The Comparison Analysis of Orthophosphoric and Maleic Acids in the Smear Layer Removal Techniques

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Abstract

Different solutions have been used to remove the smear layer during endodontic treatment. Their efficacy, biological response and side effects differ from each other. The purpose of this review article is to assess systematically the available scientific evidence about the effectiveness of orthophosphoric and maleic acids in smear layer removing.

The study of publications was produced in the electronic databases such as Google Scholar, PubMed during a systematic review of the literature. Included articles contain information about using orthophosphoric and maleic acids in smear layer removing and their difference. The publication date criterion was selected from January 2011 to September 2021.

55 articles were viewed during the review. After analyzing the literature for inclusion criteria, the total number of publications has become 10.

According to literature data, orthophosphoric and maleic acids are both effective in removing the smear layer, however, they have some differences.

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Introduction

Smear layer is a layer which is produced during instrumentation. It contains both organic and inorganic materials. It may also contain bacteria and their byproduct[1]. The smear layer adheres to dentinal surface, thus occluding the dentinal tubules. Because this layer disfavors the penetration of irrigant solutions and root canal fillings, it should be removed[2]. This enhances root end filling material adaptation and potentially eliminates or minimizes apical leakage[3]. Different methods have been used to remove the smear layer. Decalcifying solutions, such as EDTA solutions at different concentrations, sodium hypochlorite, citric acid, orthophosphoric acid, maleic acid, have been reported to be suitable in removing this layer.

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The purpose of the present review was to compare the smear layer removal by orthophosphoric and maleic acids.

Materials and methods

1. Eligibility Criteria

Publications that met the following selection criteria were included:

1) Publication year isn't earlier than 2011
2) Availability of studies proving the efficiency of each selected material (orthophosphoric acid, maleic acid)
3) Figuring the topic of the effectiveness of using orthophosphoric and maleic acids in smear layer removing and their difference.

The review didn't include publications, the title and abstract of which did not meet at least one of the presented inclusion criteria.

2. Information Sources

Up-to-date information in English from Google Scholar, PubMed electronic databases has been studied.

3. Search and Selection of Studies

A search in English with no time limit was performed by one person. Search terms included "orthophosphoric acid", "maleic acid", "smear layer". The studies were filtered and selected in several stages. Firstly, they were evaluated by titles. Secondly, individual documents at the first stage were additionally assessed by reading the abstracts and full-text articles. The first selection criterion was the selection of publications whose titles included at least one search term. Further, publications which are dated earlier than 2011 were excluded. At the last stage, the content of the full-text versions of the selected articles was examined (Figure 1).

4. Risk of Bias Assessment

Cochrane Collaboration data were used to assess the risk of bias, with tests performed at each of the selection stages, according to Higgins et al [25]. The levels of bias were classified as follows: low risk, if all the criteria were met; moderate risk, when only one criterion was missing; high risk, if two or more criteria were missing; and unclear risk if there were very few details to make a judgement about a certain risk assessment.

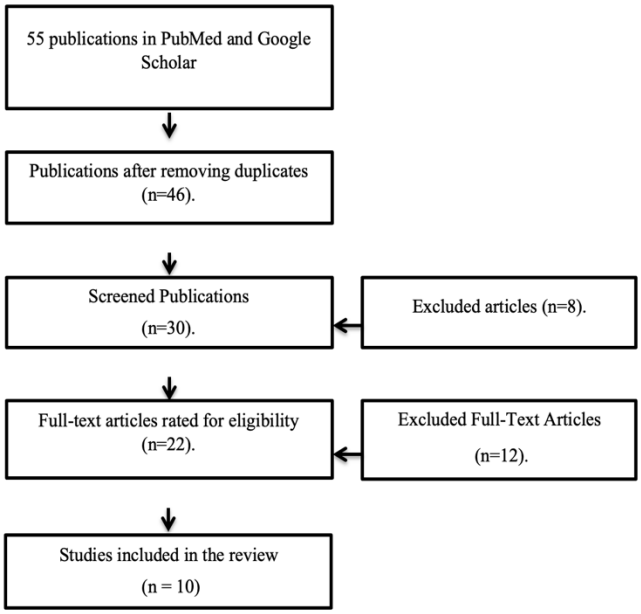

Figure 1. Article selection process.

Results

55 articles were reviewed, of which 15 were from the PubMed database, 40 were from Google Scholar. After the selection according to the exclusion criteria, the total number of articles was 10. In the selected articles, the relevant data on the effectiveness and difference of orthophosphoric and maleic acids in smear layer removing were analyzed (Table 1).

Author	Publication year	Study	Number	The material
Lo Giudice G. et al [4]	2016	Teeth	28	EDTA, 37% orthophosphoric acid, and EDTA + 37% orthophosphoric acid
Issar R. et al[5]	2016	Teeth	40	37 % phosphoric acid, Er,Cr:YSGG
Srinivasan R. et al[3]	2014	Teeth	50	35% orthophosphoric acid, 24% EDTA, 10% citric acid
Ortigara GA. et al[6]	2020	Teeth	26	37% phosphoric acid solution, 17% EDTA
Prado M. et al[2]	2011	Teeth	52	37% phosphoric acid, 17% EDTA, 10% citric acid
Kaushal R. et al[9]	2020	Teeth	120	17% EDTA, 10% Citric acid, 7% Maleic acid
Ballal NV. et al[10]	2019	Teeth	50	SmearOFF, 7% maleic acid, 18% EDTA (pH 11.4), 17% EDTA (pH 8.5) and 0.9% saline
Ballal NV. et al[11]	2018	Teeth	40	7% MA, 7% MA + 0.2% CTR, 7% MA + 0.2% CTR + 2% CHX, distilled water (control)
Ballal NV. et al[12]	2016	Teeth	40	7% MA+2.5% sodium hypochlorite, 17% EDTA+ 2.5% NaOCl, QMix+2.5% NaOCl,0.9% saline
Kuruvilla A. et al[13]	2015	Teeth	30	17% EDTA, 18% etidronic acid, 7% maleic acid

Table 1. Characteristics of the studies included in the review.

Discussion

Removing the smear layer is essential. This layer contains bacteria and necrotic tissue. It forms a barrier between the filling material and sound dentin that inhibits the penetration of irrigants into dentinal tubules, increases microleakage with commonly used sealers, and decreases the bond strength of resin based materials[2,14].

The presence of smear layer has been postulated as an avenue for leakage and source for bacterial growth and ingress, particularly following root end preparation. The debris created during root-canal instrumentation should be removed from the dentine surface of the canal wall and the dentine tubules[3,15].

There are different canal irrigation solutions, such as orthophosphoric and maleic acids, with various smear layer removal ability.

1. Orthophosphoric acid

Phosphoric acid is a chemical widely used in the dental practice of conservative dentistry, and few studies using this substance as a dentin smear layer removal agent in endodontic treatment have shown promising results. In some

studies it was shown, that 37% phosphoric acid solution was more effective in removing the smear layer and AHTD than 17% EDTA[6,16,17,18,19]. This result is in agreement with another study in which was compared the effectiveness of 37% phosphoric acid gel, 37% phosphoric acid solution with 17% EDTA and 10% citric acid in removing smear layer. In 3 min 37% phosphoric acid solution was the most effective chemical agent[2,20,21].

Another study shows, that phosphoric acid is a strong acid that has a higher demineralizing effect when compared to EDTA and Citric acid, resulting in enhanced smear layer removal, increasing dentin microporosity, higher reduction of microhardness, and an elevated surface roughness of dentin[7,23,24].

However, in some studies it was shown, that orthophosphoric acid has also the side effects. It shows cytotoxic effects comparable to those observed by 5.25% NaOCl and 2% chlorhexidine[6]. The use of a high concentration of phosphoric acid may carry a higher risk of cytotoxicity, especially when used in the apical third of the root canal. Also it was shown, that the use of orthophosphoric acid can lead to dentin erosion. Dentin erosion is related to the exposure time. At 30 seconds, it was noted only in the cervical third. However, at 1 minute or longer, the erosion was present in the middle and cervical thirds, in the same degree, in both periods of time[2,22].

2. Maleic acid

Maleic acid is a mild organic acid used as an acid conditioner in adhesive dentistry. It has been found to possess the smear layer removing quality when used as an acid etchant in restorative dentistry. In some studies 7% maleic acid was used as a mild organic acid and found to acquire the smear layer removing high quality from root canal dentine and to be more effective than EDTA at the apical third of root canal[13].

In some studies it was also shown that 7% maleic acid was more effective in removing the smear layer, than 17% EDTA and 10% citric acid[9]. This result is in agreement with another study in which was compared the effectiveness of 7% maleic acid, 17% EDTA and Qmix in removing the smear layer. Maleic acid was the most effective chemical agent[12].

The capability of maleic acid to remove the smear layer and demineralize intertubular dentin is because of its pH of 1.05. Maleic acid is more acidic and thus has a greater demineralizing effect in a shorter time duration[13,26-32].

Conclusion

Smear layer removing is an essential element in endodontic treatment. There are several chemicals with a broad range of concentrations and different irrigation regimens to remove this layer. Orthophosphoric acid and maleic acid are used for this purpose during endodontic treatment.

Orthophosphoric and maleic acids are both perfectly removing the smear layer from the dentine surface. It is proven that phosphoric and maleic acids both are a lot more effective in removing the smear layer of the apical third comparing to 17% EDTA and other irrigating solutions. However, they also have some differences. Orthophosphoric acid is a strong acid. Therefore, it is showing more aggressive results and can lead to dentine erosion. Maleic acid is a mild acid. Therefore, it has fewer side effects such as erosiveness.

Summary: Orthophosphoric and maleic acids both are showing great effects in removing the smear layer. The difference between them is that phosphoric acid is more aggressive, therefore it can lead to dentin erosion in a shorter time.

Declaration of Interest

The authors report no conflict of interest.

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