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COMPARATIVE STUDY OF THE EFFECT OF LASER IRRADIATION AND ACID ETCHING SURFACE TREATMENT ON BONDING OF SOME DENTAL RESTORATIVE MATERIALS TO DENTIN SURFACE

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ABSTRACT

This study was carried out to evaluate the effect of acid etching versus laser etching of dentin surface on the bonding of Composite and Compomer restorative materials to dentin surface by studying microleakage at the dentin-filling interface, compositional analysis of dentin surface, and Scanning Electron Microscopic (SEM) study of the bonding area. 120 freshly extracted premolar teeth were divided according to surface treatment into three groups. Group I (Acid etching group) contained thirty teeth. Twenty teeth were selected to assess microleakage by forming standardized class V cavity on the buccal surface of the selected teeth. Then, teeth were subdivided into two subgroups with 10 teeth in each. Subgroup (i) delivered composite filling while subgroup (ii) delivered compomer filling according to manufacturer instructions. microleakage at the dentin-filling interface of teeth was examined using dye penetration method. dye penetration scores at occlusal and gingival margins were recorded and tabulated. Five dentin surfaces of five teeth from group I were etched by acid then prepared for compositional analysis of dentin surface by Infra-Red (IR) Spectroscopy. Another Five dentin surfaces were etched by acid then prepared for (SEM) assessment. Group II (Laser etching group) contained ninety teeth, twenty teeth were used for assessing microleakage after laser etching taking similar steps to that of acid etching. Thirty dentin surfaces of thirty teeth were etched by laser with different parameters then prepared for compositional analysis of dentin surface by IR Spectroscopy. Thirty dentin surfaces of thirty teeth were etched by laser with different parameters then prepared for SEM assessment. Group III (Untreated group) contained ten teeth that were left untreated. Five dentin surfaces of five teeth were subjected to IR Spectroscopy assessment. Five dentin surfaces of five teeth were prepared for SEM assessment. The results revealed that acid etching of dentin surface resulted in significant less leakage compared to laser etching. IR Spectroscopy revealed changes in dentin surface structure indicating that there was a reaction occurred by the acid and laser etching. SEM assessment showed more openings of dentinal tubules in case of acid etching, while in case of laser etching, there were a surface structural changes with a melting and fusion dentin surface. Acid etching of dentin gives better results on the bonding of Composite and Compomer filling materials than laser etching and thus gives more successful clinical condition. Further investigations are needed by using different types of laser to get more benefit from applications of laser clinically.

KEYWORDS*:* Laser, Microleakage, IR spectroscopy, SEM, Dentin etching.

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INTRODUCTION

The treatment of dental tissues prior to adhesive restorative procedures is an extremely important step in the bonding protocol and determines the clinical success of restorations. Dentin is a complex structure which can influence the bonding of restorative systems; therefore, bonding to dentin surface is a greater challenge than to enamel surface [(1)]. Considering bonding to dentin, a combination of both micromechanical and chemical bonding was likely to occur. The bond between dentin and composite is more micromechanical than chemical [(2)].

Preparation with rotating instruments produces a smear layer which contains hard particles, blood, bacteria and saliva [(3)]. Acid etching dissolves the smear layer, demineralize the peritubular and intertubular dentin and exposes the collagen matrix [(2)].

The demineralized dentin is infiltrated by resin monomers which create a hybrid layer after their polymerization [(4)]. To create the hybrid layer, it is necessary to remove the smear layer and demineralize the superficial dentin layer. Etching exposes the collagen fiber network of the dentin matrix, thereby permitting infiltration of bonding agents into the spaces between the fibers [(2)]. The fibers are engulfed and the complex fiber–resin is polymerized providing improved micromechanical retention of resin polymers [(5)].

Sandblasting, acid etching and laser are methods used for enamel and dentin surface etching. However, some studies suggest that laser etching may produce bonding forces comparable to that produced by acid etching [(6-8)], while others found that lower bonding forces were produced by laser when used for enamel surface etching [(9-11)]. CO_2 laser had many applications in dentistry that might differ according to its wavelength bands. The three main CO_2 laser wavelengths used in dental treatments are 9300, 9600, and 10600 nm. with a variety of hard and soft tissue effects, [(12,13)] Bond strength with different laser treatments is not consistent either. Some studies have suggested that there was significant decrease in shear bond strength with laser etching [14,15)], while others concluded that laser etching can produce comparable results to those produced by conventional etching [(16-18)].

Consequently, this work was undertaken to evaluate the effect of acid etching and CO_2 laser etching procedures of dentin on the Microleakage between dental restorative materials and the teeth surface.

MATERIAL AND METHODS

One hundred and twenty freshly extracted sound human permanent premolars teeth extracted for orthodontic purpose were selected and stored in distilled water after removing any adherent calculus, blood, stains, debris and periodontal shreds by scaling with sharp scalers, then polished with rotary hair brush and a mix of pumice and water.

The teeth were examined under light microscope for any surface morphological defects such as enamel fracture, cracks, restoration or carious lesions. Teeth with such defects were excluded from the study.

The teeth were divided into three groups according to the type of surface treatment, Group I (Acid etching group), Group II (Laser etching group), and Group III (Untreated Control Group).

Group I (Acid etching group)

This group contained thirty teeth. Twenty teeth were selected for assessment of microleakage in which a standardized rectangular class V cavity preparation (a mesio-distal width of 3mm, an occluso-gingival length of 2mm, and a depth of 2mm) was prepared on the buccal surface of each selected premolar with a gingival border of the cavity approximately 1mm above the cemento-enamel junction.

The outline of the cavity was standardized using a window like cut to the desired cavity measurements in a metallic matrix band. The precut matrix was held over the surface of the tooth and marked with a sharp pencil on the buccal surface of the selected premolars teeth. The preparations were cut using a new cylindrical crosscut tungsten carbide burs revolving at high speed using oil free air with air/water spray coolant system. The depth of the cavity was kept constant at 2mm axially by using a pre-marked cylindrical bur and judged by using pre-marked calibrated periodontal probe. The performed cavities were rinsed for 20 seconds using air/water spray and gently dried with oil free compressed air for 30 seconds.

The teeth were then, subdivided equally into two subgroups according to the type of restorative filling materials into:

(a) Ten teeth were restored with composite filling material.

(b) Ten teeth were restored with compomer filling material.

For Composite restoration: 3M Scotchbond (3M Center, St. Paul, MN 55144-1000) etchant material was applied according to the manufacture instructions, the cleaned cavity preparation was etched with the 35 % phosphoric acid gel for 15 seconds, then the surface was thoroughly rinsed with water for another 10 seconds and air dried with oil free air. 3M Single Bond dental adhesive system was then applied according to the manufacture instructions as follow:

The adhesive was applied to the etchant area using a fully saturated brush tip for each coat. Two consecutive coats were applied, dried gently for 2-5 seconds and then light cured with light cure unit (Kulzer GmbH, Leipziger Straße 2, 63450 Hanau) for 10 seconds.

3M Filtek Z250 (3M Center, St. Paul, MN 55144-1000) restorative composite was then applied according to the manufacture instructions, the restorative material was placed into the cavity incrementally using a non-metallic instrument and the first 1mm layer were placed and adapted to the proximal box to aid in adaptation to all of the internal cavity aspects then each increment were cured by exposing it to a high intensity visible light source for 20 seconds keeping that the tip of the light guide should be held as close to the restorative as possible during light exposure, then finishing was done to contour the restoration surfaces.

For Compomer restoration:

The Prime & Bond NT (Dentsply Sirona, Susquehanna Commerce Center, 221 West Philadelphia Street, Suite 60W, York, PA 17401) adhesive system was applied after conditioning the prepared tooth with NRC Non-Rinse Conditioner according to the manufacture instructions as follow:

Applying sufficient amount of NRC (Dentsply Sirona, Susquehanna Commerce Center, 221 West Philadelphia Street, Suite 60W, York, PA 17401) with a disposable brush to the all surfaces, leave undisturbed for 20 seconds without rinsing then remove excess NRC by blowing gently with an air syringe without desiccating the dentin structure. After conditioning the dentin surface, one layer of the Prime & Bond NT was applied by dispensing it into a disposable brush and immediately applied to thoroughly wet all tooth surfaces. This surface should be saturated which may necessitate additional application of Prime & Bond NT. Leaving the surface undisturbed for 20 seconds then remove solvent by blowing with air for at least 5 seconds leaving a uniform and glossy appearance surface then light cured for a minimum of 10 seconds. After insertion of compule tip into the notched opening of the applicator gun barrel, Dyract eXtra (Dentsply Sirona, Susquehanna Commerce Center, 221 West Philadelphia Street, Suite 60W, York, PA 17401) was dispensed directly into the cavity. Each increment was cured separately with a curing light for at least 40 seconds keeping that the tip of the light guide should be held as close as possible to the restoration during curing to be sure that each area of the entire restoration was exposed to the curing light. Finishing was done immediately after curing and gross excess material was removed with fluted finishing burs or diamonds.

All specimens were then, subjected to 300 thermocycles in water between (5±5) ºC and (50±5) ºC with a dwell time of 30 seconds in each bath and a 13 seconds transfer time between baths.

Five teeth were selected to get five dentin surfaces for compositional analysis of dentin surface by Infrared Spectroscopy. The dentin surfaces were etched with 35% phosphoric acid gel for 15 seconds and then the surfaces were thoroughly rinsed with water for another 10 seconds and air dried with oil free air. Infrared analysis was performed using Bruker FT.IR Vector22 (Bruker Optik GmbH in Ettlingen, Rudolf-Plank-Str. 27, 76275 Ettlingen, Germany) infrared spectroscope. The disk was prepared by mixing 2 % of Potassium Bromide powder with finely grounded dentin, and the mix was packed in a stainless-steel die and compressed in a hydraulic press to form a transparent disc about 1 Cm in diameter. The absorption band in the range of 400 Cm^{1}– to 4200 Cm^{1}– for of each disc was recorded in a graph and got tabulated.

Five teeth were selected to get five dentin surfaces for scanning electron microscope (SEM) (JEOL JSM-T330A, JEOL USA, Inc.11DearbornRoad, Peabody, MA 01960) assessment. Standardized surface finishing of dentin surfaces was done by using a silicon carbide paper 600 fine grit and then all dentin surfaces were etched with 35% phosphoric acid gel for 15 seconds, then the surfaces were thoroughly rinsed with water for another 10 seconds and air dried with oil free air.

Group II (Laser etching group)

This group contained ninety teeth. Twenty teeth were selected for assessment of microleakage and subdivided equally into two subgroups according to the type of restorative filling materials into:

(a) Ten teeth were restored with composite filling material.

(b) Ten teeth were restored with compomer filling material.

A standardized rectangular class V cavity preparation was performed in the same manner as in acid etching group. The cleaned cavity was then etched using laser with water coolant to obtain a surface topography that could be favorable for bonding to the restorative filling materials. Laser parameters were set to deliver a beam of 3W as power, pulse frequency of 2 Hz, and pulse duration of 30 msec. in a focused mode at a constant distance. Laser interaction with the dentin surfaces was seen as pluming light and heard as a popping sound. Bonding and filling of restorative materials were then performed following the same steps as in acid etching group.

Thirty teeth were selected to get thirty dentin surfaces for compositional analysis of dentin surface by Infrared Spectroscopy (IS). The dentin surfaces were laser etched using different parameters with and without water coolant.

These surfaces were subdivided equally into six subgroups (IS subgroups) in which each subgroup contained five teeth:

IS subgroup 1: Laser etching using 1 W.

IS subgroup 2: Laser etching using 1 W with water coolant.

IS subgroup 3: Laser etching using 2 W.

IS subgroup 4: Laser etching using 2 W with water coolant.

IS subgroup 5: Laser etching using 3 W.

IS subgroup 6: Laser etching using W with water coolant.

Thirty teeth were selected to get thirty dentin surfaces SEM assessment. The dentin surfaces were laser etched with different parameters with and without water coolant.

These surfaces were subdivided equally into six subgroups (SEM subgroups) in which each subgroup contained five teeth:

SEM subgroup 1: Laser etching using 1 W.

SEM subgroup 2: Laser etching using 1 W with water coolant.

SEM subgroup 3: Laser etching using 2 W.

SEM subgroup 4: Laser etching using 2 W with water coolant.

SEM subgroup 5: Laser etching using 3 W.

SEM subgroup 6: Laser etching using 3 W with water coolant.

Group III (Control Group)

Ten dentin surfaces of ten teeth were left untreated and subdivided into two groups:

(a) Five dentin surfaces for Infrared Spectroscopy assessment.

(b) Five dentin surfaces for SEM assessment.

All groups were assessed by the following assessment:

(A) Microleakage Assessment:

The restored teeth were used for assessment of microleakage by Dye penetration methods. The restored teeth were removed from distilled water and were dried using oil free compressed air. The crown and root of each tooth were completely coated with nail polish by means of a soft brush leaving the restoration and one millimeter in all directions around the margins exposed to the action of the tracing or dye solution, then, the teeth were immersed in 2% aqueous solution of methylene blue dye for 48 hours. The tracing solution was prepared by dissolving two gram of methylene blue powder in 100 ml distilled water. Teeth were then removed from dye and rinsed thoroughly under running tap water until all dye solution was completely removed from the surface and then left to dry.

The teeth were longitudinally sectioned in a bucco-lingual direction using a slow speed diamond disc with coolant.

Both halves of each sectioned tooth were examined using a stereomicroscope to determine the extent of dye penetration at both the occlusal and gingival margins. Dye penetration along the gingival and occlusal margins was rated according to the following scores:

Score 0: indicated no dye penetration.

Score 1: dye penetration in enamel till Dentino-Enamel Junction.

Score 2: dye penetration till pulpal or axial wall.

Score 3: dye penetration through pulpal or axial wall.

The obtained results were recorded, tabulated and statistically analyzed.

(B) Infrared Spectroscopy Assessment:

Each transparent disc was analyzed and the absorption band in the range from 400 Cm^{1}– to 4200 Cm^{1}– for each group was recorded and tabulated.

(C) Scanning Electron Microscope Assessment:

The teeth of all groups were prepared and examined by SEM to evaluate the morphologic pattern and structural changes of the acid etched dentin, laser etched dentin and untreated dentin as well as microleakage study of the acid etched dentin and laser etched dentin. Then the results were recorded photographically.

RESULTS

Microleakage analysis:

The dye penetration scores of each filling material at both occlusal and gingival surfaces were recorded. The number of teeth and the penetration percentage of both surfaces in each score were also calculated and tabulated. Statistical analysis of dye penetration scores was performed using non-parametric test (One-Sample Kolmogorov-Smirnov Test) at $P \geq 0.001$. Mean and Standard deviation of dye penetration scores were also recorded, and the results were as follows:

Group I (Acid etching group)

Dye penetration scores of the filling materials in group I at different surfaces including mean and standard deviation at P ≥ 0.001 are shown in table (1). The distribution of dye penetration scores for group I was shown in figure (1).

Group II (Laser etching group)

Dye penetration scores of the filling materials in group II at different surfaces including mean and standard deviation at P ≥ 0.001 are shown in table (2). The distribution of dye penetration scores for group I was shown in figure (2).

TABLE (1) Dye penetration scores of the filling materials in group I at different surfaces including mean and standard deviation at P ≥ 0.001.

Dye penetration score	Number of teeth and Penetration percentage in Composite filling		Number of teeth and Penetration percentage in Compomer filling		Group I (Acid etching group)	
	occlusal	gingival	occlusal	gingival		
Score 0	9 (90%)	3 (30%)	8 (80%)	3 (30%)	Mean ±SD	0.48±0.599
	12 (60%)		11 (55%)			
Score 1	1 (10%)	7 (70%)	2 (20%)	5 (50%)		
	8 (40%)		7 (35%)			
Score 2	0 (0%)	0 (0%)	0 (0%)	2 (20%)	P-value	0.000
	0 (0%)		2 (10%)			
Score 3	0 (0%)	0 (0%)	0 (0%)	0 (0%)		
	0 (0%)		0 (0%)			

TABLE (2) Dye penetration scores of the filling materials in group II at different surfaces including mean and standard deviation at P ≥ 0.001.

Dye penetration score	Number of teeth and Penetration percentage in Composite filling		Number of teeth and Penetration percentage in Compomer filling		Group I (Acid etching group)	
	occlusal	gingival	occlusal	gingival		
Score 0	7 (70%)	2 (20%)	6 (60%)	0 (0%)	Mean ±SD	1.08±0.971
	9 (45%)		6 (30%)			
Score 1	3 (30%)	2 (20%)	4 (40%)	0 (0%)		
	5 (25%)		4 (20%)			
Score 2	0 (0%)	6 (60%)	0 (0%)	8 (80%)	P-value	0.019
	6 (30%)		8 (40%)			
Score 3	0 (0%)	0 (0%)	0 (0%)	2 (20%)		
	0 (0%)		2 (10%)			

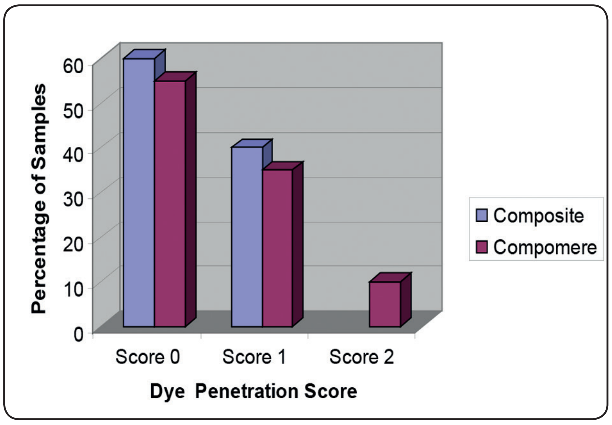

Fig. (1) Distribution of dye penetration scores for group I.

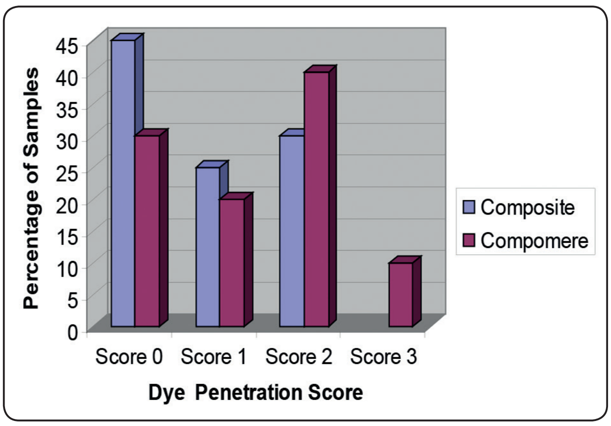

Fig. (2) Distribution of dye penetration scores for laser Etching group.

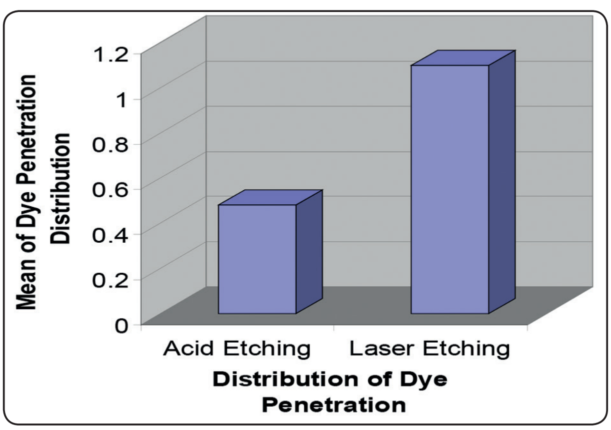

Fig. (3) Dye Penetration distribution among Acid and Laser Etching groups

The results showed a high significant difference in dye penetration scores of group II (P=0.019) compared to group I (P= 0.000)

The distribution of dye penetration scores for groups I (acid Etching group) and II (laser Etching group) was shown in figure (3).

Upon comparing groups I and II according to the filling materials, the results showed that the acid etching of composite was more significant than laser etching which was non-significant. For compomer, the results showed that the conditioning of compomer filling was more significant than laser etching as shown in table (3).

TABLE (3) Mean ±SD of groups I and II

Filling material		Acid etching group	Laser etching group
Composite filling material	Mean ±SD	0.503±0.40	0.875±0.85
	P-value	0.005	0.079
Compomer filling material	Mean ±SD	0.686±0.55	1.031±1.30
	P-value	0.020	0.160

Infra-red spectroscopy:

The term Infra-red (IR) fundamental region is often used to describe the wavelength region from 4200 cm^{1}– to 400 cm^{1}– of light spectrum. Most of the absorption bands observed in this region correspond to quantize uptake of energy into the fundamental vibration modes of the molecules under study. As a result of the acid etching and laser etching applications, the intensity of the bands was affected as compared with the normal dentin. The absorption bands of a group can be remarkably shifted owing to a number of factors specially those which change the force constant of bands. The variation in the structure as studied by IR spectroscopy appears in the form of a difference in intensities of bands, shifting and/or appearance of new bands.

There was a decrease in the intensity of bands with shifting to a lower level in case of acid etched dentin surface more than in case of laser etching and both were less than the control group.

Upon comparing laser application on dentin with and without water, it was found that the intensity of both bands was decreased in case of laser application without water. With increasing of laser parameters, there was a decrease in the intensity of the bands.

The IR spectra of the dentin surface of each group are presented by the frequencies of the wave number of the absorption bands together with their relative intensities of the dentin in tables 4 to 11.

TABLE (4) Absorption bands with their relative intensities in control group.

Wave number (cm^{-1})	**Relative intensities** (Absorbance unit)
3346.4	0.738
1645.8	0.356
1457.7	0.642
1418.1	0.164
1090.9	0.142
1078.1	0.201
1054.9	0.130
1047.2	0.940
1036.7	4.343
1022.3	0.110
1011.1	0.110
871.9	0.173
604.9	0.428
568.5	1.459
420.0	0.076

TABLE (5) Absorption band with their relative intensities of acid etched group

Wave number (cm^{-1})	**Relative intensities** (Absorbance unit)
3854.8	0.026
3386.6	0.435
2366.5	0.029
2344.7	0.027
1654.8	0.184
1543.3	0.043
1458.1	0.435
1418.8	0.106
1034.4	1.971
959.8	0.046
872.0	0.117
603.6	0.337
563.3	1.052

TABLE (6) Absorption band with their relative intensities in Laser group using 1 Watt

Wave number (cm^{1-})	Relative intensities (Absorbance unit)
3380.4	0.834
1655.9	0.314
1457.1	0.742
1416.6	0.186
1064.4	0.093
1052.8	0.485
1032.9	3.908
873.2	0.185
604.0	0.552
563.6	1.798

TABLE (7) Absorption band with their relative intensities in Laser group using 1 Watt with water coolant

Wave number (cm^{-1})	**Relative intensities** (Absorbance unit)
3398.4	0.599
2922.9	0.063
1657.3	0.497
1544.8	0.041
1456.0	0.350
1418.4	0.094
1032.7	1.516
872.3	0.123
603.7	0.221
563.6	0.851

TABLE (8) Absorption band with their relative intensities of Laser group using 2 Watts

Wave number (cm^{-1})	Relative intensities (Absorbance unit)
3855.2	0.024
3385.8	0.295
2367.4	0.026
2344.9	0.025
1654.8	0.123
1543.4	0.027
1458.1	0.294
1419.4	0.070
1034.9	1.354
959.6	0.034
872.1	0.077
603.9	0.253
563.8	0.732

TABLE (9) Absorption band with their relative intensities of Laser group using 2 Watts with water coolant

Wave number (cm^{-1})	Relative intensities (Absorbance unit)
3352.4	0.795
1654.8	0.361
1543.6	0.068
1457.9	0.727
1419.0	0.057
1032.0	2.412
871.9	0.164
603.1	0.324
561.4	1.365

Table (10) Absorption band with their relative intensities of Laser group using 3 Watts

Wave number (cm^{-1})	Relative intensities (Absorbance unit)
3904.5	0.012
3855.0	0.025
3751.7	0.016
3341.3	0.566
2345.2	0.023
1654.9	0.514
1560.3	0.023
1543.4	0.060
1508.3	0.016
1458.1	0.288
1420.3	0.077
1031.5	1.182
871.8	0.103
603.7	0.150
562.7	0.702

TABLE (11) Absorption band with their relative intensities of Laser group using 3 Watts with water coolant

Wave number (cm^{-1})	Relative intensities (Absorbance unit)
3387.2	0.606
1654.8	0.250
1458.1	0.630
1419.1	0.059
1.032	2.369
871.9	0.151
603.6	0.333
563.2	1.284

Scanning Electron Microscope (SEM):

Control group samples showed heavy deposits of smeared layer cover dentin surface with some detached areas, with few holes in the underlying dentin reflect the openings of some dentinal tubules.

More openings of the dentinal tubules were observed in case of acid etching group on the dentin surface with uniform appearance.

Laser irradiation produced changes in surface morphology. Laser etching of the dentin surface without water spray produced a surface melting and recrystallisation of smeared layer with fusion of crystals, while in case of laser etching of the dentin surface with water spray showed islands of crystals with different sizes and less degree of fusion of crystals as well as opening of the dentinal tubules and voids. It was apparent that with increasing laser parameter, more fusion of the crystals was found, in addition to the occurrence of cracks and craters on dentin surface.

The bonding agent penetrates along the etching area which was more apparent in case of acid etching with composite filling, and to a less degree in case of compomer filling material.

More fusion and formation of thick hybrid layer in case of acid etching with composite filling than that in case of compomer filling material.

Upon comparing the interfaces in case of acid etching with that of laser etching, there was more gap at the interface with laser etching than that of acid etching.

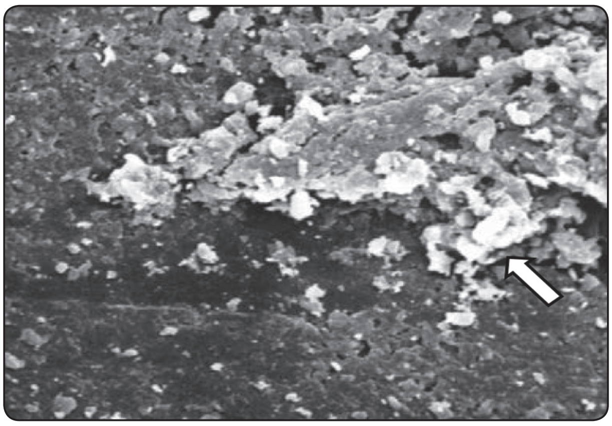

Fig. (4) Heavy deposits of smeared layer cover dentin surface with some detached areas with few holes in the underlying dentin reflect the openings of some dentinal tubules (Mag. 1000x).

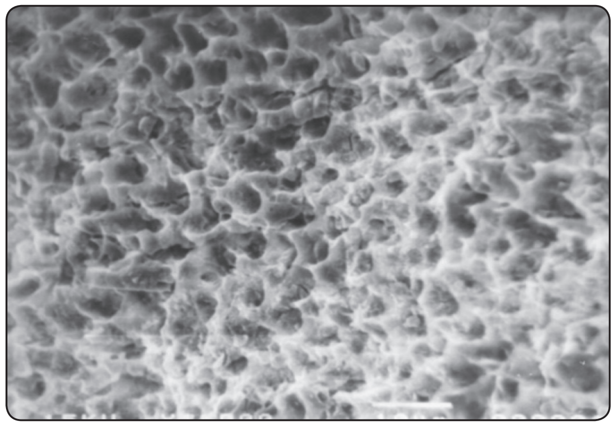

Fig. (5) Uniform appearance of dentinal tubules openings appears on dentin surface of acid etched group (Mag. 2500x).

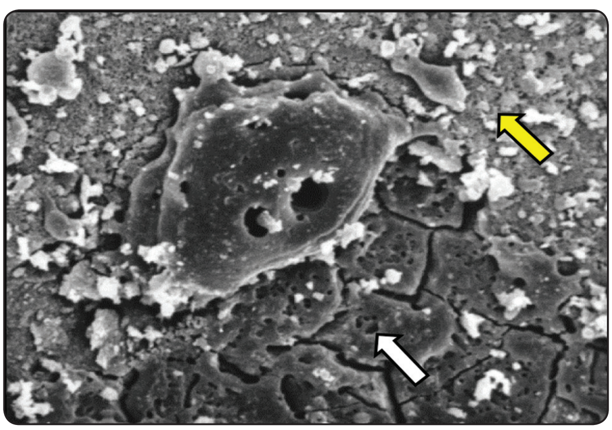

Fig. (6) laser etching of dentin at 1watt with the transitional zone between lased and un-lased area. Lased area (White arrow) appears with a distinctive squamous pattern with absence of the smeared layer and few openings of dentinal tubules appear within the molten re-solidified dentin while the un-lased area (Yellow arrow) is covered with deposits of smeared layer (Mag. 1000x).

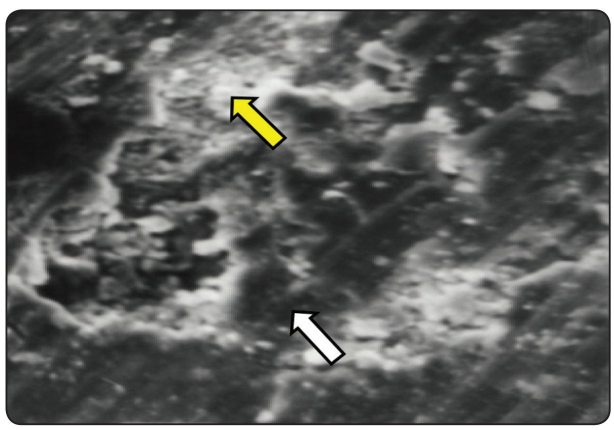

Fig. (7) Laser etching of dentin with 1watt using water shows crystals of different sizes and less degree of fusion between crystals as well as some openings of the dentinal tubules and voids. The transitional zone between lased (White arrow) and un-lased area (Yellow arrow) is less obvious (Mag. 1000x).

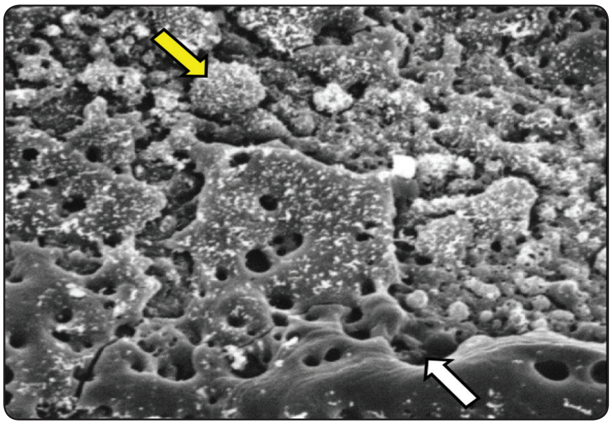

Fig. (8) Laser etching of dentin at 2watts. The transitional zone shows deep dentin craters (White arrow) caused by evaporation of some dentin spots, granular smeared layer (Yellow arrow) covers the peripheries of the area directly affected by laser irradiation (Mag. 1000x).

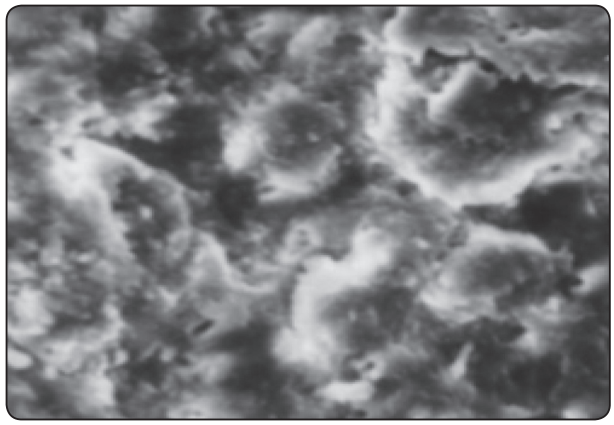

Fig. (9) Laser etching of dentin at 2watt with water. Dentin surface shows crystals of different sizes and less degree of fusion between crystals. Transitional zone is less obvious (Mag. 1000x).

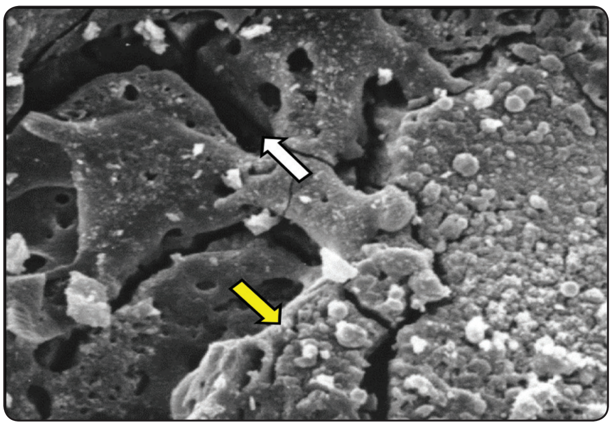

Fig. (10) Laser etching of dentin using 3watts. The transitional zone shows deep dentin craters (White arrow) caused by evaporation of some dentin spots, granular smeared layer (Yellow arrow) covers the peripheries of the area directly affected by laser irradiation (Mag. 1000x).

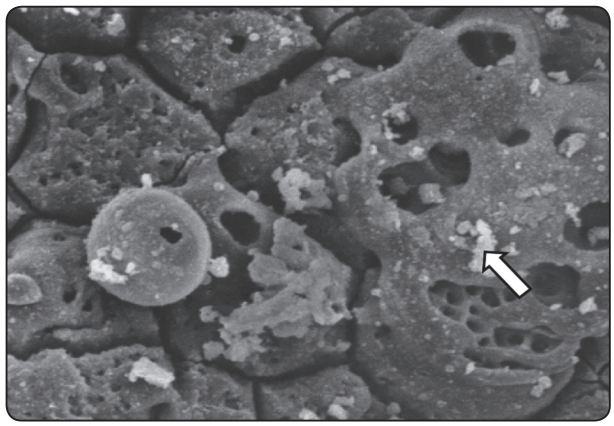

Fig. (11) Laser etching of dentin using 3watts with water. Dentin surface shows absence of smeared layer except for few debris (White arrow). Craters are less obvious than in absence of water coolant (Mag. 1000x).

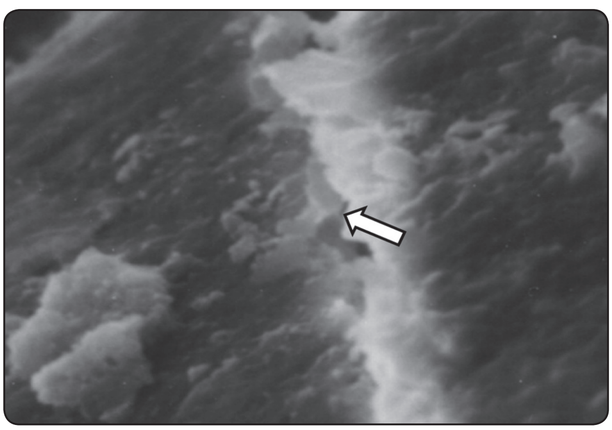

Fig. (12) Bonding area (White arrow) of acid etched dentin and composite filling material (Mag. 1000x).

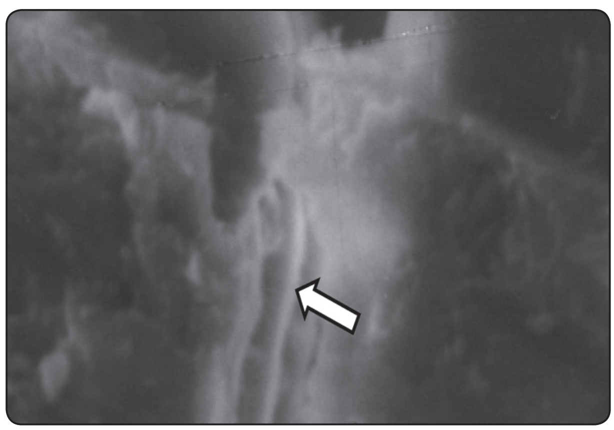

Fig. (13) Bonding area (White arrow) of laser etched dentin (White arrow) and composite filling material (Mag. 1000x).

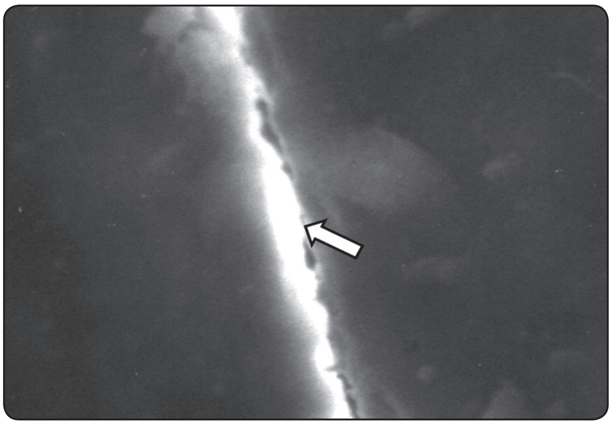

Fig. (14) Bonding area (White arrow) of conditioned dentin and compomer filling material (Mag. 1000x).

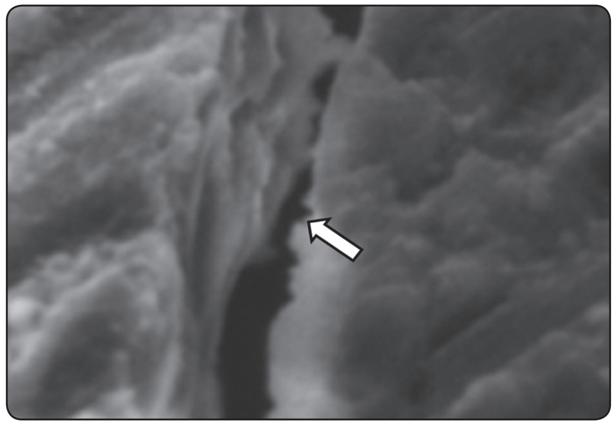

Fig. (15) Bonding area (White arrow) of laser etched dentin and compomer filling material (Mag. 1000x).

DISCUSSION

This study was carried out to evaluate the effect of acid etching versus laser etching surface treatment of dentin on the bonding of two restorative filling materials (Composite and Compomer) to dentin surface by increasing the surface area through micro-roughening of tooth.

Dentin surface etching was proved to be an adhesion promoter, enhancing the penetration of monomers into demineralized dentine to form a hybrid layer and the quality of the bond depends upon the ability of the monomers to penetrate throughout to dentin [(19)].

The acid chosen for our etching procedures in composite filling material was phosphoric acid as it was found that it removes more calcium hydroxyapatite crystals and thus gives more micro-roughness when compared by the other acids as citric acid and maleic acid. This was in agreement with Di Renzo, et al, 2001 [(20)] and Bagmar S, et al, 2013 [(21)].

The laser was considered a newer surface treatment modality to acid etching thus its effect on enhancement of bond strength had to be investigated. There is a great variety of lasers existing, each differing from the other by the emitted wavelength. The laser-matter interaction is not only wavelength dependent, but also the laser power settings, pulse duration, and the matter optical properties [(22)].

The type of laser used in this study was a Carbon dioxide laser, mid IR range, which got FDA approval as an infrared laser system for dental use. It has been vastly investigated for soft and some hard tissue applications, including cavity preparation and surface alteration. Amongst their advantages are their availability, safety, and ease of maintenance and their malleable delivery systems. It is also shows strong absorption by hydroxyapatite, therefore is highly suitable for application on dental hard tissues [(23)].

The laser parameter used in this study for laser etching in assessment for microleakage was in agreement with Andrea, et al 2000 [(24)].

Assessment of microleakage was done by using dye penetration method which is continued to be the most popular techniques that it is currently available, as it allows the production of sections showing leakage in contrasting colors to both tooth and restoration without the need for further chemical reaction or exposure to potentially hazardous reaction as revealed by Tylor and Lynch in 1992 [(25)], Magalhães et al, 1999 [(26)]and Morais et al, 1999 [(27)].

Dye penetration method was done using 2% aqueous solution of methylene blue on the basis of its advantage over other tracing materials. It is very soluble in water, easily penetrates the water compartment of the tooth, does not adsorb to the dental matrix or apatite crystals and penetrates further than any of the isotope tracing. This was in agreement with Matloff, 1982 (28).

The results obtained by dye penetration method revealed that the CO2 laser etching produced the highest leakage scores than the acid etching. This could be attributed to that the acid etching of the dentin caused removal of the smear layer, opens the dentinal tubules in a funnel configuration and exposes both intertubular and peritubular collagen by the formation of micropores in the inter and peritubular dentin which is the most affected since it contains the highest mineral content. This was further substantiated by the SEM which revealed, in case of phosphoric acid etching, complete removal of the smear system, widening of the dentinal tubules orifices with no smear plugs, the acid preferentially dissolved the peritubular dentin to create funnel-shaped dentinal tubules orifices. While Laser etching of dentin caused surface melting and loss of dentin surface architecture as a result of micro-explosions produced by the CO^2 laser due to its thermomechanical ablation. This was further confirmed by the SEM observations which revealed localized surface melting, microcracks and fissures with no evidence of opened dentinal tubules orifices. These changes would deprive the filling material from the retentive micromechanical undercuts and decrease its bond strength to dentin. So, although the laser etching roughened the surface of dentin, it did not provide a surface as retentive as a surface treated with conventional acid etching. This was in agreement with Mohsen and Shabka, 1993 (29), Ariyaratnam et al, 1997 (30) and Armengol, 2003 (31).

Acid etching produced the lowest leakage scores than the other types of laser etching such as Eximer Laser as reported by Yazici, et al, in 2001(32) and Er:YAG and Nd:YAP Laser as reported by Armengol, et al, in 2002 (33).

The results obtained by dye penetration method revealed that there was a lesser leakage scores at occlusal site in compared to the gingival site for the acid etching and the laser etching groups. This was in agreement with the finding of Amsberry et al, 1984 (34) and Fayyad and Shortall, 1987 (35).

This could be related to the presence of adequate enamel thickness at the occlusal site which is necessary for successful bonding while the enamel at the gingival site cannot offer a bond which can resist stresses due to polymerization shrinkage of the restorative materials. This was in agreement with Jordan, 1992 (36).

The difference in orientation of dentinal tubules, which is nearly parallel to the prepared surface at the occlusal site and perpendicular at the gingival site, might also contribute to these results. This difference in orientation could lead to more tubules connected to the cut surface at the gingival site providing hybrid layer of lesser quality. These results were in agreement with Yap et al, 1995 (37), Hilton and Ferrancane, 1998 (38), and Estafan et al, 2000 (39).

The results obtained by IR Spectroscopy revealed that there was a decreased of the intensity of spectral bands in case of acid etching and laser etching of dentin surface than the control group. The spectral bands were decreased in intensity in case of acid etching more than laser etching of dentin. This may be attributed to the chemical effect of acid on the dentin which caused dissolution of calcium hydroxyapatite (HAP) of the dentin surface as explained by Di Renzo et al, 2001, and the obtained effect of the laser was attributed to the ablation effect of laser energy on dentin surface.

The results obtained by Scanning Electron Microscope revealed that the acid etching of dentin caused removal of the smear layer and the superficial part of dentin exposing the apertures of dentinal tubules, demineralize the dentin surface and increase the microporosities of the intertubular dentin by exposing the dentinal collagen network. This was in agreement with Bertolotti, 1992 [40], Van Meerbeek et al, 1992 [41], Perdigao et al, 1994 [42], Matos et al, 1997 [43], and Gateva et al, 2016 [44].

However, laser etching of dentin showed irregular sealing of orifices of dentinal tubules and melting of mineral phase, as a CO_2 laser exposure of dentin decreased the organic composition of the surface, so that a recrystalization process had occurred that resulted in an increase in the size of the crystals. This was in agreement with Hedayatollahnajafi et al, 2009 [45].

Many studies have compared the bond strengths and surface morphology for CO_2 laser etched enamel and dentin with conventional phosphoric acid etching, demonstrated that CO_2 laser etching is weaker in bond strengths than acid etching. This was in agreement with Gateva et al, 2016 [44] Hedayatollahnajafi et al, 2009 [45]. The bond strength between the filling material and tooth structure in case of acid etching were superior to other types of laser etching such as Nd:YAG Laser as reported by Ariyaratnam, et al, 1997 [14] and AbdullJabbar et al, 1993 [46] and Er:YAG Laser as reported by De Munck et al, 2002 [47].

Andrea, et al 2000 [24], Staninec, et al 2009 [48] and Moretto, et al 2011[49] concluded that, there was no significant difference between CO_2 laser etching used after phosphoric acid etching, CO_2 laser etching used alone and phosphoric acid etching alone in microleakage using dye penetration, and these groups showed lower microleakage scores than group when the CO_2 laser etching was used before phosphoric acid etching.

On the other hand, this finding contradicted that of Cooper et al, 1988, who reported that an increased in shear bond strength of composite to laser treated dentin due to the associated increase in surface roughness by the effect of CO_2 laser beam, the source of contradiction might be attributed to the fact that in that study, CO_2 lased dentin was only compared to untreated dentin and not to acid-etched dentin regarding surface roughness and shear bond strength to composite. Moreover, this finding also contradicted Groth et al, 2001 [50], who claimed that laser irradiation could provide an effective and alternative method to the acid etching technique. The source of contradiction may be related to the difference in laser type, energy density and time of laser application.

CONCLUSION

From the previously mentioned, it could be concluded that acid etching of dentin gives better results on the bonding of Composite and Compomer filling materials and thus gives more successful clinical condition. Consequently, the laser etching when applied using the preset parameters has less etching and more damaging effect on dentin. Further investigations are needed by using different types of laser and different parameters to get more benefits from applications of laser clinically.

RECOMMENDATION

Further investigations are needed by using different types of laser to get more benefit from applications of laser clinically.

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