

MICROLEAKAGE EVALUATION OF NANO CERAMICS AND NANO COMPOSITE RESINS USING SELF ETCH ADHESIVE IN CLASS V CAVITIES USING SINGLE INCREMENT TECHNIQUE

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Received :

17th April, 2013

Accepted:

27th July, 2013

Available online:

25th August, 2013

ABSTRACT

Micro leakage plays an important role in the success of composite restoration, this have led to researcher to find newer composite restorative material with present study it was observed that Self-etch adhesive systems and single increment technique are advantageous in that it reduces the application time and technique related sensitivity.

Keywords: Ceramics, Composite resins, Permanent dental restoration.

INTRODUCTION

One of the important aspects for the long term success of composite resin restoration is Microleakage. Microleakage may be defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material.¹ The clinical conditions as a result of Microleakage include – postoperative sensitivity, secondary caries, staining, break down of the restorative material and ultimately pulpal damage. Therefore, prevention of Microleakage is one of the important criteria when developing an adhesive system. The major disadvantage of composites is polymerization shrinkage, resulting in gap formation between composite material and tooth structure. This shrinkage can produce stress up to 10 MPa at the adhesive interface, leading to marginal breakdown and gap formation.²

The conventional acid - etch technique pioneered by Buonocore³ for composite resin restoration has been used in dentistry for almost 50 years, with passing years advances in adhesive dentistry have led to the development of other adhesives to not only facilitate greater bond strength and sealing but also to provide convenience and ease of application. Recently, “7th generation” adhesive system have been introduced which has greatly simplified the clinical procedure by

incorporating the etchant, primer and bonding agent into a single formulation for a one step application. This newer dentin bonding agents tend to overcome the problem of lower bond strength to dentin as compared to enamel.

The introduction of nano-ceramics and nano-composite have shown new dimension in esthetic dentistry. In this study Ceram X (Dentsply) and Filtek Z350 (3M ESPE) composites were used. Filtek Z350 (3M ESPE) is a universal composite, utilizing unique nanofiller technology, that combines the strength of a hybrid with the beauty of a microfill. The filler contains a combination of a non-agglomerated/non-aggregated, 20 nm nanosilica filler, and loosely bound agglomerated zirconia/silica nanocluster, consisting of agglomerates of primary zirconia/silica particles with size of 5-20 nm fillers. The cluster particle size range is 0.6 to 1.4 microns. The filler loading is 78.5% by weight.⁴ Ceram X merges hybrid composite filler technology with advanced nanotechnology which results in nanoceramic technology. It contains organically modified nanoparticles (2.3nm) and nanofillers (10nm) along with the conventional glass fillers (~1µm). Nanoparticles are inorganic-organic hybrid particles where the organic siloxane part provides strength and the organic methacrylate part makes the

particles polymerisable with the resin matrix. The filler loading is 76 % by weight.⁵

The combination of etchant and primer into one system of Self-etch adhesive systems is advantageous in that it reduces the application time and technique-related sensitivity and has become increasingly popular in the last decade.⁶ However, there is an ongoing debate regarding the efficacy of bonding to enamel with self-etch adhesive systems.⁷ Therefore this study was undertaken to evaluate microleakage at the enamel and dentin margins of class V cavities using the newer 7th generation bonding agent- G bond with nano composite - Filtext Z350 and nanoceramic-Ceram X .

MATERIALS AND METHODS

Twenty four (24) human freshly extracted molar were randomly selected for this study. The teeth were stored in 0.1 % thymol solution diluted in 0.4% saline. Class V cavities were prepared at the cemento-enamel junction on the buccal surfaces of each tooth. The dimensions of each preparation were 3mm mesiodistal, 2mm occlusal gingival measurement and axial depth of 1.5mm.

The cavities were prepared using diamond burs in high speed water-cooled hand piece. A 45^o bevel with 0.5 mm width was made on the enamel part of each cavity, using a flame bur, where as no bevel was given in the dentinal/cementum part of the cavity. One coat of 7th generation bonding agent G – bond (GC Japan) was applied to all the samples and left undisturbed for 10 sec, followed by air drying for 5 sec. Subsequently, light curing of the surface was done for 10 sec. The samples were randomly divided into 2 groups of 12 samples each. All the samples were restored with composite resin using single increment technique as per the grouping.

Group I: Restored with Filtext Z 350 (3M ESPE, USA) nano composite material.

Group II: Restored with Ceram X duo (DENTSPLY, Asia) nano ceramic composite material.

All the samples were restored using single increment technique and light cured for 40 sec (Translux Power Blue LED polymerization lamp, Heraeus, USA). The restorations were then finished with Sof-Lex (3M ESPE, USA) discs as per the manufacturer's instruction.

The teeth were then stored at 37^o C water, except when they were removed from storage and subjected to thermo cycling for 1000 cycles in water between 5^o C and 55^o C for 30 sec in each bath and 15 sec transfer between bath. After thermo cycling, the samples were dried superficially and two coats of nail varnish applied to the entire sample surface, leaving a 1mm window around the restored cavity margins. All teeth were immersed in 2% methylene blue solution for 24 hours at room temperature. The teeth were rinsed, cleaned, gently dried, mounted in acrylic epoxy resin, and sectioned in the bucco – lingual direction across the center of the restoration using a slow speed saw (Isomet 1000, Buchler, USA). The sectioned teeth were examined by two calibrated inspectors for dye penetration levels along the occlusal and cervical margins under stereomicroscope (Almicor zoom stereoscopic binocular microscope, India) at 20 X magnification. Microleakage at the enamel and dentin margins was evaluated and scored using the following criteria:-

- 0 No leakage.
- 1 Dye penetration extended for less than or up to 1/3 of preparation depth.
- 2 Dye penetration greater than 1/3 of preparation depth, but not extending to the entire axial wall.
- 3 Dye penetration extending to the axial wall.
- 4 Dye penetration past the axial wall.

The results were analyzed using Mann – Whitney U test. The p value less than 0.05 were considered as significant.

RESULT

Mann – Whitney U test showed that there was no significant difference in dye leakage between Group I and Group II as shown in table I.

However, at experimental level, when observing the enamel and dentinal margin, Group II showed greater degree of leakage than Group I.

TABLE I: MANN – WHITNEY U TEST SHOWING DYE LEAKAGE BETWEEN THE GROUPS.

Group	N	Mean rank at enamel margin	Mean rank at dentinal margin
Group I	24	10.71	10.96
Group II	24	14.29	14.04
Mann – Whitney U test		50.5	53.5
P -Value		0.179	0.233

DISCUSSION

The bond between the restorative materials to the tooth substance is one of the factors that determine the longevity and clinical performance of dental restorations. Marginal leakage, can lead to post-treatment sensitivity, marginal staining, recurrent caries, pulpitis leading to necrosis. Advances in adhesive dentistry have led to the development of other adhesives that provide greater bond strength and sealing thereby reducing microleakage, this advancement has also made it less technique sensitive and user friendly with their convenience and ease of application. The sealing ability of adhesive resins is affected by cavity configuration (C-factor), dimensional changes as a result of polymerization shrinkage or thermal/ hygroscopic expansion and the bonding capacity of the adhesive resins.⁸ Polymerization shrinkage is influenced by type of resin, filler content of the composite, elastic modulus of the material, curing characteristics, water sorption, cavity configuration, and the intensity of the light used to polymerize the composite.⁹ The consequence of polymerization shrinkage is formation of a gap between resin-based composite and the cavity wall. This gap may vary from 1.67 to 5.68 percent of the total volume of the restoration.¹⁰ As the bond strength of resin to etched enamel ranges from 16 to 20 MPa^{11, 12}, Polymerization shrinkage is insufficient to overcome this bond. However, during etching when enamel is unavailable or little enamel remains at the margin, polymerization shrinkage can cause marginal gaps to develop because bonding to dentin produces a weaker bond than does bonding to etched enamel. However, advances during the last few years in dentin bonding have overcome many of these problems. Bonding to dentin can be achieved with a bonding system which provides an effective mechanical as well as chemical interaction of the dentin smeared surface. Today, the progress in adhesive dentistry has led to the better marginal integrity and consequently improving the clinical performance of dental restorations. However, in spite of all this progress microleakage still remains to be a clinical problem. Moreover, restorations having margins located below the cement-enamel junction where achieving properly sealed restorative margins even with esthetic restorative materials using newly developed adhesive systems is still a problem.¹³⁻¹⁹ The bond strength of an adhesive does not always predict the sealing ability of the material. Adhesives

with high bond strength may still exhibit undesirable levels of microleakage. Therefore, the evaluation of microleakage in addition to bond strength evaluation for each adhesive is very important for determining the success of the restoration. In this study Class V cavities were prepared as, half of the restoration covers enamel and the other half covers dentin, therefore keeping the entire parameter equal, the evaluation of microleakage between enamel and dentinal margins can be compared. Attempt were made to produce an identical cavity size to avoid the effect of cavity configuration and the quantity of composite material used during restoration as single increment technique was involved. The single increment technique is recommended by some authors as it reduces stress at the cavosurface margins.^{20,21} Studies²² showed that the depth of cure does not exceed more than 2 mm when curing resin-based composites with modern light-curing units. In our study the depth was kept at 1.5mm and the cavity was relatively small, more over as discussed, the advancement of bonding agent has made it less technique sensitive and user friendly with their convenience and ease of application, therefore in our study single increment technique was used so as to simplify the procedure and to save chair time during restoration still further. Thermocycling was performed in this in vitro study so as to simulate the in vivo conditions.

In this study the newer 7th generation bonding agent-G Bond was used. G-Bond presents with a submicron hybrid layer that still contains hydroxyapatite crystals available for additional chemical interaction with the functional monomers included in the adhesive at the interface with dentin. Being 'mild' self-etch adhesives it bond to tooth tissue by a mechanism that closely resembles the twofold micro mechanical/chemical bonding mechanism used by the self-adhering glass-ionomers. This is possible because of its extremely thin nano-interaction zone (NIZ) of G-Bond, which forms as a result of the mild acid and two functional monomers – for double the adhesion to enamel and dentine. In addition, G-Bond has a pH of about 2 which is sufficiently acidic to deal with the smear layer, and thus to provide both micro-mechanical retention sites as well as chemical bonding receptors at both enamel and dentin. The consequence of the HEMA-free formulation of G-Bond is that upon evaporation of the acetone solvent (once supplied within the cavity), the adhesive monomers separate

from the water content. These water droplets that are formed within the adhesive layer can only be removed from the surface by strongly air-drying the adhesive with maximum-power air-pressure. Therefore, G-Bond has a unique build-in system to separate water from the other adhesive ingredients, once it has played its role in the self-etching process. By strongly air-drying the adhesive, the water droplets are removed; leaving an adhesive layer that is substantially more hydrophobic and can result in better polymerization.^{23,24}

In this study microleakage was observed in both enamel and dentinal margins in both the groups, although there is no statically difference in the amount of dye penetration as shown in table 1. The microleakage in the enamel margin can be because of it is difficulty to ensure perfect marginal adaptation at enamel cavosurface margins. More over enamel being a highly mineralized tissue and having modulus of elasticity higher than that of dentin, results in a lower flexibility due to which the ability to relief of shrinkage stress is decreased. When bonding composites to enamel poor marginal adaptation and seal can occur due to incorrect application of bonding adhesive, and the bonding interface remains intact but microcracks develop just outside the cavosurface margins due to the stress of polymerization shrinkage.²⁵⁻³³ Polymerization shrinkage is particularly common in high-C-factor restorations³⁴ and may be increased by use of high-modulus composites as they may transmit more polymerization shrinkage forces to the tooth. The higher polymerization shrinkage of ceram X (2.3%) (group II) and the use of single increment technique may be one of the factors why dye penetration is marginally more in enamel than in dentin as shown in table I. When materials that are bonded to enamel shrink quickly, the result is white line formation. These white lines are cohesive cracks in the enamel that traverse the entire thickness of the enamel right into the dentin. According to studies³⁵ this makes white lines an avenue for bacteria, and their presence means that the composite no longer has structural integrity within that enamel wall, making it basically an amalgam.

The microleakage in the dentinal margins can be attributed to the following- less mineralized tooth structure and more water of the dentin than enamel, the presence of the smear layer that makes wetting of

the dentin by the adhesive more difficult and the presence of fluid in the dentin tubules reducing the stability of the composite resin to dentin.

In this study the dye penetration between Filtex Z350 (group I) and CaremX (group II) was statically insignificant, however at the experimentally level the dye penetration was less with Filtex Z350 (group I) and more in CaremX (group II) as shown in table I. This may be due to the fact that the polymerization shrinkage of ceramX was (2.3% v/v) more than Filtex Z350 (2.09%). More over majority of TEGDMA was replaced with a blend of UDMA (urethanedimethacrylate) and Bis-EMA (Bisphenol Apolyetheylene glycol diether dimethacrylate). TEGDMA is used in minor amounts to adjust the viscosity. UDMA and Bis-EMA resins are of higher molecular weight and therefore have fewer double bonds per unit of weight. Thus, the higher molecular weight of the resin results in less shrinkage, reduced aging and a slightly softer resin matrix.

The lower polymerization shrinkage (2.09%) and hence better ability of Filtex Z350 (group I) to withstand the stress at the tooth –restoration interface and softer resin matrix may be one of the reason why dye leakage is less than when compared with CaremX (group II) and why the dye leakage is marginally better in enamel than dentin in Filtex Z350 (group I).

CONCLUSION

- Self-etch adhesive systems are advantageous in that it reduces the application time and technique-related sensitivity.
- Single increment technique is advantageous in that it reduces the application time.
- Micro leakage was observed in both enamel and dentinal margins in both the groups, although there is no statically difference in the amount of dye penetration.

Dye penetration between Filtex Z350 (group I) and CaremX (group II) was statistically insignificant, however at the experimentally level the dye penetration was less with Filtex Z350 (group I) and more in CaremX (group II) in both the enamel and dentinal margins.

With advancement of dentin bonding agents there is no significant difference in the micro leakage

between the enamel and dentinal margins with the restoration. As shown in this study, microleakage in the enamel and dentinal margins are inevitable. Therefore, more studies and advances in the material and technique are required to prevent microleakage.

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Source of Support: Nil, Conflict of Interest: None Declared