Microleakage of Sealants after Phosphoric Acid, Er: YAG Laser and Air Abrasion Enamel Conditioning: Systematic Review and Meta-Analysis

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Purpose: *The aim of this systematic review and meta-analysis is to answer the focused question: Does the application of phosphoric acid, Er:YAG laser and air abrasion enamel conditioning methods previous to the oclusal sealant application in human permanent molars influence the microleakage?* ***Study design***: *A literature research was carried out in the Pubmed Medline, Web of Science, Scopus and Cochrane databases using with the MeSH terms and keyword search strategy. A supplemental hand search of the references of retrieved articles was also performed. Inclusion criteria comprised ex vivo studies (extracted teeth) with permanent human teeth that used chemical (phosphoric acid) or mechanical (Er:YAG laser and air abrasion) conditioning methods previous the sealant application. The studies should evaluate microleakage as an outcome. Meta-analysis pooled plot were obtained comparing the microleakage after pre-treatment with phosphoric acid, Er:YAG and air abrasion enamel conditioning for sealant application using RevMan software.* ***Results:*** *The search resulted in 164 articles, 55 records were excluded because they were duplicated. The analysis of titles and abstracts resulted in the exclusion of 105 studies. Four studies were included in the systematic review and the meta-analysis. According to the risk of bias evaluation, the four studies were considered low risk of bias. The meta-analysis showed that phosphoric acid had lower microleakage than Er:YAG laser ($p < 0.001$) and air abrasion ($p < 0.001$), with heterogeinity of $I^2 = 0\%$ and $I^2 = 71\%$, respectively. It was not found statistical difference when compared phosphoric acid and phosphoric acid combined with Er:YAG laser and air abrasion ($p > 0.05$).* ***Conclusion***: *The evidence supports that the pre-treatment with phosphoric acid leads lower microleakage in oclusal sealants than Er:YAG laser and air abrasion.*

Key words: *Microleakage; Sealants; Enamel conditioning; Systematic review; Meta-analysis*

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INTRODUCTION

Pit and fissure caries account for 90% of caries-affected tooth surfaces.[1] Caries develop more readily in pits and fissures on occlusal surfaces that presents retentive morphology when compared to smooth surfaces. In addition, newly erupted tooth suffer post-eruptive maturation and are more liable to suffer demineralization.[2] Sealants can be applied to prevent caries in these areas where correct oral hygiene is more difficult. Serving as a barrier against accumulation of biofilm and penetration of microorganisms.[3]

An effective tooth-sealing interface requires a pretreatment of the enamel surface.[3,4] The conditioning of the enamel is a crucial step for the sealant retention, durability and sealing. Several surface treatment techniques have been previously used for the application of sealant mostly Er: YAG laser, air abrasion and acids.[4] Total etching in the range of 30-40% phosphoric acid is the standard method for enamel treatment.[5]

The lasers have been used on hard dental tissue and can vary the pulse mode, irradiation time, frequency and energy outputs. Previous investigations[6,7] have reported the ability of Er:YAG laser to cut or ablate tooth structure, remove carious lesions, prepare cavities and modify dentin and enamel surfaces before acid-etching for increasing bond strength.[2] In addition, some studies have evaluated the Er:YAG laser as enamel conditioning before application of the sealant.[8,9,10,11]

Likewise, air-abrasion technology has been used in dentistry. This technique uses a high-speed stream of purified aluminum oxide particles delivered by air pressure and has been reported as an effective and safe alternative to treat and/or prepare the enamel[11,12] before application of the sealant.[12,13]

Although many studies attempted to compare different technique for the enamel conditioning before application of a fissure sealant, there is no consensus regarding the better technique. Therefore, the aim of this systematic review and meta-analysis is to answer the focused question: Does the application of phosphoric acid, Er:YAG laser and air abrasion enamel conditioning methods previous to the oclusal sealant application in human permanent molars influence the microleakage?

MATERIALS AND METHOD

This systematic review was carried out in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) Statement[14] and Maia and Antonio guideline (2012).[15] Also, it was registered in PROSPERO database (PROSPERO registry number: CRD42015019826).

Search Strategy

Two examiners performed the search process independently. A search of Pubmed (1990–2015), Web of Science (1990–2015), Scopus (1990–2015), and Cochrane (1990-2015), Lilacs and Clinical Trials register (ClinicalTrials.gov) databases was conducted using the following search terms from Medical Subject Heading terms (MeSH) or Text Word [tw] and their combinations: "fissure sealants" (MeSH terms) AND "tooth" (MeSH terms) OR "teeth" [tw] AND "conditioning" [tw] OR "teeth" [tw] AND "conditioned" [tw]. The gray literature was also consulted trough SiGLE. Experts were also contacted to identify unpublished and ongoing studies. The searches were complemented by screening the references of selected articles in attempt to find any article that did not appear in the database search.

Inclusion/Exclusion Criteria

The titles and abstracts generated by the search engines, along with relevant articles, were screened according to the following inclusion and exclusion criteria. Two examiners (A.C.F and D.L.L.) evaluated titles, abstracts and full text. If there was a divergent opinion, disagreement among examiners was reexamined in consensus meetings. The following eligibility criteria were based on the PECOS strategy: *ex vivo* studies that included permanent molars teeth (P–participants), exposition to phosphoric acid and/or air abrasion and/or laser as a pre-treatment for sealant application (E–exposition), studies that compare microleakage after enamel conditioning technique (C–comparison), microleakage values as an outcome (O–outcome) and *ex vivo* transversal studies (S – study design).

Studies published other languages besides English language, patents, *in vivo* or *in situ* studies, case reports, serial case, review articles, opinion articles, letters, and animal studies were not included. All potentially relevant studies were identified by the title and the abstract. Full articles were retrieved and examined when their title and abstract did not provide enough information for a definite decision. After the full text analyses of the potentially relevant studies, the selected studies were included in the systematic review. Articles appearing in more than one database search were considered only once.

Data extraction and analysis

The extracted data was placed on tables and divided into experimental groups, number of teeth in each group. For the studies that evaluate the laser, data about power, energy output, frequency, diameter, distance and duration were extracted. For the studies that evaluate the air abrasion, data about particle size, pressure, duration, distance and angle were extracted. The data extraction was performe by two examiner (A.C.F and M.C.B)

Quality assessment and control of bias and data extraction

Methodological quality was assessed by two investigators (E.C.K. and A.C.F), when disagreements between the reviewers occurred, it were solved by consensus. Assessment of risk of bias Risk of bias was conducted based on an adaptation of previous studis[16,17] and evaluated according to the description of the following parameters for the study's quality assessment: randomization, presence of caries, conditioning method, procedure conducted by the same operator and sample size. The blinding of the operator was not considered since the conditioning techniques are very different are not able to blind the operator. When the information were absent in the papers the authors were contacted, if the authors did not reply the email about that information, the information was characterized as "unclear". If the authors reported the parameter, the paper had a Y (yes) on that specific parameter; if it was not possible to find the information, the paper received an N (no). Papers that reported 1 or 2 items Y were classified as high risk of bias, 3 Y as medium risk, and 4 or 5 Y as low risk.

Data such as powder, output energy, frequency, diameter of laser, distance and duration were extracted from the papers.

Meta-analysis

The meta-analysis was performed using the RevMan software (Review Manager–RevMan–Computer program. Version 5.2. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012). The articles that presented mean and standard deviation of microleakage were included. Calculations were performed to compare the efficiency of the Er:YAG laser and the air abrasion methods in comparison with the phosphoric acid using fixed effect.

The continuous variables were used and included in the software as means and standard deviation. When the results were presented in the article as median, the mean value and the standard deviation were calculated using the formula proposed by Hozo in 2005.[18] We used the inverse-variance meta-analysis. The fixed-effects model was used to summarize the outcomes. The standardized mean difference in microleakage between groups were derived for each article and the results of the meta-analysis were presented in a forest plot.

Heterogeneity was assessed using the I^2 index, with significance set at $p < 0.05$, where I^2 values of 25%, 50% and 75% indicated low, medium and high heterogeneity, respectively.[15,16]

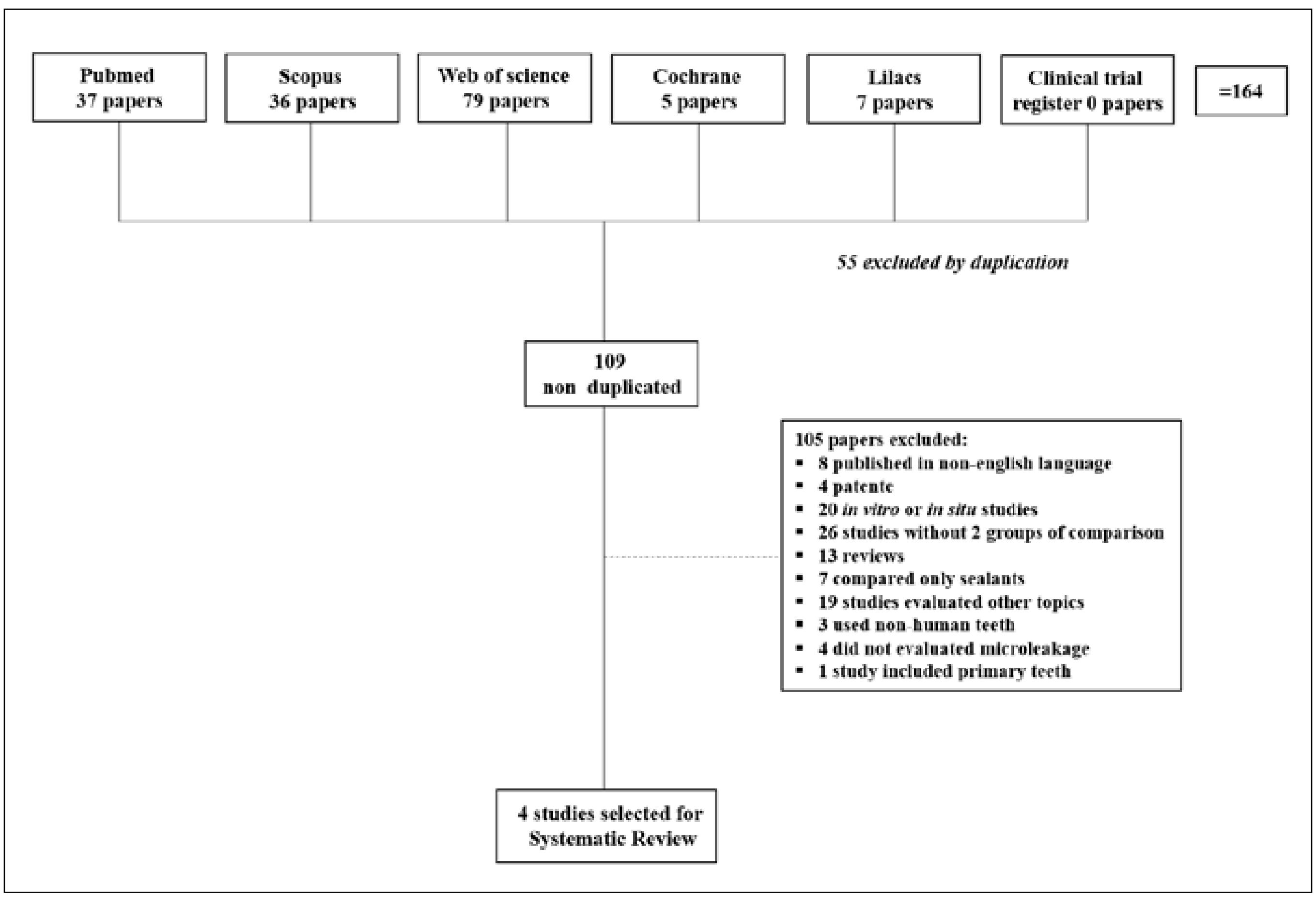
RESULTS

A flow diagram of the search strategy is presented in the Figure 1. Initially, the search resulted in 164 published studies. Fifty-five records were excluded because they were duplicated, resulting in 109 non duplicated studies. The analysis of titles and abstracts resulted in the exclusion of 105 of the published studies, resulting in 4 studies included in the systematic review and the meta-analysis for laser Er:YAG,[8,19-21] and the same 4 studies for the air abrasion. The contacted authors informed that there was no ongoing studies neither on gray literature. After the electronic search, the references of the included studies were hand searched, however no further articles were found.

Table 1 shows the methodological quality of the included studies. Regarding the risk of bias, Ciucchi *et al* ,[19] Borsatto *et al* ,[8] Manhart *et al* ,[20] and Sancakli *et al* [21] presented low risk of bias. Sancakli *et al* [21] presented one answer "N" due to small sample size, lower number of samples than the ISO standards requires. It was not possible contact Manhart *et al* [20] for clarifications regarding the number of operating during the sample preparation, thus this parameter was "unclear".

The data collected from the selected studies such as experimental groups, sample size, type of sealant, type of dye and number of cycles is summarized in Table 2. In addition to these data, others information are exhibited in tables according to the enamel conditioning method before application of a fissure sealant. The Table 3 shows the number of teeth in each group, the experimental groups, power, energy output, frequency, diameter of the laser, distance and duration of irradiation of laser. For the studies that used air abrasion, the collected data were particle size, pressure, duration, distance and angle in Table 3. The absent information on the studies that was not

Figure 1: Flow diagram showing the process of identifying, screening, assessing for eligibility, excluding and including the studies.



possible to be obtained even after the contact with author were also reported as “missing data”.

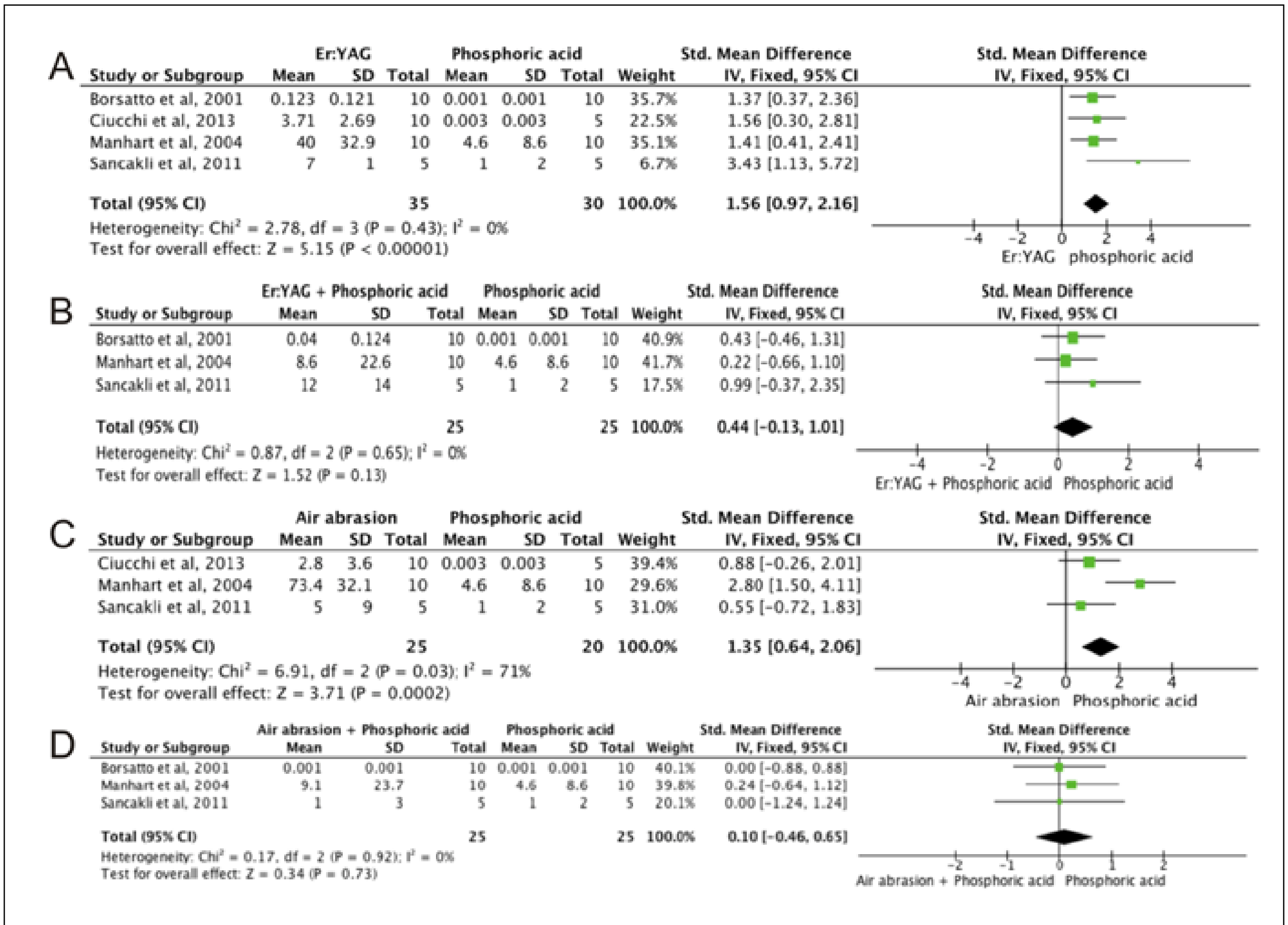
Data from the selected studies compared through the meta-analysis[8,19,20,21] showed lower microleakage for phosphoric acid in comparison with Er:YAG laser and air abrasion. Figure 2A exhibit the forest plot of the comparison between the phosphoric acid and Er:YAG laser enamel conditioning method, phosphoric acid showed lower microleakage ($p < 0.001$) and the heterogeneity among studies was 0% (I^2). Figure 2B shows the meta-analysis comparing the phosphoric acid and Er:YAG laser combined with phosphoric acid enamel conditioning method, no statistical difference was found ($p = 0.13$) with heterogeneity of 0% (I^2). Figure 2C exhibit the forest plot of the comparison between the phosphoric acid and air abrasion, phosphoric acid also demonstrated lower microleakage ($p < 0.001$) and the heterogeneity among studies was 72% (I^2). Figure 2D shows the meta-analysis comparing the phosphoric acid and Er:YAG laser combined with air abrasion, no statistical difference was found ($p = 0.73$), the heterogeneity was 0% (I^2).

DISCUSSION

Dental caries prevention may covers many aspects, including the treatment of the occlusal fissures with sealants. To establish the best steps during selant application is a critical step for the clinicians in the dental practice. Currently, 37% phosphoric acid is largely used in the dental practice in the enamel conditioning before the sealant application. However, in order to minimize microleakage of oral fluids, other enamel conditioning methods have been proposed. In the present work, we aimed to evaluate the current evidence regarding the best option for enamel conditioning before the sealant application.

Although many articles have reported several advantages of the laser, such the absence of vibration and heat during caries removal,[21] the present systematic review and meta-analysis demonstrated that phosphoric acid conditioning technique presented lower microleakage values. This could be explained by the previous studies that demosntrated that pits and fissures prepared exclusively by Er:YAG laser did not result in optimal penetration of sealant into etched enamel.[2] The laser irradiation was not able to produce a

Figure 2: A- Meta-analysis forest plot comparing ER:YAG and phosphoric acid. B- Meta-analysis forest plot comparing phosphoric acid associated with ER:YAG and phosphoric acid. C- Meta-analysis forest plot comparing air abrasion and phosphoric acid. D- Meta-analysis forest plot comparing phosphoric acid associated with air abrasion and phosphoric acid.



high-quality, dye penetration-resistant interface, and therefore the laser group provided the highest degree of microleakage. When a subsequent 37% phosphoric acid-conditioning was accomplished, the marginal integrity of the sealant was considerably enhanced. These observations are also in agreement with a previous study.[22] In addition, our pooled data showed in the meta-analysis, did not indicate that the combination of the both techniques was better than phosphoric acid alone.

Following a similar pattern, results of the present study did not demonstrate that air-abrasion is more efficient than phosphoric acid in the enamel conditioning before sealant. This could be explained by the air abrasion characteristics. The air stream pressure and aluminum oxide particles size creates a roughened enamel surface.[23] Nevertheless, it has been demonstrated that the air-abrasive treatment results in an irreversible removal of both organic and inorganic components of the enamel matrix, producing a smoother and less retentive surface, likely due to the minimal etching effects of air abrasion.[24,25] On the other hand, the standard acid solutions promote a selective dissolution of just the inorganic components of the enamel matrix; the organic component remains intact, leading to a more appropriately micro retentive surface.[26] Although air-abrasion produces a roughened surface, there is no effective penetration of sealant into the abraded enamel surface and the bonded resin material lacks the seal obtained with acid-etching[17] thus showing an unsatisfactory clinical performance.

There was substantial heterogeneity among studies. This could be explained by the methodological variations, such as laser and air abrasion characteristics, termocicling characteristics and type of dye. However, these differences did not affect the methodological quality of the included studies as well as the final result.

It is important to emphasize that *in vitro* studies has several limitations. Although clinical studies commonly offer a highest level of evidence for treatment options, some outcomes, such as microleakage are better evaluated in *in vitro* studies. In general, the in vitro studies included in this systematic review and meta-analysees have a high methodological quality adding important information regarding the subject.

Phosphoric acid alone, or its combination with laser or air abrasion presented better results. However, we should consider that the economical aspect of sealant treatment should be taken into consideration.[27] Sealant application has to remain simple and rapid and affordable in order to be used as prophylactic measures.[28] The present results clearly hilights that phosphoric acid etching alone is the best treatment option before application of a fissure sealant regarding the microleakage. In addition, it should also be considered the phosphoric acid does not require extra time and additional equipment and is easily used in the dental practice.

CONCLUSION

The different conditioning techniques influence the microleakage. Phosphoric acid had lower microleakage in comparaison with Er:YAG laser and air abrasion which demonstrated that it is the best technique to use in the enamel conditioning before application of a fissure sealant.

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