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Research Article

Investigate Microleakage of Composite Filling in Class V Cavities with Use Different Laser Irradiations

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Abstract

Objective: This study's objective was to assess how diode laser exposure affected microleakage in class V restored by composite.

Materials and Methods: Materials used in this investigation; sixty human molars were used. All specimens had Class V cavities created on their buccal and lingual surfaces. uniform class V cavity (3 mm width, 4 mm length, 1.5 mm depth). A gel containing 37% phosphoric acid was used to etch each tooth cavity for 15 seconds. After that, the teeth received a 5-second water rinse. An LED was used to light cure the glue for 15 seconds after it had been applied to the whole cavity's surface. Composite resin was then poured into the cavity and exposed to light for 40 seconds to cure it. The filled teeth were divided into two groups (30 individuals each) depending on surface treatment with different laser applications. Group A: teeth with surface treatment by Nd:Yag laser application, Group B: teeth with surface treatment by diode laser application. Dye penetration become measured below a stereomicroscope. The specimens was examined by scanning electron microscope.

Result: No significant difference in the microleakage at buccal and lingual surface margin between Na:Yag and diode laser groups.

Keywords: *Composite Resins; SEM; Diode Laser; Nd:Yag Laser*

Introduction

Polymerization shrinkage, which creates a contraction's stress constrained structure like tooth cavity [1]. In composite, this contraction stress is necessary for marginal adaption [2]. A contraction gap of microleakage forms when the tension caused by polymerization shrinkage is greater than the adhesive resin's binding strength to cavity walls and the floor [3,4].

After curing, the linear shrinkage of composites was between 2 and 3 percent. From 0.6 - 1.4%, hybrid composites and micro-hybrid composite decreased [5]. Due to holes at the resin-to-tooth contact, this shrinkage induced microleakage. Teeth decay and damage are caused by saliva, liquid, food particles and microbes trapped in the gaps. This is a major issue for restorative materials and their aesthetics; thus, it is important to offer materials with excellent mechanical capabilities and minimal shrinking due to polymerization. It was expected that composites using nanosilica filler and epoxy resin would be able to meet these requirements [6,7].

Numerous studies have attempted to limit polymerization shrinkage in composite resin by regulating the composite's own components, such as the quantity and kind of matrix resin. the inclusion of non-bonded micro- filler particles [8], filler level [9], curing chemistry [10], initiator level [11,12]. The alternative strategy involves using a modified application process [13,14], a sandwich repair using glass ionomer [15], resin inlay [16] and light energy management to regulate the restoration pace [17,18].

Depending on the kind of laser used, several conditioning effects, including as drying, melting, cratering, cracking, and roughening, can be observed at the cavity surface. Laser wavelength, pulse repetition and duration, absorption, beam intensity, frequency, energy characteristics and reflection are some of the characteristics that define the process of laser-tissue interaction [19].

Since the invention of Maiman's laser [20], researchers have studied the application of lasers in dentistry. Additional cutting-edge dental uses for both hard and soft tissues are available.

Nd:YAG lasers have a wavelength of 1064 nm and are pulsed infrared lasers, highly absorbed by tissues with color. Used on the hard structure of teeth to increase resistance to acid attack, remineralize incipient caries, debride and correct enamel pits and cracks to prevent caries lesions, disinfect preparations for caries, ivory Used to treat hypersensitivity, reduce bacterial counts in root canals, enhance fluoride penetration into dental enamel and sanitize laser-irradiated surfaces. When enamel and dentin surfaces are exposed to laser radiation, it produces liquefaction and recrystallization. resulting in a vitreous morphological appearance and surfaces free of microorganisms [21].

Recent developments in laser technology have enabled the surface modification of materials for improved adhesion to tooth structure [22].

Diode lasers are becoming increasingly important owing to their compactness and affordability. It is advised because it employs thin, flexible fibers and has an infrared wavelength. Laser diode with wavelengths of 810 nm [23] and 980 nm [24] have been shown to be effective germicidal agents in several investigations.

This investigation was to find out how microleakage in composite restorations of class V cavities was affected by diode and Nd:Yag laser irradiation.

Materials and Methods

Sixty extracted caries-free molars were collected, cleaned prior to testing, sample was scaled with ultrasonic scaler and kept in filtered water at 37°C.

Two standardized cavities class V on buccal surface and lingual surface; each measuring 3 mm broad by 4 mm long by 1.5 mm deep of each specimen by conventional bur using bur #330 and diamond straight fissured burs using high-speed water-cooled hand piece. Each tooth cavity was etched with 37% phosphoric acid gel (Eco-Etch. Ivoclar Vivadent) for 15 seconds. Then Teeth rinsed with water and dried. Apply the adhesive on full cavity surface and dilute it with air for 15 s to spread the material thinly, evenly and on a shiny surface and apply it to the light- emitting diode (LI-189 Li-Cor Inc. Lincoln, NE 68504, USA).

The cavity was then filled with the composite (Clearfil majesty posterior, Kuraray) and the tip as near the surface as possible for 20 seconds while the light was curing. The light intensity was maintained consistent during the polymerization of all samples using a curing radiometer equipment. With a disc, all repairs were completed and polished (3M Company, St. Paul, MN, USA).

According to surface treatment with different laser application, filled teeth separated into two groups: each with 30 teeth. Group A: teeth with surface treatment by Na:Yag laser application, Group B: teeth with surface treatment by diode laser application.

Methods of diode laser application

The (Quanta system, Italy) used a diode laser in contact mode with a 2 W power output every 15 seconds (Figure 1) and an optical fiber transmission system. Fiber tip diameter with 320 micrometer was positioned perpendicularly to buccal and lingual areas [33]. During laser application; all the standard safety concerns were followed during the experiment.

Figure 1: *2 W Diode 980 nm.*

Methods of Nd:Yag laser application

Fiber optic laser with 320 microns of wavelength. Energy per pulse: 40 mJ; repetition frequency: 15 Hz; power: 0.6W; pulsed and non-contact; distance from surface: 1 mm. 30 second scan period. There was a 49.76 J/cm 42 energy density. Fibers were placed perpendicular to the occlusal and fissure regions.

The tooth was prepared for microleak assessment by sealing the root tip with acrylic resin and a block. Restorations and all other surfaces apart from the edges by 1 mm covered with three coats of nail polish to prevent color bleed. Teeth were kept in filtered water for 48 hs, then they spent 24 hours submerged in 2% methylene blue solution. With a low-speed diamond disc (CDA65, Germany) and water cooling, all teeth were partially sliced in half. A stereomicroscope (Olympus SZ-PT-Japan) was used to measure the dye penetration at a 10x magnification. For each sample in the two groups, linear color penetration (measured in microns) was determined automatically using analysis program for images (Image Ware, Image J 1.3 lb, USA). The gingival bed and axial wall both had linear dye penetration measurements done.

Each sample's linear dye penetration was estimated to provide a percentage. To compare groups, a Tukey's post hoc analysis was used after one-way ANOVA, which was utilized to evaluate the data.

Results were scored in (0, 1, 2, 3):

- 0= no microleakage
- 1= penetration of dye inside cavity wall one-third.
- 2= penetration of dye inside cavity wall two-third.
- 3= penetration of dye spreading to floor of restoration

Scanning electron microscope specimens

The prepared specimens for SEM examination, (C_1…C_{10}) and (D_1…D_{10}), were sectioned, dehydrated and sputter coated with gold coating Edwards (Sputter Coater). The samples were then scanned with scanning electron microscope (JSM-T20, JEOL, Tokyo, Japan).

A sample was randomly selected from each group, a water-cooled disc was used to vertically cut the center of class V cavity, and SEM was used to assess the impact of laser irradiation at junction of the composite cavity and the enamel.

Results

Microleakage assessment

Microleakage scoring of the dye penetration along the buccal and lingual of two group [Group A: teeth with surface treatment by Nd:Yag laser application, Group B: teeth with surface treatment by diode laser application]. In table 1 demonstrates the descriptive statistics of the dye penetration microleakage scoring through buccal and lingual margin for Nd:YAG group, the dye penetrates through buccal and lingual margins recording score 0, 1 and 2 respectively, According to analysis, there was no discernible differentiation between Nd:YAG group's microleakage scores at the buccal and lingual margin (Figure 2).

	Buccal (%)	Lingual (%)	Kruskal-Wallis ANOVA	P
Score 0	5 (50)	3 (30)	0.27	0.83
Score 1	6 (60)	8 (80)		
Score 2	1 (10)	1 (10)		
Score 3	0	0		

Table 1: *Microleakage scores for Nd:YAG group.*
**Significant at P ≤ 0.05.*

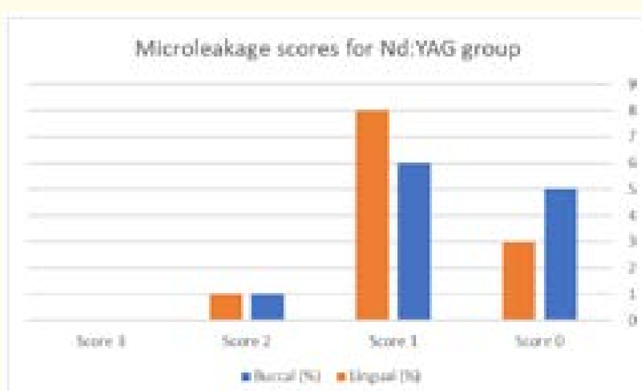

Figure 2: *Bar chart of microleakage score of Nd:Yag.*

In table 2 shows the statistical descriptions of the microleakage scoring of the dye penetration through buccal and lingual cavosurface margin for diode laser group, the dye penetrates through buccal and lingual margins recording score 0, 1 and 2 respectively, As analyzed, there were no discernible differentiation in the microleakage scores at buccal and lingual margin for diode laser group (Figure 3).

	Buccal (%)	Lingual (%)	Kruskal-Wallis ANOVA	P
Score 0	6 (60)	7 (70)	0.22	0.84
Score 1	5 (50)	4 (40)		
Score 2	1 (10)	1 (10)		
Score 3	0	0		

Table 2: *Microleakage scores for diode laser group.*
**Significant at P ≤ 0.05.*

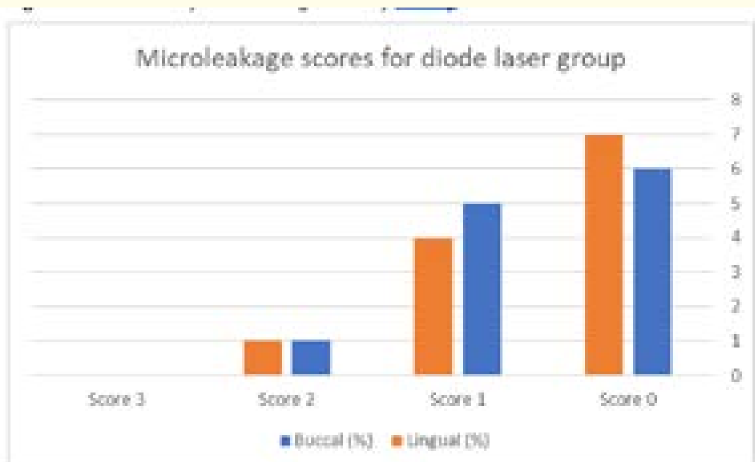

Figure 3: *Bar chart of microleakage score of diode laser.*

The dye penetrates through surface margins recording score 0, 1 and score 2 respectively, as analyzed there were no discernible differentiation in microleakage scores at buccal and lingual margin between Nd:YAG and diode laser groups (Figure 4).

Scanning electron microscope assessment

Based on results of SEM presented that surface effect of diode laser 980 nm when applied at the margins of the composite restoration (Figure 5). A clear gap at the periphery of composite restoration and enamel margin at the buccal surface denoting an increased dose of laser effect on that spot due to the hand movement with the fiber tip delivery. Also, another gap at the lingual surface was there denoting

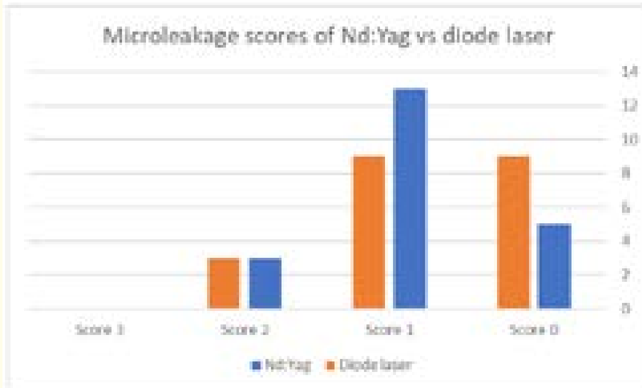

Figure 4: *Bar chart of microleakage score of Nd:Yag vs diode laser in overall surface (Both buccal and lingual margins).*

	Nd:Yag	Diode laser	Kruskal-Wallis ANOVA	p
Score 0	5	9	5.22	0.79
Score 1	13	9		
Score 2	3	3		
Score 3	0	0		

Table 3: *Microleakage scores of Nd:Yag vs diode laser in overall surface (Both buccal and lingual margins).*
**Significant at P ≤ 0.05.*

slight composite shrinkage leaving this gap. The measurement of the gap that extends along the path of laser applied movement which is about a third the spot size of the laser fiber tip (320 µm). Figure 6 shows an axial gap separating composite from the dentin with an average width of 4 µm, this gap was clear with high magnification of X1000. This gap does not extend from the margin till the axial wall of the composite cavity, which might be due to the differentiation in coefficient of expansion between dentin and nanofilled composite, as a reaction to the rapid heating effect of the diode laser. Figure 7 shows the gap with the area of destruction and loss of composite structure that appears also to be superficial.

Discussion and Conclusion

Microleakage was assessed by dye penetration. This is a commonly used method to test the integrity of adhesively bonded tooth restorations [25].

External stress from biting and internal stress from polymerization shrinkage cause slight leakage of composite restorations. These stresses can affect material properties by opening the edges and deforming the teeth [26,27]. Shrinkage stresses in composites vary with type and level of filler content. In general, polymerization shrinkage should be reduced by increasing filler content. Here, shrinkage of

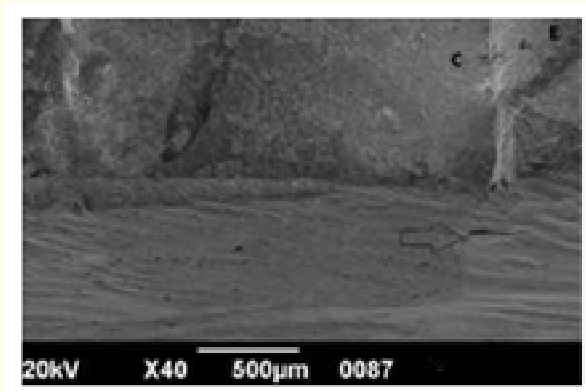

Figure 5: *Scanning electron micrograph showing a gap at the periphery of composite restoration at the buccal surface X40. E= Enamel, C= Composite.*

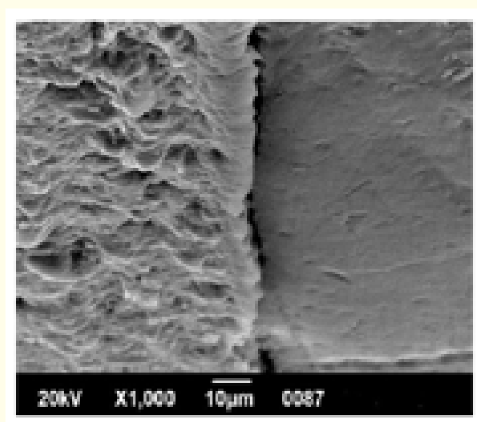

Figure 6: *SEM showing the axial gap which shows separation of composite from the dentin X1000.*

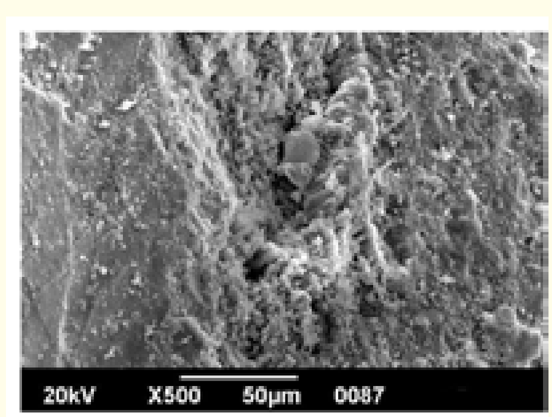

Figure 7: *SEM micrograph of the gap with destruction of the composite.*

the polymer matrix determines the amount of polymerization shrinkage [28]. Additionally, high filling levels increase the stiffness of the composite. According to Hooke's law, higher stiffness increases stress for a given shrinkage strain. Thus, stiffness and shrinkage play an important role in composite restoration stress generation [29,30].

Normally, diode laser radiation is poorly absorbed by hard tooth tissue, allowing light to propagate, scatter, or diffuse through dentin [31,32].

The term microleakage refers to leaks that are clinically undetectable accumulation of bacterial and ions between cavity wall and filling material [33]. In root canal treatment, the frequent use of diode lasers has been reported to overcome the problems of insufficient penetration of antiseptics, removal of smear layers created by instruments, and their antibacterial activity [34]. Lee., *et al*. laser irradiation through 500 μm dentin discs eliminated 97.7% of *Streptococcus mutans*, compared to 54% reduction in bacterial counts when chlorhexidine was used, demonstrating greater efficacy of the diode laser [35]. Application of Nd:YAG by Obeidi., *et al*. [36] from the laser (1094 nm) to energy of laser beam. According to Kwaguchi., *et al*. [37], small microleakages in composite resin restorations were not affected by near-infrared Nd:YAG lasers. The Nd:YAG laser was found to minimize microleakage in composite restorations by Navarro., *et al* [38].

Nd:YAG lasers and photodynamic therapy have been found to maintain marginal microleakage of composite resin restorations when used for cavity disinfection by Savadi Oskoee., *et al* [39]. Due to priority of our studies on enamel using the high power diode laser effect on marginal integrity of composite restoration on class V, there were lack of researches to revert our results of the microleakage assessment revealed by the dye penetration scoring between the dental composite and the tooth enamel interface, there were no discernible difference in the microleakage scores at the buccal and lingual margin between Nd:YAG and diode laser groups. Red and near-infrared laser wavelengths are poorly absorbed by tooth minerals. Due to the low absorption coefficient of enamel (< 1 cm^{-1}), light wavelengths in this range pass almost completely through the enamel, resulting in minimal absorption and low scattering coefficient (400 - 15 cm^{-1}). optimally transmitted and scattered by the enamel [40].

This low absorption coefficient of diode laser wavelengths in dental enamel can show great advantage as causes a quick rise during exposure in surface energy and rapid temperature loss after cessation. As a result, it performs necessary act, but at the same time does not pierce deep, so it not affects the pulp and underlying structures [41].

Our results showed a gap that does not extend from the margin till the wall of the composite cavity, similar to gaps found in Nermin MY., *et al*. study which might be due to increased degree of conversion of the nanocomposite used in tiny areas in addition to the increased enamel surface temperature to 67°C while intra-pulpal increase only 1°C [41], causing shrinkage and difference in the marginal adaptation.

Areas showing filler particles and melted fibers, with areas of melting and clumping resolidified composite resin, and intact enamel and scarce composite debris on the surface, are due to the difference in coefficient of absorption between enamel/nanocomposite and dentin/nanocomposite, when diode laser hits the enamel surface and reaching dentin [42].

The utilization of the high power diode laser at 980 nm and Nd:YAG in current study not affect microleakage at enamel/nanocomposite margins in a significant manner and mostly an intact enamel. It is proposed that more research might be done by implementing the conditions and aging to determine the time factor on the marginal integrity [43].

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