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Effect of Microleakage in Class V Cavities Following Er: Yag Laser Conditioning And Self-Etch Adhesive On Fluorosed And Nonfluorosed Teeth - An In Vitro Study

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Abstract

Aim: To evaluate and compare microleakage in class V cavities following Er:YAG laser conditioning and self-etch adhesive on fluorosed and nonfluorosed teeth.

Materials and Methods: Forty freshly extracted human permanent premolar teeth were taken and standard class V cavities were prepared. The cavities were randomly assigned into fluorosed and non fluorosed groups. Each group was further divided into 4 subgroups. Subgroup I: Control; Subgroup II: Etched with self-etch adhesive; Subgroup III: Er:YAG laser conditioning with high power mode followed by self-etch adhesive; Subgroup IV: Er:YAG laser conditioning with lower power mode followed by self-etch adhesive. The cavities were sealed with composite resin. The specimens were then immersed in a solution of 2% Rhodamine B dye for 24 hours. The marginal sealing ability was indicated by the depth of dye penetration around the enamel or dentin margins under a stereomicroscope.

Statistical analysis: Results were tabulated and analysed by one-way analysis of variance (ANOVA) and Kruskal-Wallis tests.

Results: None of the subgroups tested in this study completely eliminated microleakage. Marginal leakage of Er: YAG laser conditioning with low power mode followed by self-etch adhesive showed the least amount of dye penetration.

Conclusion: Er: YAG laser conditioning with low power mode followed by self-etch adhesive showed less microleakage than self-etch adhesive and high power mode for both the groups.

Keywords: Er: YAG Laser, Fluorosed teeth, Microleakage, Self-etch adhesive.

Introduction

Dental fluorosis is endemic in several parts of the world. Fluorosed enamel is characterized by an outer hyper mineralized surface & subsurface layer.[1] One of the option for treating moderately or severely fluorosed teeth can be composite restorations. [2] Hypermineralized surface of fluorosed enamel is difficult to acid etch. [3] Bonding of resin restorations on fluorosed teeth involves the etching of acid resistant enamel and may necessitate prolonging the etching time. [1]

One of the most important requirement for the durability of composite restoration is proper sealing of the cavity. Marginal integrity and secondary caries results in treatment failure. The amount of microleakage is influenced by marginal adaptation of the restorative material to the tooth, polymerization shrinkage and coefficient of thermal expansion between tooth structure and restorative material. [4] Microleakage may be decreased by proper acid etching technique and bonding systems. [5]

Currently used adhesives may be classified as total-etch and self-etch adhesives. Total-etch adhesives require a separate acid etching step prior to adhesive infiltration which promotes an aggressive substrate treatment, whereas self-etch adhesives have self etching efficiency on tooth structure. Although self-etch adhesives rely on the same bonding mechanism, they differ from each other such as number of application steps, acidic monomer composition, water content and acidity. [6] In the present study, one-step self-etch adhesive (Optibond All-In-One Adhesive, Kerr, Italy) was used. The success of dentin bonding procedure is affected by many variables and it is critical for the success of the restoration. [4]

Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser was one of the first laser to be used in studies for caries removal and cavity preparation. Er:YAG laser has been proposed as an alternative method for enamel and dentin etching. When enamel and dentine are irradiated with laser, surface alterations created by laser may affect the microleakage of adhesive restorative materials. [7] Previous studies reported the effects of Er:YAG laser on fluorosed and non fluorosed root surfaces but the comparative evaluation of Er:YAG laser as a conditioning agent on fluorosed and non fluorosed teeth was not found in the literature. [8] Dental fluorosis and different adhesives may affect microleakage levels of Class V composite restorations on permanent teeth. Till date there is no supporting data on the comparative evaluation of microleakage of composite restorations comparing Er:YAG laser with self-etch adhesive system.

The purpose of this in vitro study was to compare the microleakage of class V composite resin restorations using Er:YAG laser conditioning with high power mode, low power mode followed by self-etch adhesive and self-etch adhesive on fluorosed and nonfluorosed teeth.

Materials & Methods

In the present study, freshly extracted fluorosed and nonfluorosed healthy single rooted premolar teeth were collected from the Department of Oral and Maxillofacial Surgery, Kamineni Institute of Dental Sciences, Narketpally. All teeth were collected and stored in 0.2% thymol solution till use. For fluorosed teeth, the stains were confirmed by the clinical examination and history of the subjects hailing from natural high water fluoride areas in and around Narketpally (fluoride concentration >5-10ppm). A total 20 fluorosed and 20 nonfluorosed teeth specimens were included in this study. Standard class V cavities were prepared on buccal surfaces (width: 4mm, height: 3mm, depth: 1/5mm) with high-speed hand piece in a way that occlusal margin was located in enamel and gingival margins in dentin. Each group was further subdivided into four sub groups (n=5).

Sub Group 1 (Control Group): After the cavity preparation without etching only bonding agent (Prime and Bond NT, Adper Single Bond, 3M ESPE) was applied according to manufacturer's instructions and then light cured for 20 secs.

Sub Group 2 (Self-Etch): After the cavity preparation self-etch adhesive (Optibond All-In-One Adhesive, Kerr, Italy) was applied according to the manufacturer's instructions and then light cured for 20 secs.

Sub Group 3 (Er:YAG Laser Conditioning with High Power mode followed by Self Etch Adhesive): After the cavity preparation, Er:YAG laser (Pulser, Fontana, Italy) with high power mode was used to condition the surfaces. Laser was applied with frequency of 40Hz and power of 2W was used with time duration of 30 sec and percentage of air 60% and water 30% was kept constant. To simulate clinical conditions the laser was placed at 0.5 mm from the surface, without contact of the handpiece tip with the cavity surfaces. Then self-etch adhesive (Optibond All-In-One Adhesive, Kerr, Italy) was used to condition the surfaces according to manufacturer's instructions and then light cured for 20 secs.

Sub Group 4 (Er:YAG Laser Conditioning with Low Power mode followed by Self Etch Adhesive): After the cavity preparation, Er:YAG laser with low power mode was used to condition the surfaces. Laser was applied with frequency of 40 Hz and power of 1W was used with time duration of 30 sec and percentage of air 60% and water 30% was kept constant. To simulate clinical conditions the laser was placed at 0.5 mm from the surface, without contact of the handpiece tip with the cavity surfaces. Then self-etch adhesive (Optibond All-In-One Adhesive, Kerr, Italy) was applied according to manufactures instructions and then light cured for 20 secs. The cavities then restored with restorative composite resin incrementally (Herculite Ultra, Kerr, Italy). Each layer with 2mm thickness was light cured for 40 secs. The restored samples were accurately polished with Soflex polishing discs (3M Dental Products, USA) and were stored in distilled water at 25°C for 24 hrs. The specimens were thermocycled for 500 cycles between water baths held at 5°C and 55°C with a 30 sec dwell time in each bath. Then a double coated nail varnish was applied to the whole surfaces of the teeth, leaving 1 mm wide border around the restoration margins. Then the samples were immersed in 2% Rhodamine B dye (SDFCL, Mumbai, India) for 24 hrs.

The teeth were then rinsed and sectioned longitudinally using a low speed air cooled diamond disc and the extent of dye penetration was visualized. The specimens were evaluated under a stereomicroscope (Olympus CX 31, Olympus America Inc) at 10X magnification. The microleakage evaluation was based on degree of dye penetration and was scored via a graded qualitative scale under a blinded manner (Table 1).

Table 1: Distribution of Microleakage by Standardised Scoring.

SCORE	DEFINITION
0	No Dye Penetration
1	Dye Penetration less than one-third of the cavity wall
2	Dye Penetration less than two-thirds of the cavity wall
3	Dye Penetration more than two-thirds of the cavity wall without axial wall involvement
4	Dye Penetration to the full extent of the cavity wall, reaching the axial wall or penetrating it

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) 16 was used for statistical analysis. To assess the microleakage using dye penetration technique between two main groups i.e., fluorosed and nonfluorosed and between the four subgroups. Mean and standard deviation were estimated from the sample from each study group. The mean values were compared by one way Analysis of Variance (ANOVA) and Kruskal-Wallis statistical tests. In the present study, the level of significance was set at p=0.05.

Results

Relative distribution of microleakage scores in test analysis of variance and kruskal-wallis statistical tests established that no statistical differences existed among the fluorosed and nonfluorosed groups. None of the procedures tested in this study eliminated the microleakage as seen in figures 1 to 4.

Figure 1: Stereomicroscopic image of control subgroup of Fluorosed group

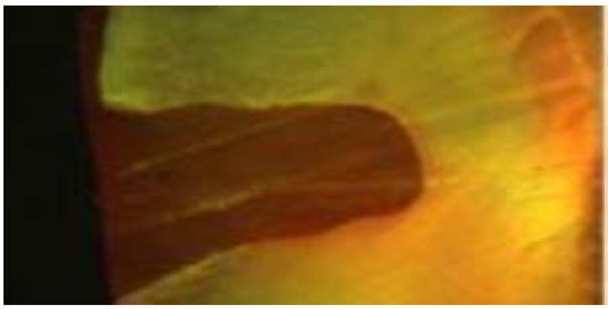

Figure 2: Stereomicroscopic image of Etched with self-etch adhesive subgroup of Fluorosed group

Figure 3: Stereomicroscopic image of Er:YAG laser conditioning with high power mode followed by self etch adhesive subgroup of Fluorosed group.

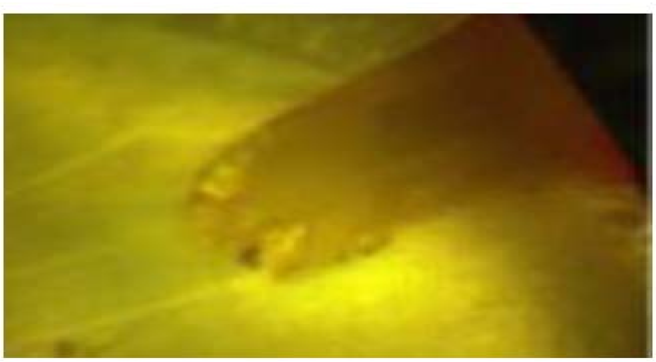

Figure 4: Stereomicroscopic image of Er:YAG laser conditioning with low power mode followed by self-etch adhesive subgroup of Fluorosed group

The greater mean of microleakage was found in Subgroup 1(Control) for both fluorosed and non fluorosed groups as seen in Table 2. Less microleakage was seen in non fluorosed groups compared to fluorosed groups. One way Analysis of Variance (ANOVA) and Kruskal-Wallis statistical tests showed no statistical differences between fluorosed and non fluorosed groups as seen in table 2 and table 3. However, Group 4 (Er:YAG laser conditioning with low power mode followed by self-etch adhesive) exhibited less microleakage than Group 1,2 and 3 for both fluorosed and non fluorosed groups.

Table 2: Mean values of fluorosed and non fluorosed teeth

Sub groups	Non fluorosed teeth		Fluorosed teeth	
	Mean	S.D	Mean	S.D
1	3.7	0.64	3.8	0.62
2	3.4	0.54	3.5	0.32
3	3.3	0.44	3.4	0.52
4	2.8	0.54	2.9	0.54

Table 3: One way ANOVA (Fluorosed Group)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.440	4	2.360	9.077	.000
Within Groups	5.200	20	.260		
Total	14.640	24			

One way ANOVA (Nonfluorosed Group)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.640	4	1.660	7.545	.001
Within Groups	4.400	20	.220		
Total	11.040	24			

Table 4: Kruskal-Wallis Test for Fluorosed and Non Fluorosed Groups

	GP	N	Mean Rank
Fluorosis	1.00	5	7.00
	2.00	5	4.00
	Total	10	
Nonfluorosis	1.00	5	6.00
	2.00	5	5.00
	Total	10	

P value =0.001

Discussion

Microleakage is one of the important criteria in assessing the success of any restorative material used for tooth restoration. [4] Asmussen reported that gap formation is caused due to differences in the coefficients of thermal expansion between tooth structure and the restorative material. Due to temperature variations in the oral cavity, the tooth and the restorative material expand and shrink at different rates, which causes gap formation at the restoration-tooth interface where microleakage can occur. [9] In the present study, to obtain the realistic results restorations were thermocycled between 5 and 55°C for 500 cycles to simulate the thermal changes taking place in oral environment, which caused the gap formation at tooth restoration interface.

Microleakage is determined by several in-vitro studies such as dye-penetration tests, chemical agents, compressed air, neutron activation analysis, radioisotope materials etc. For dye-penetration tests commonly used solutions are basic fuchsin (0.5-2%), silver nitrate (50%), crystal violet (0.05%), methylene blue (0.2-2%), Rhodamine B (0.2-2%), eritrosin (2%).[10] In this study, a conventional and dependable dye-penetration method with 2% Rhodamine B solution was used for the microleakage examination. In the present study, bulk placement technique was used, which is most commonly used in microleakage studies.

In the present study, microleakage was more in fluorosed teeth than nonfluorosed teeth. This is in accordance with a study done by Kucukesmen et al. [11] The reason for higher microleakage levels in fluorosed teeth may be explained that composite restorations form weak bonds to fluorosed teeth because of the pitted and detachable fluorapatite structure of fluorosed enamel which has hypermineralized surface layer and extensive subsurface porosity. [1] Use of proper acid-etching technique may reduce the microleakage, however the type and concentration of etching agents affect the demineralization rates of enamel. [12] As the fluorapatite present in the hypermineralized surface layer of fluorosed teeth is comparatively more resistant to acid dissolution than the hydroxyapatite in non-fluorosed teeth, it was suggested that the etching time of fluorosed enamel can be doubled. [13,14] It was seen that by doubling the etching time for fluorosed teeth, microleakage was considerably decreased. [9] The drawback of prolonging the etching time results in increased duration of time and also weakening of the dentinal tubules. To overcome these drawbacks, in the present study Er:YAG laser was chosen as a conditioning agent on fluorosed and non fluorosed teeth.

Er: Er:YAG laser when used as a conditioning agent has an abrasive effect by roughening dentinal surfaces with open dentinal tubules with no smear layer formation inducing changes on dentinal surfaces which will lead to elimination of acid etching. [7] Many studies proved that Er:YAG laser conditioning on dental surfaces improves the quality of restorative material adhesion. [15,16]

Zavareh et al. reported that the use of Er:YAG laser for conditioning with different dentin adhesive systems influenced the marginal sealing of composite resin restorations and surface conditioning with Er:YAG laser followed by the self-etch adhesive Optibond FL showed a very lower amount of microleakage. [7] Walter et al. reported that self-etch adhesives formed excellent bonds to enamel and dentin. [17]

In the present study, among the four subgroups Er:YAG laser conditioning with low power mode followed by self-etch adhesive (Group 4) exhibited lesser microleakage than Er:YAG laser conditioning with high power mode followed by self-etch adhesive (Group 3) for both fluorosed and non fluorosed groups. The probable reason for higher microleakage in Er:YAG laser conditioning with high power mode (Group 3) might be due to melting of tooth surface and subsequent smear layer formation which has a negative impact on the bonding, whereas lesser microleakage was reported with Er:YAG laser conditioning with low power mode (Group 4) might be due to absence of smear layer and low thermal effect. [8] Another reason may be irradiation with low power and pulses of lower energy may produce an irregular tooth surface, which is more prone to better adhesion at the time of bonding whereas higher power pulses may lead to increased temperature on the treated area which causes more damage to the remaining tooth surface. [4]

Furthermore, there are no studies which compared the microleakage on fluorosed and non fluorosed teeth after conditioning with different laser energy parameters. Therefore, the results of the current study are rather important for adding more knowledge on microleakage levels of composite restorations on fluorosed and nonfluorosed teeth with different laser energy parameters.

Conclusion

Within the limitations of this in vitro study, there was no significant difference of microleakage between fluorosed and non fluorosed teeth. It can be concluded that Er:YAG laser conditioning with low power mode followed by self-etch adhesive showed the least amount of microleakage when compared to self-etch adhesive and Er:YAG laser conditioning with high power mode followed by self-etch adhesive.

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Legends

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Table 3: One way ANOVA for Fluorosed and Non fluorosed Group)

Table 4: Kruskal-Wallis Test for Fluorosed and Non Fluorosed Groups

Image 1: Stereomicroscopic image of control subgroup of Fluorosed group

Image 2: Stereomicroscopic image of Etched with self-etch adhesive subgroup of Fluorosed group

Image 3: Stereomicroscopic image of Er:YAG laser conditioning with high power mode followed by self- etch adhesive subgroup of Fluorosed group

Image 4: Stereomicroscopic image of Er:YAG laser conditioning with low power mode followed by self -etch adhesive subgroup of Fluorosed group