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THE EFFECT OF SILICA GEL TO THE ADHESIVE PROTOCOL STAGES IN THE TREATMENT OF CARIES AND ITS COMPLICATIONS

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ABSTRACT — The etching solution is used to remove the inert surface layer of the hard tissues of the tooth, change the wetting parameters and create conditions for micromechanical adhesion. The most commonly used gel is 37% orthophosphoric acid.
However, silicic acid as a thickener in the composition of etching gels, when interacting with hydroxyapatite of the tooth, gives a precipitate in the form of silicon oxide — silica.
Scanning electron microscopy makes it possible to see the accumulation of round silica nanoparticles, approximately 20–40 nm in diameter.
According to studies, the formation of silica particles does not affect the quality of restoration, so there is no need to remove them from the surface of demineralized dentin.
THE PURPOSE of this review article is to study scientific data on the formation of an insoluble precipitate after the interaction of inorganic acid in the form of a gel with components of the inorganic enamel matrix (hydroxyapatite), and its effect on the adhesion quality of the filling material.
MATERIALS AND METHODS: Electronic search of articles was carried out using search engines and databases Google Scholar, Pub Med. The articles are included, the content of which concerns the topic of determining the sediment formed when etching the tooth surface with orthophosphoric gel. The publication date criterion has been selected since 2011.
RESULTS: 69 articles were reviewed during the review process. After analyzing the literature according to the inclusion criteria, the total number was 20 publications.
CONCLUSION: When etching dentin with a solution of orthophosphoric acid in the form of a gel, a precipitate of silicon oxide is formed. This is due to the presence of a thickener in the gel in the form of silicic acid.
Silicic acid, or silica gel, reacts chemically with hydroxyapatite of the tooth. As a result, silica is formed, which remains on the surface of demineralized dentin in the form of round nanoparticles with a size of 20–40 nm.
According to studies, the formation of silica particles does not affect the quality of restoration, so there is no need to remove them from the surface of demineralized dentin.

KEYWORDS — orthophosphoric acid, silica gel, precipitate, enamel etching, hydroxyapatite.

INTRODUCTION

Composite materials for dental restoration are the youngest and developing class of materials in dentistry [1, 2]. However, despite many positive qualities, one of the disadvantages of composites is polymerization shrinkage [3, 4].

According to numerous studies, the amount of polymerization shrinkage of composites reaches 3–5% volume units [5, 6]. Shrinkage of the composite leads to the formation of a compressive force directed deep into the composite material and may exceed the force of adhesion to the walls of the cavity of the tooth being restored. As a result, an edge gap is formed, which leads to a color change at the border of the restoration, the penetration of microorganisms and the development of secondary caries. Therefore, adhesive systems are used to improve the edge fit of the seal to the walls of the prepared tooth cavity [7].

Despite the variety of dental adhesive systems currently being produced, the following general and fundamental components of their composition can be distinguished: etching solution, primer and adhesive.

The etching solution is used to remove the inert surface layer of the hard tissues of the tooth, change the wetting parameters and create conditions for micromechanical adhesion. The most commonly used gel is 37% orthophosphoric acid [8,9].

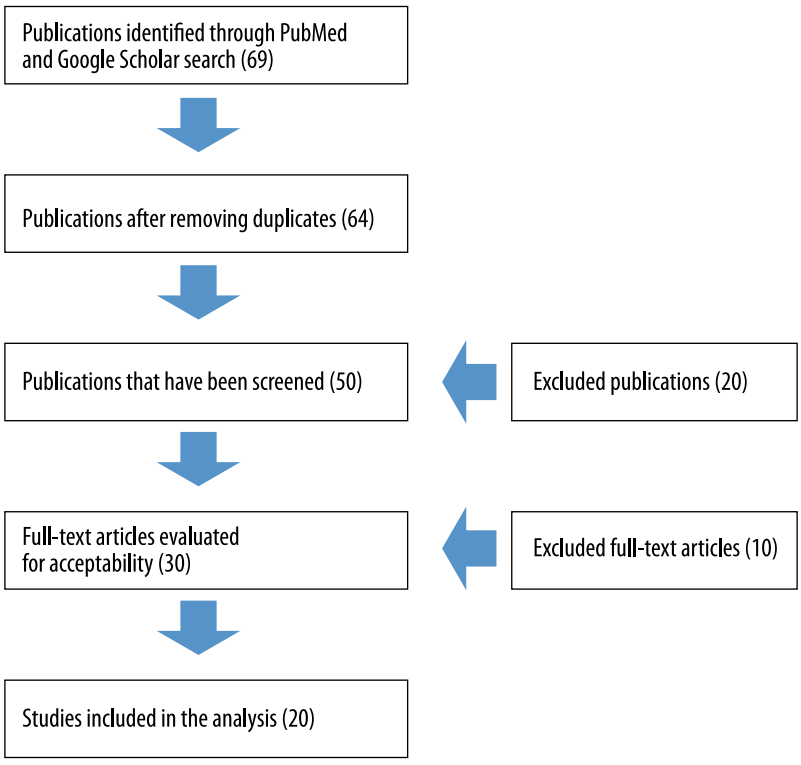
However, it is believed that the silica gel (silicic acid) contained in the gel, when interacting with hydroxyapatite of the tooth, gives a precipitate in the form of silicon oxide — silica [10].

The purpose of the study: to evaluate scientific data on the formation of insoluble precipitate after the interaction of inorganic acid in the form of a gel with the components of the inorganic enamel matrix (hydroxyapatite), and its effect on the adhesion quality of the filling material.

MATERIALS AND METHODS

Electronic search of articles was carried out using search engines and databases Google Scholar, PubMed. The articles are included, the content of which concerns the topic of determining the sediment formed when etching the tooth surface with orthophosphoric gel. The publication date criterion has been selected since 2011.

Table 1. *Article selection process*



Search terms included *orthophosphoric acid*, *silica gel*, *precipitate*, *enamel etching*, *hydroxyapatite*.

The studies were filtered and selected in several stages. Firstly, they were evaluated by name. Secondly, individual documents at the first stage were additionally evaluated by reading abstracts and full-text articles. The difference in choice was resolved by discussion. The selection of publications was also carried out according to the following inclusion criteria — the date of publication of the article no earlier than 2011, the subject of determining the sediment formed when etching the tooth surface with orthophosphoric gel.

The first exclusion criterion was the selection of publications dated earlier than 2011. Further, the review did not include works whose title and summary did not meet at least one of the submitted inclusion criteria. At the last stage, the content of the full-text versions of the selected articles was studied.

During the study of all the selected information, the possibility of a systematic error was considered. The Cochrane Collaboration system was used to determine the risk of the possibility of a systematic error during the study of the selected information [11]

The levels of systematic error were systematized as follows: low risk if all 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 too few details to decide on a certain risk assessment.

Summing up the risk of bias for each study, most studies were classified as unclear risk. A number of studies have been found to have a low risk of bias. There were several limitations in the current review, including studies written only in English, which could lead to publication bias. In each study, there were different degrees of heterogeneity in the materials and methods of the study.

RESULTS

69 articles were reviewed, 49 of which were based on PubMed, 20 on Google Scholar. Having made the selection according to the exclusion criteria, the total number of works was 20. In the selected articles, current data on the inorganic sediment that is formed when etching the tooth surface with orthophosphoric gel were analyzed.

DISCUSSION

Orthophosphoric acid is used in dentistry for etching enamel and dentin [12].

The interaction of etching agents with dentin is limited by the buffering effect of hydroxyapatite and other dentin components. Acidic agents remove the smear layer and the upper and lower part of the dentin, open the dentine tubules, demineralize the dentin surface and increase the microporosity of the intertubular dentin. The penetration of acids occurs mainly through the tubules [13].

It is believed that the adhesion to dentin mainly depends on the micromechanical adhesion of hydrophilic resins in this demineralized microporous dentin, thus forming a mesh intertwined hybrid tissue consisting of collagen, residual mineral particles and resin [14].

Despite the fact that for many years they have been sold in the form of liquids, most modern etchants are currently gels of either thick or thin consistency. To make a gel from liquid phosphoric acid, it is necessary to use silicic acid as a thickener. Manufacturers add thickeners to their gels to facilitate processing. The advantages of gel forms are that a clinician can easily

control the spread of acid over the surface and visually determine the presence of acid [15].

The demineralizing effect is clinically observed when gas bubbles accumulate inside the gel. Pickling gels thickened with silica microparticles leave a precipitate in the form of particles on the dentin surface, which cannot be completely removed even with intensive rinsing [16].

As a result of acid etching of dentin, a layer of denatured collagen and particles of the residual smear layer may form on the dentin surface, which prevent the complete exposure of the collagen network. It has not been established whether the silica component of some etchants partially prevents the formation of this residual surface layer [17].

Studies using scanning electron microscopy demonstrate the demineralization of dentin. At a higher magnification, three zones are visible: the upper porous zone with a residual lubricated layer, denatured collagen and silica particles; the intermediate zone with randomly oriented collagen fibers; the lower zone with a submicron break, a small amount of collagen fibers and inclusions of hydroxyapatite [18].

A large magnification (100,000) showed the accumulation of round silica nanoparticles, approximately 20-40 nm in diameter, with needle-like apatite crystals on top of exposed collagen fibrils [19].

Silicic acid as a thickener in the composition of etching gels, although it gives a precipitate in the form of silica on the surface of dentin, but, according to research, does not affect the quality of restoration [13].

In addition, the use of gels is more practical in clinical settings, when the etching area can be precisely controlled using phosphoric acid gels, rather than liquids [12].

CONCLUSION

When etching dentin with a solution of orthophosphoric acid in the form of a gel, a precipitate of silicon oxide is formed [7]. This is due to the presence of a thickener in the gel in the form of silicic acid [16]. Silicic acid, or silica gel, reacts chemically with hydroxyapatite of the tooth. As a result, silica is formed, which remains on the surface of demineralized dentin in the form of round nanoparticles with a size of 20–40 nm [20]. According to studies, the formation of silica particles does not affect the quality of restoration, so there is no need to remove them from the surface of demineralized dentin [19].

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