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ADAPTATION OF RESIN COMPOSITE TO ENAMEL SURFACE PREPARED BY DIFFERENT CUTTING TOOLS - SEM STUDY ORIGINAL RESEARCH ARTICLE

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ABSTRACT

Aim: To investigate the effect of four different cutting tools on the adaptation of resin composite to enamel.

Materials and methods: Twenty extracted sound human premolar teeth were used. Occlusal surfaces were ground flat and four random groups were formed according to the received surface treatment as follow, 600-grit silicon-carbide paper (control), carbide-bur, diamond-stone and air abrasion. Two successive layers of self-etch bonding agent were applied followed by composite build-up. Teeth were sectioned longitudinally, the interface between composite and enamel was examined by SEM and micrographs were obtained.

Results: the best adaptation and least surface roughness were seen in the control group while the roughest surface was observed in the air abrasion group with presence of scanty microgaps.

KEY WORDS: adaptation, composite, cutting tools, enamel.

INTRODUCTION

Many restorative materials and cutting instruments are available for use in operative dentistry; attempts have been exerted to improve the adaptation of resin composite to enamel, but even with the improvements of the restorative materials and cutting techniques, marginal integrity is still one of the frequent problems associated with composite restorations (Beznos,2001)[1]. The marginal gap refers to poor marginal adaptation which may result in occurrence of secondary caries, staining and postoperative sensitivity, finally leading to clinical failure of the restoration (Priyalakshmi and Ranjan., 2014)[2] so proper sealing of a cavity is one of the most important requirements for the durability and success of a composite restoration and avoidance of marginal leakage. Marginal leakage and postoperative sensitivity result if the composite polymerization shrinkage stresses exceed the bond strength which might lead to adhesive failure (Kaurani and Bhagwat, 2007)[3]

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(Jörgensen et al., 1975)[4] and gap formation between the composite and cavity walls (Sakaguchi, 2005)[5]. Prismatic structure of the enamel can be easily separated and pulled apart when stressed. When the stress of polymerization contraction exceeds the strength of a tooth, cracks and micro-gaps often initiate in the enamel (Nishimura et al., 2005).[6]

The available tools for cavity preparation and tooth cutting are numerous, so that the clinician is confused in choosing the appropriate tool in order to approach the best adaptation between the resin composite restorative material and the cavity margins in order to reduce postoperative problems.

Among the recent ultra-conservative techniques of cavity preparation is the air abrasion, which is used by some conservative dentists, while other dentists prefer the conventional carbide burs and diamond stones. Air abrasion technique depends on, high-speed stream of aluminium oxide particles delivered by air pressure. Its advantage over the rotary instruments is elimination of pressure, heat, noise and vibration associated with the rotary instruments, along with reduction of need of local anesthesia. Cavity preparation by air abrasion also introduces a surface roughening, which seems to be suitable for direct bonding techniques. This could possibly improve the sealing ability of adhesive restorative materials (Reis etal.,2004).[7]

OBJECTIVES

This *in vitro* study was carried out to investigate the effect of different cutting tools used in cavity preparation on the surface adaptation of resin composite to enamel by using scanning electron microscope (SEM).

METHODOLOGY

Experiment design:

A total number of 20 sound human premolar teeth extracted for orthodontic reasons were used in the study. For each tooth; the occlusal surface was flattened using a model trimer(Quock et al., 2012)[8] exposing the mid dentin surface with outer enamel rim. Teeth were cut longitudinally into halves before composite build up using a diamond disc to avoid any disturbance for the area of interface between tooth surface and composite and for standardized surface roughness before the final surface treatment of enamel, so that all teeth were treated by using 600 grit silicon carbide paper for 15 seconds under continuous copious water washing. Then, the teeth were divided into 4 groups (n=5) according to the type of cutting tool used on enamel surface; as shown in table 1.

TABLE (1)

Group	Enamel surface treatment	Details
1	600 grit silicon carbide paper	(control)
2	Carbide bur	Straight fissure carbide bur (HM21 008 Hager and Meisinger GmbH, ISO #500 314 107 006 008).
3	Diamond stone	Cylindrical diamond stone coarse grit (blue code) (Edenta ISO #806 314 107 524 012).
4	Air abrasion	air abrasion system (RONDOflex plus).

The carbide bur and diamond stone were passed 20 times on the tooth surface, as uniformly as possible, using light pressure as described by (Peerzada etal., 2010)[9]and by one operator only. While for air-abrasion a 27 μm particle size was used with narrow tip, applied with 90 degrees angle from 5 mm distance for 10 seconds.

Composite build up:

One-step all-in-one bonding system; Tetric N-Bond Self-Etch (Ivoclar Vivadent Liechtenstein), was applied according to the manufacture instructions; in two successive layers and composite build up with Tetric N-Ceram(Ivoclar Vivaden Liechtenstein) (a micro-hybrid resin composite) was done in two sequent layers of 2 mm thickness and each layer was light cured for 40 seconds.

Samples preparation:

The interface between enamel surface and composite restoration was examined by scanning electron microscope, Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 30 K.V., magnification 14x up to 1000000 and resolution for Gun.1n) (FEI company, Netherlands). Micrographs were obtained and used to reveal the adaptation of the composite restorations to enamel surface at a magnification of 1000X.

RESULTS

Scanning electron microscope micrographs of the enamel surface of all groups showed an accepted degree of adaptation, that was expected to be clinically successful.

The control group of silicon carbide paper produced a fine enamel surface and no gaps with best composite adaptation. Enamel prepared with, rotary instruments carbide bur and diamond stone groups, gave a similar adaptation to that of the control group with no gap formation.

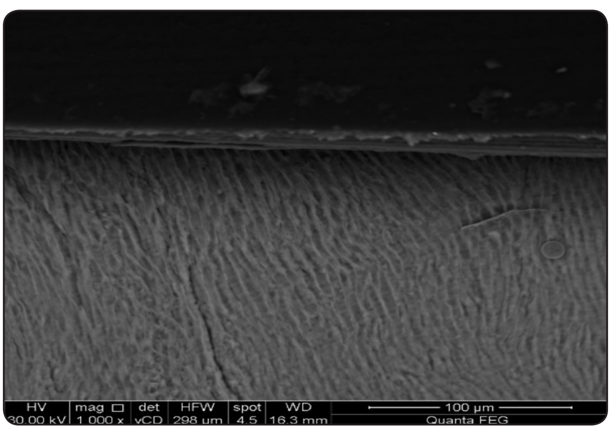

Fig. (1) SEM micrograph of enamel surface treated with 600 grit silicon carbide paper (control)

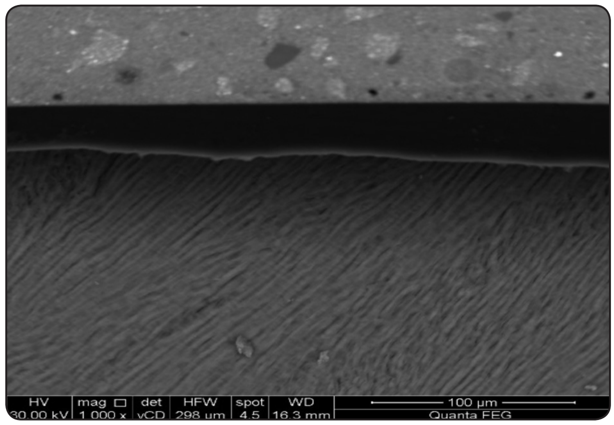

Fig. (2) SEM micrograph of enamel surface treated with carbide bur.

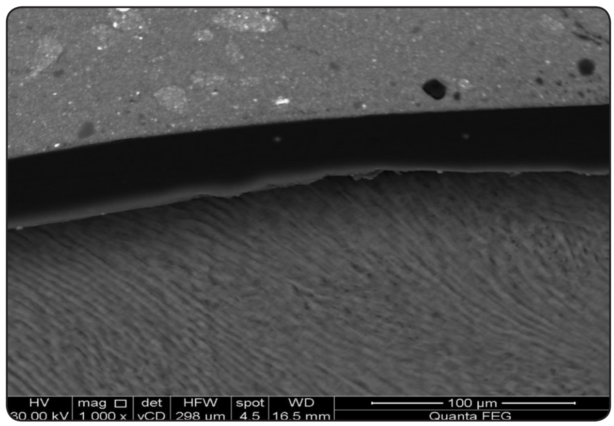

Fig. (3) SEM micrograph of enamel surface treated with diamond stone.

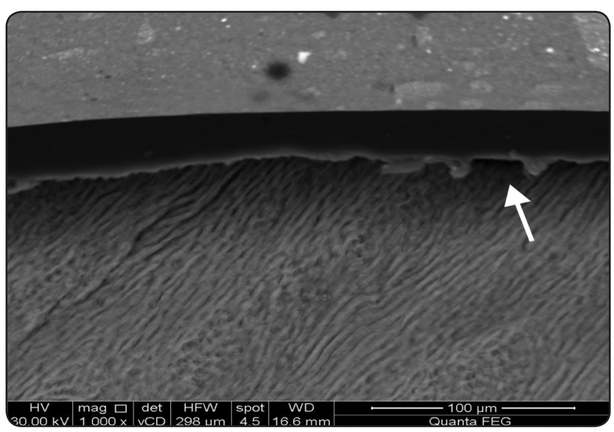

Fig. (4) SEM micrograph of enamel surface treated with air abrasion. Note the micro-gap created (Arrow).

On the other hand, the air abrasion group showed the roughest surface with few microgaps that appeared in SEM micrograph. Also, the resin tags were noticed to be longer than the other groups.

DISCUSSION

One of the most important aims of cavity restoration is to establish a predictable marginal seal in order to prevent leakage and its clinical consequences such as marginal discrepancies, marginal staining, recurrent caries, sensitivity and pain (Delgado et al., 2015)[10]. In the current study the resin composite adaptation to the enamel surface prepared with different cutting tools, showed good adaptation and marginal seal using the self-etch adhesive, except the samples treated with air abrasion, as enamel surface showed irregularities and small gap formation, but still the gap was not big enough (less than50 μm) to affect the marginal seal (Gorjensen and Wakumoto, 1968)[11] (Nassar and Cabezas, 2011) [12]. The use of air abrasion resulted in appearance of irregular rough surface of enamel and some microgaps as (Atoui et al., 2010) [13] (Hannig and Fu, 2001)[14] showed that adhesive interface with walls of cavity prepared with air abrasion was more irregular when air abrasion was used more than carbide bur and diamond stone, on the other hand, (Burnett et al., 2008)[15] who reported that air abrasion with aluminum oxide has led to appearance of irregular dentin surface and also reported that, it might be difficult to completely remove aluminum oxide particles with air-water spray, the presence of unwashed particles may act as weak sites for bonding between adhesive and dentin. (Bevilacqua et al., 2007)[16] reported that using the air abrasion in enamel surface as pretreatment resulted in irregularities and higher incidence of leakage.

Carbide bur generated less irregularities and gab formation than regular grit diamond unlike what (Nishimura et al., 2005)[6] showed in their study that carbide bur generated more enamel cracks. But the results are in agreement with (Delgado et al., 2015) [10] who compared the effect of different finishing technique on the gap formation between composite restoration and tooth structure; they found that carbide bur generated less mean gap values when compared to diamond stone at enamel margin. Another study compared the surface roughness of composite after finishing using different finishing techniques, it has shown that carbide burs resulted in lower surface roughness compared to diamond burs, despite the type of the composite resin tested (Botta et al., 2008) [17].

The current study showed that gaps were expected not to significantly affect the marginal sealing, as their width was found to be less than 50 microns which is the gap width enough for bacterial invasion (Nassar and Cabezas, 2011) [12]. On the other hand, micro-tags were more prominent that is expected to improve the resin retention (Sherawat et al., 2014)[18].

The use of self-etch in the current study was to avoid any morphological changes that might follow etching of enamel surface with phosphoric acid which in turn could affect the surface characteristics resulting from the cutting methods.

(Hasan, 2017)[19] reported in his review that using self-etch adhesive lead to less morphological changes causing shorter microtags formation and less micromechanical interlocking retention between resin and enamel. several studies showed the use of ultra-mild self-etch adhesive systems revelied lower adhesive properties to enamel when compared to etch-and-rinse systems and using one step self-etch resulted in lower marginal adaptation properties when compared to two step self-etch and total etch systems.

(Hasan, 2017) He also reported that etch and rinse system prevented leakage when used in enamel margin, while self-etch adhesive resulted in higher dentin sealing capability than etch and rinse system.

The use of self-etch adhesive provides less time and steps prior to composite restoration application, (Sabatini, 2013)[20] showed that the acidity of the monomers strength in self-etch adhesive system on un-etched enamel achieved intimate micro-mechanical retention, self-etch systems exhibited fewer gap-free margins when bonded to both enamel and dentin when compared to etch-and-rinse system (Lührs et al., 2008)[21].

Self-etch adhesive system is less aggressive than phosphoric acid when etching enamel. It was reported that intact unground enamel surface reduced the efficacy of bonding when self-etch was used (Nishimura et al., 2005)[6]. Also, they reported that self-etch system exhibited considerable strength in bonding to enamel with parallel prismatic enamel structure (in occlusal two thirds of crown compared to the cervical region where prismatic enamel structure starts to deviate to apical direction) than total-etch adhesive systems preceded by acid etch step. Furthermore, cracks along the enamel prisms near the bonding interface were produced when phosphoric acid was applied, leading to decrease in the bond strength. (Shimada and Tagami; 2003)[22]. Phosphoric acid was found to produce more cracks at the cavity margin than self-etch system (Nishimura et al., 2005)[6].

SEM can produce very high-resolution images of a sample surface, revealing high details, which allowed assessment of enamel surface topography. Analysis of enamel surface using SEM revealed smooth surface and no microroughness with best adaptation in relation to enamel surface prepared with 600 grit silicon carbide paper (control group), followed by enamel surface prepared with carbide bur which showed good adaptation and smooth enamel surface, while the diamond stone group showed smooth surface with less adaptation properties and the air abrasion group showed rough surface with small gaps in the enamel surface, which was expected to appear as air abrasion can be used for surface conditioning before application of the bonding agent replacing acid chemical conditioning (Bevilacqua et al., 2007)[15].

The scanning electron microscope examination showed that there was no difference, despite the type of instrument used for preparation.

CONCLUSION

No difference was observed regarding the instrument used for preparation, all samples prepared with the different cutting tools used in the current study showed good adaptation of resin composite to enamel, with small gap formation resulted with enamel surface prepared with air abrasion.

The use of self-etching adhesive system produced short resin tags in all SEM micrographs and did not significantly affect the enamel surface topography, which might necessitate selective enamel etching before their use.

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