 4 in meta-analysis. Acid-etching times higher than 15s do not influence adhesive systems' bond strength to primary enamel ($Z=0.02$; $p=0.98$). Heterogeneity was moderate ($I2=49\%$; $p=0.10$). All studies presented a high risk of bias.

Conclusion: Conventional acid-etching time (15 seconds) seems sufficient to promote similar bond strength values to longer times.

Keywords: primary tooth; adhesive system; systematic review; enamel; acid-etching

1. INTRODUCTION

Restoring cavitated carious lesions in primary teeth is part of the routine in pediatric dentistry. Besides the negative impact of caries on preschool children's oral health-related quality of life, increasing with severity,[1] dental restorations may be necessary to stop lesion progression and restore tooth integrity.[2] Thus, adhesive systems have been used combined with composite resins and compomers to restore the aesthetic and function of anterior and posterior primary teeth in long-lasting restorations.[3,4] Adhesive systems have been improved over the years both in composition and versatility, and in terms of the application protocol. The use of phosphoric-acid etching, however, is unquestionably necessary to promote stable bonding to enamel,[5,6] increasing the surface free energy, roughness, and wettability.[7,8]

The standard acid-etching time recommended for the enamel of permanent teeth is 15 seconds,[7,9] whereas, for primary enamel, longer times have been used in clinical trials.[10-12] It might be due to the thicker prismless (aprismatic) layer observed in primary than permanent teeth, with perpendicular hydroxyapatite crystals arrangement to the enamel surface,[13,14] suggesting a strong resistance of this prismless enamel layer to acid-etching.[15] However, there is a controversial clinical significance of the irregular etching pattern observed in scanning electronic microscopy in acid-etched prismless enamel. Regardless of the more pronounced prismless layer, in general, the enamel in primary teeth is usually thinner and less mineralized, more permeable, and more porous compared to permanent enamel. Therefore, some studies pointed out that the standard 15 seconds seems to be enough to obtain adequate etching patterns in primary enamel.[16,17] However, other studies recommend longer acid-etching times for acceptable enamel bond strength in primary teeth.[18,19]

It is imperative to consider that, whereas etch-and-rinse adhesives provide superior performance in primary teeth,[20] the etching time protocol for primary enamel remains undefined. Longer enamel acid-etching times may not be necessary and could also increase the risk of dentin

over-etching, impairing adhesive infiltration into the demineralized depth, leaving exposed collagen fibrils,[21] raising the bond degradation. For this reason, shortening acid-etching time for primary dentin is recommended,[22,23]and it does not seem clinically reasonable longer acid-etching times in enamel and reduced times in dentin.

Thus, this systematic review and meta-analysis aimed to synthesize and provide quantitative analysis of the evidence on the enamel acid-etching time when bonding to primary teeth. The tested null hypothesis was that acid-etching for 15 seconds is sufficient to obtain similar bond strength values to higher acid-etching times in the enamel of primary teeth.

2. METHODS

This systematic review has been conducted and reported in accordance with Cochrane Handbook[24] and Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).[25] The research PICO question was: "Does the acid-etching time influence the bond strength to primary enamel?"; in which the enamel of primary teeth was the 'population'; shorter acid-etching times (up to 15 seconds) was the 'intervention'; longer acid-etching times (higher than 15 seconds) was the 'control'; and bond strength was the 'outcome'.

2.1 Search strategy

The online databases PubMed/MEDLINE, SCOPUS, and ISI Web of Science were considered to identify literature up to June 2021 related to the research question. A search strategy for PubMed/MEDLINE was developed by combining controlled vocabulary (Mesh terms) and free terms as follow: (((((dental enamel[MeSH Terms]) OR (dental enamel)) OR (enamel)) AND ((((((((((((((((((((tooth, deciduous[MeSH Terms]) OR (tooth, deciduous)) OR (deciduous tooth)) OR (dentition*, deciduous)) OR (deciduous dentition*)) OR (dentition*, primary)) OR (primary dentition*)) OR (milk tooth)) OR (tooth, milk)) OR (primary teeth)) OR (teeth, deciduous)) OR

(deciduous teeth)) OR (teeth, primary)) OR (tooth primary)) OR (milk teeth)) OR (teeth, milk)) OR (baby teeth)) OR (teeth, baby)) OR (baby tooth)) OR (tooth, baby)) OR (primary tooth))) AND (((((((acid etching, dental[MeSH Terms]) OR (acid etching, dental)) OR (acid etch*)) OR (phosphoric acids[MeSH Terms])) OR (phosphoric acids)) OR (phosphoric acid)) OR (phosphoric condition)) OR (acid condition))) AND ((((((((((((((tensile strength[MeSH Terms]) OR (tensile strength)) OR (tensile strength*)) OR (tensile)) OR (microtensile)) OR (micro-tensile)) OR (micro tensile)) OR (Shear strength[MeSH Terms])) OR (shear strength)) OR (shear strength*)) OR (shear)) OR (microshear)) OR (micro-shear)) OR (micro shear)) OR (bond strength)) OR (bond*)). For the other databases, an adaptation of the strategy developed for PubMed/MEDLINE was used, considering the terms (TITLE-ABS-KEY ("dental enamel") AND TITLE-ABS-KEY ("acid etching") AND TITLE-ABS-KEY ("primary teeth") OR TITLE-ABS-KEY ("deciduous teeth")) for SCOPUS and (enamel) AND (acid etching) AND (primary teeth) for ISI Web of Science. The search was performed without any date or language restrictions. The records of the three databases were cross-checked in an electronic spreadsheet (Numbers 11.1, Apple Inc, Cupertino, CA, USA) to eliminate duplicates and analyze the inclusion and exclusion of studies.

2.2 Study selection, inclusion and exclusion criteria

Two trained and calibrated reviewers (C.S.G. and R.O.R) (Kappa= 0.78) independently evaluated the titles and abstracts of all studies identified in the electronic search. To be included, studies needed to meet the eligibility criteria: compared at least two acid-etching times on the bond strength of adhesive systems to the enamel of primary teeth. In case of disagreements between reviewers, inclusion was decided by consensus together with a third reviewer (F.Z.M.S.). The final inclusion of studies was made after reading the text in its entirety, considering the exclusion criteria: 1) absence of bond strength values as means and standard deviation; 2) no comparison of the same acid-etching time for the same adhesive system; 3) did not evaluate the bond strength of adhesive

systems - studies that evaluated glass ionomer cement, sealants or orthodontic brackets were excluded. A manual search of the references of the selected studies was performed to identify studies not registered in the search databases.

2.3 Data extraction

The relevant data were extracted by one researcher (R.O.R.), considering: first author, year of publication, country of the first author, tooth type, number of teeth in each experimental group, adhesive systems (commercial brand), composite resins (commercial brand), acid etching agents (concentration), acid-etching times, bond strength test, and bond strength values (means and standard deviations). Data were recorded in a standardized form (Numbers 11.1, Apple Inc, Cupertino, CA, USA). Corresponding authors were contacted by email to obtain unclear or not reported data. Unanswered information made the study excluded. If different studies reported the same bond strength data only the first published study was considered.

2.4 Assessement of risk of bias

The risk of bias of each study was assessed based on the criteria described in a previous systematic review[26] and adapted for the present review, considering the following items: random sequence for specimens preparation, sample size calculation, the same number of teeth in each experimental groups, adhesive systems used according to the manufacturer's instructions, a single operator responsible for adhesive procedures, failure mode evaluation, and blinding of the operator responsible for the outcome analysis. Each identifiable item in the primary study text received a 'YES', and each missing piece of information received a 'NO'. 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 and 5 = medium risk of bias; 6 and 7 = low risk of bias.

2.5 Data analysis

The data were meta-analyzed using the inverse of variances (Z test) with random effects model, and a significance level of 5%. The bond strength data were considered only from groups with ground enamel and acid-etching with phosphoric acid in concentrations between 36% and 40%. Phosphoric acid in a concentration of 10% was not considered. For the studies that considered more than two enamel acid-etching times or more than one adhesive system, the data were grouped, as mean and standard deviation, using a predefined formula,[24] considering times up to 15 seconds and times higher than 15 seconds. Data obtained from unground enamel, and using 10% phosphoric acid[17] were not considered. Only immediate bond strength data were considered. The data of 500 thermal cycles were considered as immediate bond strength.[16] The data from Hosoya and Goto's study were not included as non-thermal cycled data were previously published.[18,19]

Heterogeneity (I^2) among studies was assessed by the Cochran Q test with a significance greater than 0.1. Value higher than 50% was considered heterogeneous.[24] The Review Manager software (RevMan version 5.3; Cochrane Collaboration, London, UK) was used for statistical analysis.

3. RESULTS

3.1 Study selection

Initially, 313 records were obtained (129 from PubMed, 103 from Scopus, and 81 from Web of Science). After subtraction of duplicates, the title and abstract of 219 studies were reviewed, and 213 did not meet the inclusion criteria, mainly not to evaluating primary teeth, and were excluded. After assessment of full-text, five studies were selected. One study could not be included as it did not

present the data as mean and standard deviation values, even after a requested to the authors by email. Figure 1 depicts the study selection process as a PRISMA flowchart.

3.2 Study characteristics

The descriptive data of included studies are summarized in Table 1. Three studies were published in English, from Spain,[16] the United States,[17] and Japan.[18,19,27] Three studies were conducted in Japan by the same research group,[18,19,27] and two were published in Japanese.[18,19] The most recent study was published in 2004.[16]

Ground[17-19,27] or polished[16] enamel were considered the substrate for adhesion and shear bond strength test was used in all studies for bond strength assessment. Only one study[17] evaluated acid etching time on unground enamel, so data from unground enamel was not considered in this systematic review and meta-analysis. Phosphoric acid was used in 10%, 36%, 37%, and 40% concentrations. Evaluated etching times ranged from 5 s to 60 s. In two studies, bond strength was evaluated after 500[16] and 10,000 thermal cycles (between 5 ºC and 55 ºC).[27] Four etch-and-rinse adhesive systems were evaluated in the included studies.

3.3 Risk of bias assessment

The risk of bias assessment for the included studies is displayed in Table 2. Statement of the sample size calculation, a single operator performing the bonding procedures, and blinding the bond strength test operator were not observed in all evaluated papers. Moreover, a lack of information about the randomization, manufacturers instructions, and failure mode evaluation were also observed. All studies were classified as high risk of bias.

3.4 Meta-analysis

The meta-analysis was conducted with 4 studies (Figure 2). The overall effect was not statistically significant ($Z=0.22$; $p=0.82$), i.e., the acid etching times higher than 15s do not influence

adhesive systems' bond strength to primary enamel (Figure 2). The meta-analysis resulted in no significant heterogeneity (I^2=52%; p = 0.10).

4. DISCUSSION

Findings from the current systematic review and meta-analysis pointed out that longer acid etching times did not improve the bond strength of adhesive systems to the enamel of primary teeth. Therefore, the hypothesis that there is no influence of acid etching time on enamel bonding of primary teeth must be accepted. Nevertheless, some aspects of the included studies must be discussed.

In general, adhesive systems have been used on primary teeth following the same protocol suggested for permanent teeth, although the chemical and morphological differences between primary and permanent teeth as bonding substrates. Bond strength values are lower in primary than in permanent dentin, as was shown in a previous systematic review.[4] However, bonding to the enamel of primary teeth seems to be similar to the enamel of permanent teeth. Currently, for permanent enamel, the standard acid etching time is 15 seconds,[7] as it seems to be enough to promote adequate bonding also on primary enamel; the results of this meta-analysis reinforce the evidence on shortened enamel acid etching time. Longer acid etching times have been suggested for primary enamel on account of a thicker aprismatic layer, with hydroxyapatite crystals arranged parallel to each other and perpendicular to the surface.[13,14] In fact, heterogeneous acid etching patterns have been observed in the prismless layer in primary enamel;[28] however, bonding to this substrate is uncertain.

The included studies compared acid etching times from 5 to 60 seconds. Boj et al.[16] compared the standard time of 15 seconds to 5 and 30 seconds, whereas Gwinnet and Garcia-Godoy[17] compared 15 to 60 seconds. The three studies from the same Japanese research group evaluated the minimum time of 10 seconds compared to higher acid etching times (20, 30 and 50 seconds).[18,19,27] For this reason, in the meta-analysis, the acid etching times were dichotomized in up to 15 seconds (considered as reduced time), and over 15 seconds (considered longer acid etching time), as sub-

group comparisons did not seem reasonable. Likewise, only phosphoric acid concentrations close to 37% were considered, although Gwinnett, Garcia-Godoy[17] had also used 10% phosphoric acid.

It is worth considering that, in the present review, all included studies evaluated the bond strength, according to the acid etching time, to ground or polished enamel. Although Gwinnet, Garcia-Godoy (1992)[17] had included two unground enamel groups, these data were not considered, and only the bond strength values from ground enamel were included in the meta-analysis. Besides being easier to standardize the surface in laboratory studies, also in pediatric dentistry clinical practice, in most clinical situations, even in minimal intervention approach, some level of grinding instrumentation is required, resulting in prismless enamel layer removal, exposing a more uniform prismatic structure, as a substrate for adhesive materials.

It is important to emphasize that the findings of this systematic review are not affected by the type of teeth used in the included studies. Only two studies evaluated the bond strength in human teeth; one study used primary molars[16] and the other, primary incisors.[17] Three studies from the same Japanese research group used bovine primary incisors[18,19,27] a reliable substitutes for human teeth in bond strength studies.[29,30] Furthermore, in all included studies, the shear bond strength was the mechanical test used, certainly because the five included studies were published before the development of "micro-bond" strength tests.[31,32] It is reasonable to consider that, despite its limitations regarding the non-homogeneous stress distribution and the occurrence of cohesive failures,[33] shear bond strength tests have been the most used method in bonding studies,[5,33] probably because it has a fast and straightforward methodology.[33] Similarly, regarding the year of publication of the included studies, only one of the adhesive systems evaluated in the primary studies is still available. However, similar results can be expected with current adhesive systems, as bonding to enamel depends mainly on the adhesive micromechanical interlocking in the irregularities created by acid etching[21] than on the composition or other factors related to the adhesive systems. Although bonding to enamel has been considered stable over time, only immediate bond strength data were

considered as no included study considered aging. Boj et al.[16] subjected the specimens to 500 thermal cycles before the shear bond test; however, according to the ISO 11405, 500 thermal cycles is considered a short-term aging simulation,[34] and thus it was not considered aging.

The quality of evidence is essential in systematic reviews, affecting the findings. Low heterogeneity was found in the meta-analysis, probably because all the included studies performed the shear bond strength test, reducing the variability of methodologies. Even so, based on the assumption that methodological heterogeneity was likely to exist and have an effect on the results, the random effect model was used in meta-analysis. However, most of the parameters evaluated in the risk of bias were not described in the primary studies, and all of them were considered high risk of bias. Whereas the low quality of the included studies, the findings of this systematic review should be interpreted with caution. Nevertheless, the quality of the evidence, the few studies available, all published more than 20 years ago represent limitations of the present systematic review. The literature search in only three electronic databases has been considered a limitation in systematic reviews. However, PubMed/MEDLINE, Web of Science, and Scopus seem to be sufficient to provide records from in vitro studies on bonding to enamel and dentin.[23,35] Furthermore, incomplete data can result from the gray literature search, with an unclear impact on studies screened. Thus, further high quality studies are needed to substantiate the obtained results.

Even though laboratory studies have significant limitations, mechanical loading of bonded interfaces are helpful in identifying related substrate and material variables[36] and can provide more effective bonding protocols.[35] Thus, even based on the results of this systematic review, supporting the primary enamel acid etching time of 15 seconds, further well design laboratory investigations are suggested.

5. CONCLUSION

The evidences from laboratory studies support the enamel acid etching time of 15 seconds in primary teeth. Thus, shorter enamel etching time is suggested for primary teeth.

Why this paper is important to pediatric dentists

Enamel acid etching time of 15 seconds is sufficient to promote adequate bonding of adhesive systems in primary teeth.

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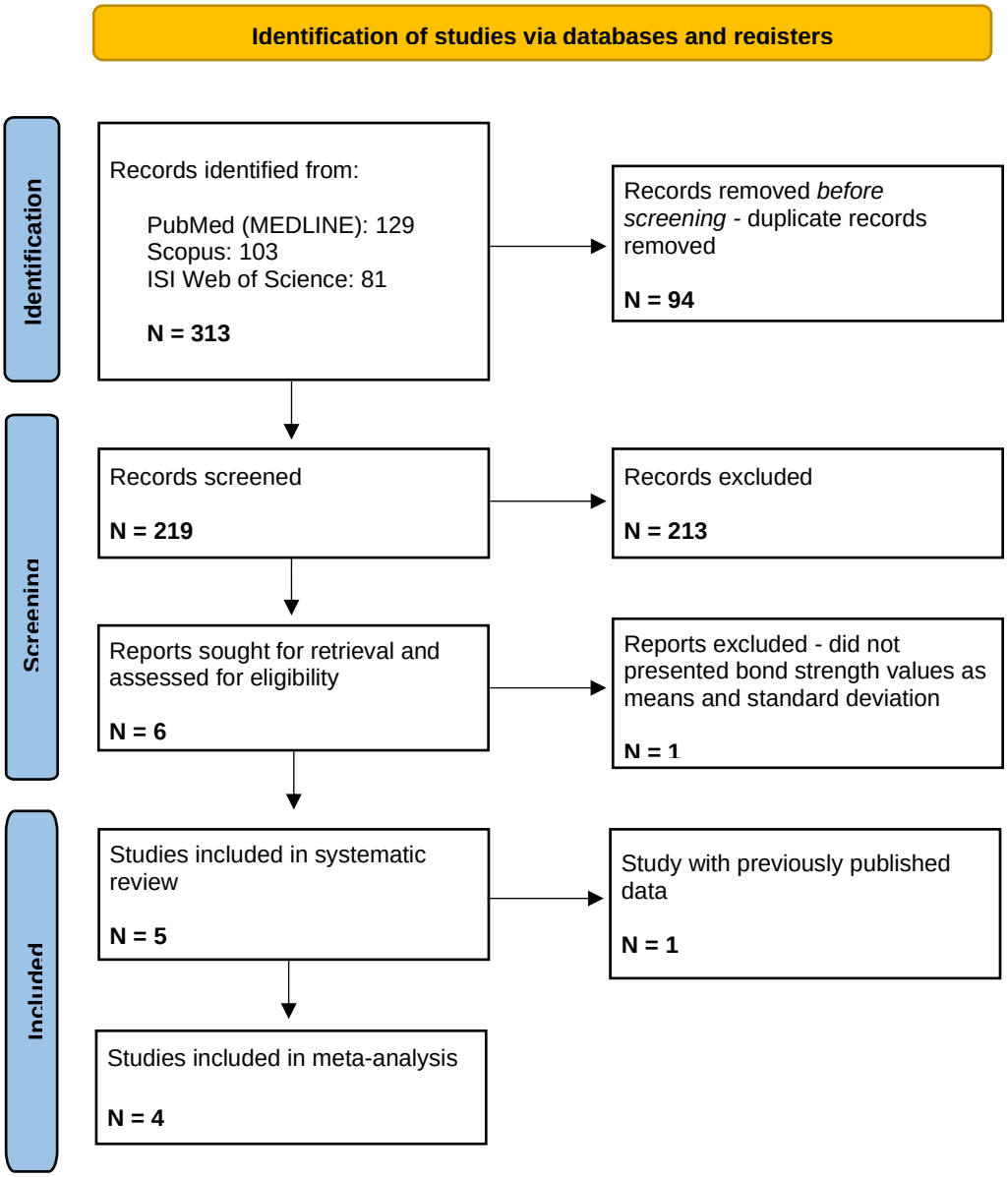
Figure legends

Figure 1. Flow diagram for studies' search and inclusion according to PRISMA 2020

Figure 2. Forest plot for bond strength values according acid-etching times (acid-etching times >15 vs acid-etching times < 15s)


Identification of studies via databases and registers
Identification
Records identified from:
PubMed (MEDLINE): 129
Scopus: 103
ISI Web of Science: 81
N = 313
Records removed *before screening* - duplicate records removed
N = 94
Screening
Records screened
N = 219
Records excluded
N = 213
Reports sought for retrieval and assessed for eligibility
N = 6
Reports excluded - did not presented bond strength values as means and standard deviation
N = 1
Included
Studies included in systematic review
N = 5
Study with previously published data
N = 1
Studies included in meta-analysis
N = 4

Study or Subgroup	< 15 seconds Mean	SD	Total	> 15 seconds Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Boj et al., 2004	25.66	7.14	20	19.25	6.37	10	24.3%	0.90 [0.11, 1.70]
Gwinnett, Garcia-Godoy, 1992	18.13	1.24	10	18.86	4.21	10	22.0%	-0.23 [-1.11, 0.65]
Hosoya et al., 1990A	65.65	13.11	10	65.76	20.6	30	26.9%	-0.01 [-0.72, 0.71]
Hosoya et al., 1990B	68.46	14.11	10	73.39	11.71	30	26.8%	-0.39 [-1.11, 0.33]
Total (95% CI)			**50**			**80**	**100.0%**	**0.06 [-0.49, 0.62]**

Heterogeneity: Tau² = 0.17; Chi² = 6.24, df = 3 (P = 0.10); I² = 52%
Test for overall effect: Z = 0.22 (P = 0.82)

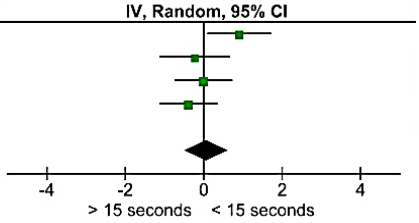


Table 1. Descriptive data of included studies

Author	Country	Substrate	Specimens per group	Enamel condition	Adhesive system*	Composite resin*	Acid etching time (concentration)	Bond strength test
Boj et al., 2004	Spain	Primary molars	10	Polish	Prime & Bond NT (Dentsply)	Spectrum (Dentsply)	5 s 15 s 30 s (36% orthophosphoric acid)	Shear bond strength
Gwinnett, Garcia-Godoy, 1992	United States	Primary incisors	10	Ground and unground[#]	Prisma Universal Bond 3 (LD Caulk Co.)	APH (LD Caulk Co.)	15 s 60 s (10%*and 37% phosphoric acid siliceous gel)	Shear bond strength
Hosoya et al., 1990A	Japan	Bovine incisors	10	Ground	Photo Bond (Kuraray Co.)	Photo Clearfil A (Kuraray Co.,)	10 s 20 s 30 s 60 s (40% phosphoric acid gel)	Shear bond strength
Hosoya et al., 1990B	Japan	Bovine incisors	10	Ground	Scotch Bond (3M Co.) Photo Bond[&] (Kuraray Co.)	Silux (3M Co.) Photo Clearfil A[&] (Kuraray Co.,)	10 s 20 s 30 s 60 s (37% phosphoric acid gel)	Shear bond strength
Hosoya, Goto, 1992[&]	Japan	Bovine incisors	10	Ground	Photo Bond[&] (Kuraray Co.) Scotch Bond (3M Co.)	Photo Clearfil A[&] (Kuraray Co.) Silux (3M Co.)	10 s 20 s 30 s 60 s (37% and 40% phosphoric acid gel)	Shear bond strength

* As described in the study.
[#] Only ground enamel groups were considered.
[$] Not considered.
[&] Data already published; not considered in meta-analysis

Table 2. Risk of bias

Study	Random sequence	Sample size calculation	Same number of teeth per group	Manufactors' instructions	Failure mode evaluation	Single operator	Blinded operator	Risk of bias
Boj et al., 2004	No	No	Yes	No	No	No	No	High
Gwinnet, Garcia-Godoy, 1992	Yes	No	Yes	Yes	No	No	No	High
Hosoya et al., 1990A	No	No	Yes	No	Yes	No	No	High
Hosoya et al., 1990B	No	No	Yes	No	Yes	No	No	High
Hosoya, Goto, 1992	No	No	Yes	No	Yes	No	No	High

3 CONCLUSÃO

A presente dissertação, avaliou sistematicamente os valores de resistência de união de diferentes tempos de condicionamento ácido do esmalte de dentes decíduos. Os dados obtidos indicam que o condicionamento ácido do esmalte de dentes decíduos, pelo tempo de 15 segundos é suficiente para proporcionar a adesão de sistemas adesivos.

Por meio deste, sugere-se a utilização de 15 segundos de condicionamento ácido em esmalte dentes decíduos.

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