Influence of Prepared Cavity Surface on Microleakage - Pilot Study

Alena Knežević[1]
Marija Ujević[2]
Goran Šalković[2]
Višnja Negovetić-Mandić[1]
Vlatko Pandurić[1]
Jozo Šutalo[1]

[1]Department of Dental Pathology
School of Dental Medicine
University of Zagreb
[2]Fourth Year Students
School of Dental Medicine
University of Zagreb

Summary

Enamel and dentin are, by their very chemical structure, two different substrates which necessitate different preparation before placing of composite resin. The aim of this study was to show how various enamel and dental pretreatment methods ("total etch" technique and self etching adhesives) affect the quality of bonding with composite resin.

The results obtained showed optimal etching time, using 37% orthophospohoric acid, of 20 seconds for enamel and 10 seconds for dentin.

Key words: *etching, self etching adhesives, microleakage.*

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Address of correspondence:

Alena Knežević
Zavod za dentalnu patologiju
Stomatološki fakultet
Gundulićeva 5, 10000 Zagreb
Croatia

Introduction

Durable and quality composite restoration not only implies the right choice of composite material and dental adhesives, but primarily adequate preparation of the cavity for composite restoration. Since enamel and dentin have different chemical structures they require different preparation.

Enamel surface preparation. Etching of enamel is a process that enables formation of a bond between enamel and restorative material. Margins of the enamel are etched with 37% orthophophosphoric acid which causes demineralization of hydroxylapatite crystals and formation of microspaces. This procedure causes removal of the old and chemically saturated enamel surface, thus removing glycoprotein membrane and smear layer that forms as a result of heat and plastic deformation of hard dental tissue while drilling. As a result, the reactive surface or enamel surface porosity increases, which leads to significant increase in the area for penetration and micromechanical wedging of low- viscosity composite resin (1, 2).

Dental surface preparation. Because of differences in the enamel and dentinal structure (enamel contains 83-86% anorganic mattter, 2-5% organic and 12% water, while in dentin anorganic part equals 65-70% weight, organic !8% and water 16%), dentinal preparation will differ from enamel preparation for composite resin filling application. Dental conditioning removes the smear layer and causes demineralization of dentin to a certain depth. Dental conditioners affect smear layer differently. Kelation systems like EDTA-e, polymaleic and polyacrylic acid

remove only the surface smear layer without simultanously opening dental tubules and demineralising the dental surface (3-6).

Treatment of the dental surface with phosphoric acid (10-37%) causes complete melting of the smear layer as well as surface demineralization of peri- and inter tubules dentine to the 10 μm and melting of the inorganic component. Collapse of collagen fibers significantly decreases porosity of the dental surface as well as penetration of the adhesive resin. Great differences in depth of resin infiltration are found when etching with 10%, 35%, 65% phosphoric acid because it is a weak acid that does not completely disassociate at any concentration. It is proven that 65% phosphoric acid etches shallower at any time frame than 10% acid. Phosphoric acid contains a large concentration of dehydrogen sulfate which by chemical reactions forms relatively meltable products that still might have a passing influence on monomer and resin infiltration by precipitating as Ca salts (7,8). The amount of adhesive on the surface and subsurface layer are substantially different which results in the breakage of bonds and low quality of filling and as a consequence marginal leakage (9)

After etching and rinsing of acid, primers are used, integral parts of adhesive systems of 3rd, 4th, 5th and 6th generation. Applied to the wet dentine surface they penetrate through the demineralized areas where they give support to the collapsed collagen fibers, lift them up, widen intercollagen spaces and allow for better adhesive penetration and formation of strong interface between the dentinal tissue and monomer at the molecular level. Newly formed compound is called hybrid layer. In the broader sense, the hybrid layer represents resin infiltrated dentin. It forms by micromechanical netting of demineralized collagen net with low-viscosity resin. For formation of the hybrid layer two factors are necessary to enable penetration and diffusion between collagen fibers i.e. appropriately prepared substrate achieved by removing the smear layer and demineralization of dentin as well as an appropriate resin monomer. The hybrid layer can act as an "elastic repellent" because it absorbs polymerization stress which prevents formation of a marginal gap (10-12).

Purpose of the study

In order to show whether there is correlation between the length of enamel and dentin etching time and marginal leakage in cavities containing composite filling, a pilot study was carried out, in which microleakage of composite fillings placed on variously treated enamel or dentin surfaces was microscopically examined.

Materials and methods

On 15 extracted teeth, 7 molars and 8 premolars, two cavities were prepared, one on the oral and the other on the vestibular side. Cavities were prepared using diamond fissure burr 2mm deep and 4 mm wide with beveling of enamel margins. The teeth were separated into five groups and each demanded different pretreatment of enamel and dentin before application of adhesive and composite resin.

For groups I, II and III total-etch technique was used in such a way that;

Group I. - etching time was 15 sec for enamel and 5 sec for dentin

Group II. - etching time was 20 sec for enamel and 10 sec for dentin

Group III. - ething time was 30 sec for enamel and 15 sec for dentin.

37% orthophosphoric acid (Vivadent, Schaan, Liechtenstein) was used for etching. After rinsing of acid and drying of cavity, Te-Econom (Vivadent, Schaan, Liechtenstein) dental adhesive was placed on enamel and dentin in one layer, gently air-blown and polymerized for 20 seconds by Elipar Trilight (ESPE, Seefeld, Germany) halogen lamp. Cavity was filled with Tetric Ceram (Vivadent, Schaan, Liechtenstein) composite material (color A3).

For group IV and group V self-etch technique was used:

Group IV. - enamel was etched for 15 seconds, after rinsing and drying self-etching adhesive Prompt-L-Pop (ESPE, Seefeld, Germany) was placed.

Group V. - on non-etched enamel and dentin self-etching adhesive Prompt-L-Pop was placed.

Self-etching adhesive was polymerized for 20 seconds and the cavity filled with composite material Tetric ceram (color A3).

After the placement of composite filling, the tooth crown was cut from the root and the coronary section coated with protective enamel. Prepared samples were immersed for 48 hours in black ink. After passing of the stated time, the samples were dried and each cavity was cut down the middle in the vestibulo-oral direction in order to form two equal halves. Samples obtained in this way were examined using an Olympus Stereomicroscope (Olympus Optical Co. Europa, GMBH, Hamburg, Germany).

The research system applied in this investigation was composed of five basic parts:

1. Research stereomicroscope Olympus SZX-12 with cold light source
2. Olympus DP-12 digital camera
3. PC Pentium IV
4. Olympus DP-Soft 3.2 programme for digital image analysis.

Each sample was photographed and the photograph examined for the depth of ink penetration in degrees:

Degree 0 - no leakage

Degree 1 - leakage up to 1/3 enamel depth

Degree 2 - leakage up to 2/3 enamel depth

Degree 3 - leakage up to enamel-dentin junction

Degree 4 - leakage in dentine.

For each sample three images were made: one of the entire cavity (magnification 32X), one of the mesial section (magnification 40X) and one of the distal section (magnification 40X).

Results

Analysis of the images gained showed that if marginal leakage existed, it encompassed mostly part of the enamel in the beveled area of enamel margins (Figure 1).

Greatest leakage was observed in the samples where self-etching dental adhesive Prompt-L-Pop was used (groups IV and V) (Figure 2, 3), and in the samples where enamel was etched for 15 seconds and dentin for 5 seconds (Figure 4).

In Group II, where enamel was etched for 20, and dentin for 10 seconds, and in Group III (Figure 5), where enamel was etched for 30 and dentin for 15 seconds, no microleakage was observed.

Figure 6 presents a graphical illustration of microleakage based on sample groups and degree of leakage.

Discussion

Adhesion of composite material to enamel and dentin is reached differently because of differences in composition and chemical structure of these two tissues. Enamel is built rather homogeneously, from hydroxylapatite crystals, with a small amount of organic matter and water, while dentin structure is very heterogeneous, consisting of more organic matter and water. These differences demand longer etching of enamel than dentin (13).

Ernst et al. investigated microleakage on 160 extracted teeth, divided into 8 groups in which they used various combinations of dental adhesives and composite materials to produce fillings. After preparation, teeth were immersed in methylene blue for 10 seconds. Depth of penetration was measured on a stereomicroscope. Deepest average marginal penetration of methylene blue as well as the largest number of color penetrated marginal parts of the filling were found precisely in the group where self-etching addhesive Prompt-L-Pop was used (14, 15).

Despite usage of different means for marking mikroleakage and shorter color exposure time, the described study is in accordance with our own findings, because greatest mikroleakage was observed in those samples where identical self-etching adhesive was used as well as in the group where enamel was etched for 15 and dentin for 5 seconds.

Nakabayashi et al. also investigated microleakage of composite fillings. They immersed samples of prepared teeth in silver nitrate for 24 hours and found existence of mikroleakage by light microscope. Observing the same samples on an electron microscope they found silver in the hybrid layer in the absence of microgap between the composite fill-

ing and hybrid layer. They named this process nanoleakage in order to distinquish it from microleakage. (16).

Furthermore, the age of the tooth, composite application technique, source of polymerization light and polymerization shrinkage as a negative consequence of polymerization all have an influence on the final results. It can be concluded that optimal etching time for enamel is 20 seconds and for dentin 10 seconds, while it is recommended that the enamel of permanent young teeth as well as sclerotic dentin should be etched for 30 seconds and dentin for 15 seconds which is in accordance with the current research of some authors (16, 17).

Every marginal leakage that leads to diffusion of oral fluid, bacteria and their products into the dentin area can lead to pulp damage and secondary caries. Numerous research has showed that marginal relationship between cavity surface and filling material is not fixed, inert and impermeable margin, but rather consists of microgaps in which intensive transfer of ions and molecules occurs (10).

Conslusion

Analysis of images obtained determined the existence of marginal leakage mostly in the area of enamel margins in the samples where enamel was etched for 15 and dentin for 5 seconds as well as in the samples where self-etching adhesive was used, while in the samples where enamel was etched for 20 or 30 seconds and dentin 10 or 15 seconds no microleakage was observed.

On the basis of the results obtained it can be concluded that etching time influences the quality of the bond between composite material and hard dental tissue and further deduced optimal etching time for enamel to be 20 seconds and for dentin 10 seconds.