Original Article

Comparative Evaluation of Microleakage of Type IX Glass Ionomer Cement and Nano-Ionomer Cement Restoration, in Cavities Prepared by Erbium: Yttrium, Aluminum, Garnet Laser and Conventional Bur Method: *In vitro* Study

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Abstract

Background: A major goal of restorative dentistry is the maintenance of a marginal seal over a long period. One of the main problems in adhesive restorations is the lack of suitable adhesion to the tooth structure and microleakage between the tooth and the fi lling material. This seal can be affected by various factors, including adhesive bonding to the tooth structure, linear coeffi cient of thermal expansion, curing shrinkage, and water sorption. Longevity and stability of the treatment are the most important factors in the success rate. Providing chemical bonding between the filling material and the enamel or dentin tissue is another concern Aim: The purpose of this study was to assess and compare the Microleakage of Type IX Glass Ionomer Cement and Nano Ionomer Cement in Class V Cavities prepared by Er-YAG Laser and Conventional Bur Method. **Objectives:** This study compared the microleakage of Type IX Glass Ionomer Cement and Nano Ionomer Cement and Nano Ionomer Cement in Class V preparations done by Er-YAG Laser and Conventional Bur Method. **Materials and Methods:** Forty-four multirooted freshly extracted primary second molars were taken. Class V cavities were prepared on the buccal surface of each tooth. The cavity was standardized in the following dimensions: mesiodistal length of the cavity: 3.0 mm, occlusocervical width: 2.0 mm, and depth: 1.5 mm. The teeth were randomly divided into four groups. Three thousand cycles of thermocycling was used in this study to simulate oral conditions. **Results:** The microleakage of restorations was evaluated by measuring the dye penetration (1% Methylene Blue) under a stereomicroscope at x10 magnification at the lab, along with the image analysis software for the maximal dye penetration from the enamel margins. The value of the sections of the tooth was calculated in mm and subjected to statistical analysis.The comparison of the 4 experimental groups and the control group for apical microleakage was done using SPSS Software. Analysis of variance (ANOVA) and Post-HOC tests was performed. **Conclusion:** The results of the present study showed that nano-fi lled resin-modifi ed glass ionomer is more advantageous than high-viscosity glass ionomers from the perspective of effective marginal sealing in Class V cavities, irrespective of the mode of cavity preparation.

Keywords: Class V cavities, microleakage, nano-ionomer, resin-modified glass ionomers cement

Introduction

Microleakage continues to be one of the major concerns around cavities restored with esthetic materials in the field of restorative dentistry.[1] The interface separating the tooth and the restoration is a susceptible area for microleakage.[2] This causes hypersensitivity, discoloration of restoration, secondary decay, pulpal insult, and accelerated breakdown of restorative materials. Hence, advancement in the adhesive restorative materials and the restorative methods is a great step forward in solving this problem.

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Caries removal has greatly changed from historical times, i.e., use of laser in dentistry, and infrared laser has substituted the conventional methods of cavity preparation. Different types

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of lasers, i.e., erbium:yttrium, aluminum, garnet (Er:YAG), carbon dioxide laser, neodymium-doped yttrium aluminum garnet, and argon are extensively used in dentistry due to their unique properties. Two wavelengths, the Erbium, chromium-doped yttrium, scandium, gallium and garnet(Er,Cr:YSGG) at 2780 nm and Er:YAG at 2940 nm, are successfully used for treating dental hard tissues.[3-5]

Thus, this study is posed to evaluate *in vitro* the microleakage of glass ionomer cement (GIC) and nano-ionomer cement in Class V cavities prepared using Er-YAG laser and conventional bur method.

Methodology of the Study

Forty-four multirooted freshly extracted noncarious primary second molars were collected and the teeth were debrided and placed in 0.1% thymol solution to prevent the growth of mold and bacteria. Cylindrical blocks of putty were made to stabilize the teeth during the cervical cavity preparation. On the facial surface of each tooth, cavities were prepared. The cavity will be standardized in the following dimensions as shown in Figure 1:

- Mesiodistally: 3.0 mm
- Occlusocervically: 2.0 mm
- Occlusopulpally: 1.5 mm.

For specimens in Groups I and II, Class V cavities were made using a straight fissure diamond bur (Mani SF 41) under water spray using air-rotor according to the dimensions mentioned. After every five preparations, new burs were used. The prepared cavities were checked for uniformity using calibrated William's periodontal probe. For specimens in Groups III and IV, Class V cavity preparation was done using a short-pulsed laser, Er-YAG laser (AT Fidelis, Fotona Laser, USA) with output energy of 300 mJ at 10 Hz and 3 W power, emitted at a wavelength of 2.94 µm under spray coolant. The diameter of the laser beam at the tooth surface was 2.0 mm, and a handpiece (2051) with a removable tip attached to the flexible delivery system was used.

Sterilization of instruments was carried out Class B front loading autoclave as shown in Figure 2. Cements were assigned to the respective groups, manipulated using manufacturer's instructions, and placed into the prepared cavities. Finishing and polishing of the restorations were done using GIC finishing burs (Shofu) as shown Figure 3.

Selected teeth were divided into 4 groups acoording to the method of cavity preparation as shown in Table 1.

Preparation and processing of samples for dye penetration

The specimens were then painted with three layers of nail paint excluding the apical 1 mm. The specimens were kept in

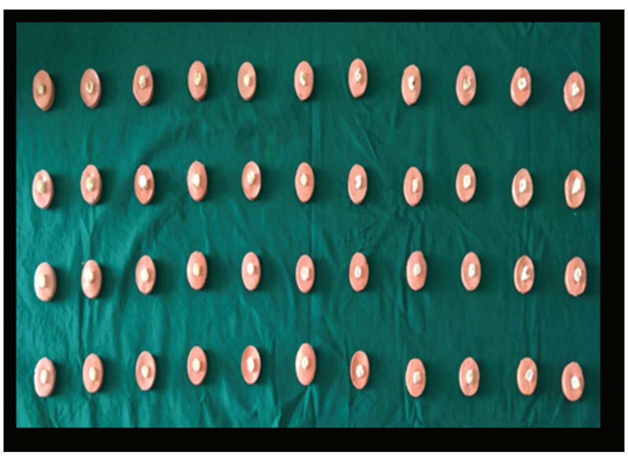

Figure 1: Mounting of samples.

Figure 2: Sterilization of teeth and instruments.

Figure 3: Restorative materials. 1. GOLD LABEL 9, GC Corporation, Tokyo, Japan. 2. Ketac™ N100 Nano Ionomer Restorative, 3M ESPE, USA

Figure 4: Stereomicroscope.

1% methylene blue dye for 3 days and then rinsed for 15 min under running water.

Sectioning of the samples

Clear acrylic blocks were made to stabilize the teeth; they were sectioned longitudinally in a buccolingual cross-section using a double-sided carborundum disc. The section of teeth showing maximum dye penetration was considered for examination under a stereomicroscope (Vardhan, India) at a magnification of ×10 in the laboratory, along with the image analysis software to determine the microleakage in millimeters as shown in Figure 4.

Discussion

Maintenance of a marginal seal over a long period is a major goal of restorative dentistry.[6] The main problem in adhesive restorations is the lack of suitable cohesion to the tooth and microleakage between the tooth and the filling material.[7] This seal is affected by a variety of aspects, including adhesive bonding to the tooth structure, linear coefficient of thermal expansion, curing shrinkage, and water sorption. Providing chemical bonding between the filling material and the enamel or dentin tissue is another concern. Saliva along with microorganisms may percolate into the interference between the tooth and filling materials which results in tooth discoloration, recurrent caries, failure of restoration, and sensitivity of pulp after treatment.[8,9]

Thermocycling was done to simulate oral conditions; past studies range from 300 to 5000.

The Er,Cr:YSGG at 2.78 m and Er:YAG at 2.94 µm are two wavelengths, successfully used for treating dental hard tissues. Erbium laser for cavity preparation and caries removal dates back to 1989. Hibst and Keller first discussed its cutting ability on human teeth. Olivi and Genovese approved its effectiveness in cavity preparation and carious tissue removal, discussing the optimal parameters for its use. Scanning electron microscopic images of laser prepared cavities showed no smear layer, exposure of enamel rods, and open dentinal tubules, which are suitable for retention of adhesive materials.[10]

In children, obtaining proper field isolation is difficult; therefore, selecting the proper adhesive restorative material and bonding system is of primary importance. Light-cured resin-modified glass ionomers (RMGIs) or hybrid ionomers were introduced to overcome these shortcomings. RMGIs have a command set, longer working time, superior appearance, better translucency, and higher strength compared with the conventional GICs.[11,12]

A nano-structured material exhibits unique properties as compared to macroscale and offers more technological benefits. Their properties are attributable to their molecular size that range in the scale of 1–100 nm in dimension. When the size decreases, optical character gets enhanced. To achieve materials with the greatest efficiencies, these unique properties obtain the greatest focus during research. Due to a command set light initiation, the material has superior initial bond strength and reduced susceptibility to moisture and dehydration.

In 2007, Ketac Nano (KN) N100 (3M ESPE) was introduced; Nano-particle-filled RMGIC is developed by the addition of nano particles (100 nanometer compared to 30 microns in traditional GIC, which is equivalent to 30,000 nm) to RMGI materials. The addition of nano particles to Ketac Nano would

Table 1: Methods of cavity preparation for class V

Groups	Cavity Preparation	Restorative System	Manufacturer
I	Bur Preparation	Glass Ionomer Cement	Gold Label 9
II	Bur Preparation	Nano Ionomer Cement	Ketac N100 Nano Ionomer Restorative
III	Er-YAG Preparation	Glass Ionomer Cement	Gold Label 9
IV	Er-YAG Preparation	Nano Ionomer Cement	Ketac N100 Nano Ionomer Restorative

Table 2: Mean microleakage in mm of Type IX Glass Ionomer Restorations in Class V Cavities prepared by Conventional Bur Method (Group I), Er-YAG Laser (Group II) and Nano Ionomer Cement prepared by Conventional Bur Method (Group III) and Er-YAG Laser (Group IV)

Groups	*n*	Microleakage (Mean)	Standard Deviation	Std. Error Mean
Bur with GIC	11	1.7978	0.65527	0.19757
Er-YAG Laser with GIC	11	1.3700	0.48222	0.14540
Bur with Nano Ionomer	11	0.6718	0.22627	0.06822
Er-YAG Laser with Nano Ionomer	11	0.6482	0.29969	0.09036

Table 3: Mean microleakage in mm of inter-groups and intra-groups obtained via *Analysis of Variance* (ANOVA).

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.399	3	3.466	17.269	0.000
Within Groups	8.029	40	0.201		
Total	18.429	43			

be expected to provide an improved finish and a smoother, more esthetic restoration without adversely affecting other advantageous properties, including fluoride release, adhesion to enamel and dentin, high early bond strength and less susceptibility to moisture and dehydration.

In this study, no material completely eliminated microleakage. Dye penetration scores of the two glass ionomer materials revealed a significant difference in the leakage values. Nano-ionomer demonstrated lesser microleakage when compared to Type IX GIC in both methods of cavity preparation. Nano-ionomer cement had the lowest leakage when the Er-YAG Laser was the mode of cavity preparation, with a mean score of 0.65 mm [Figures 5-8 and Tables 2 and 3].

Results of the present study were similar to results obtained by El Halim *et al.*, Sumitha *et al.*, and Diwanji *et al.*,[13] who observed that nano-ionomer showed the least microleakage under *in vitro* conditions. Perdigao *et al*.[14] also observed good marginal adaptation of nano-ionomer than RMGIC, clinically after 1-year follow-up in noncarious cervical lesions. Good sealing ability of nano-ionomer could also be related to high filler loading and lower coefficient of thermal expansion, which withstands the polymerization contraction stresses. Srirekaha *et al*., in a three-dimensional finite-element analysis, observed that nano-ionomer developed the lowest stresses in the gingival third of the tooth.[15]

In our study, the maximum values of microleakage were associated with the teeth that were restored by Type IX GIC in cavities prepared by the conventional bur method, with a mean microleakage score of 1.79 mm. In the present study, Type IX glass ionomer showed more microleakage and was less consistent. Mali *et al*. found similar results with more microleakage with conventional glass ionomer as compared to resin glass ionomer and composite [Tables 2 and 3].

Dehydration of Fuji IX is controlled by the presence of tubular fluid in dentin. Brackett *et al.*[16] stated that continuous outward flow of fluids from the freshly cut dentin increases the wetting of dentin, improves hydrated gel phase during solidification, and allows self-repairing process. In nano-ionomer, smaller

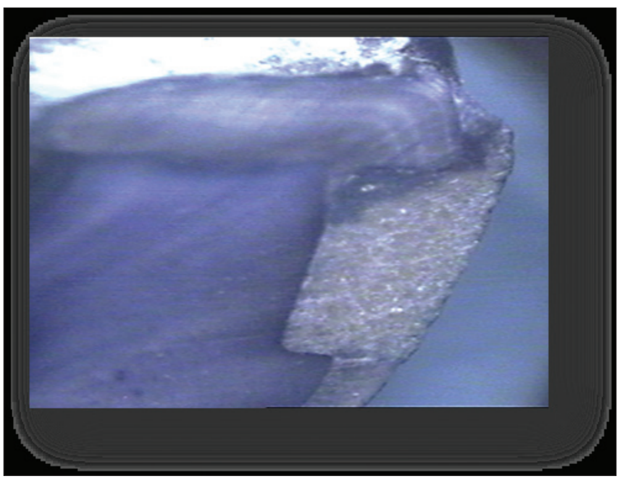

Figure 5: Steriomicroscopic image of dye penetration seen in bur with gic.

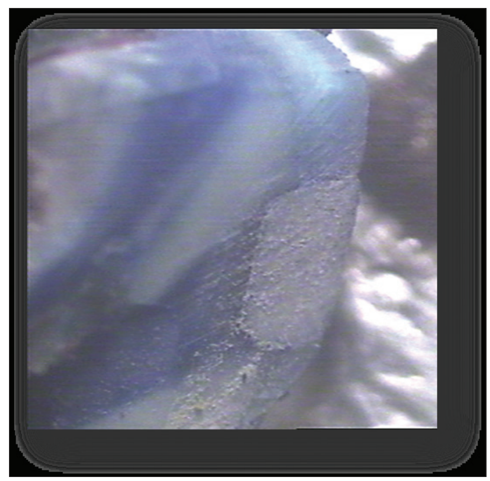

Figure 6: Steriomicroscopic image of dye penetration seen in laser with gic.

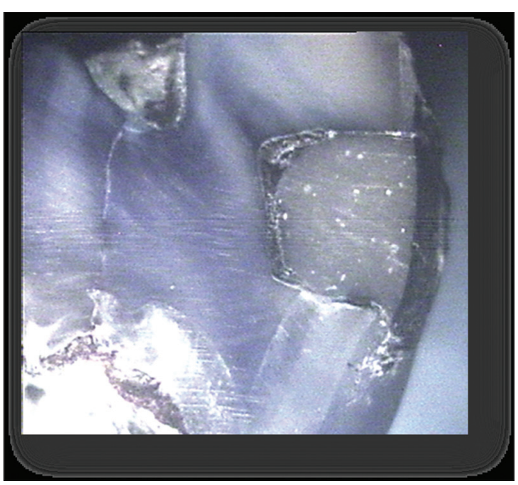

Figure 7: Mixing pad, 4. Agate spatula, cement carrier, cement condensers, 5. Composite finishing burs (SHOFU), 6. Light-curing unit (Confident, India), 7. Contra Angle Handpiece (NSK, Japan), 8. Putty Impression Material (3M ESPE, USA).

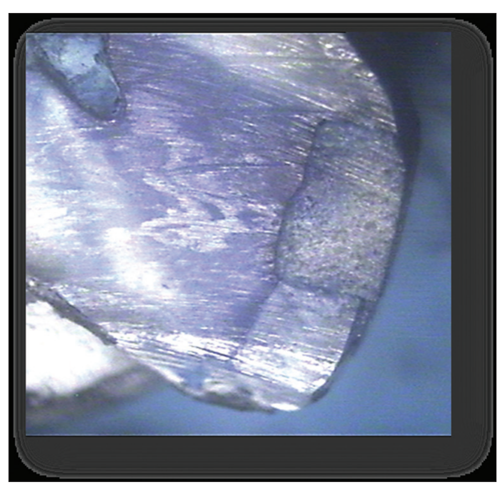

Figure 8: Erbium-yttrium aluminum garnet laser (AT Fidelis, Fotona Laser, USA).

particle size may have provided more surface area and better flow of the material, resulting in better adaptation with tooth interface. Incremental layer technique for the placement of KN 100s may have resulted in better adaptation, leading to reduced microleakage.

Our study could not show a statistically significant difference in microleakage between cavities prepared by diamond bur and laser in the primary teeth. Similar observations were made by Rossi *et al*.[17] and Yamada *et al*.[18] Further, the results of Quo *et al*., Navarro *et al*., Aranha *et al*., Niu *et al*.,[19] and Wright *et al*. were in a good agreement with those of our study, but they used composite for restoration of permanent teeth. Kohara *et al*.[20] found a lower microleakage by laser.

In the current study, as similar to the study by Niu *et al*.,[19] all margins of the restored Class V cavities were located in enamel. Some of these factors are the type of prepared cavity, the cavity size, the type and energy level of laser, the restoration material, the method of microleakage evaluation, the type of dye used for microleakage measurement, the study design (clinical or experimental), and the person who prepares the cavities.

Conclusion

The results of the study suggest that Nano-filled resin-modified glass ionomer cement demonstrated the least microleakage and proved to be better than the conventional glass ionomer cements in class V cavities with better efficacy in terms of cavity sealing.

Er:YAG laser with its advantages in pediatric dentistry may be suggested as an alternative device for cavity preparation. Further clinical studies are necessary to find the new generation of restorative materials that can best interact with laser prepared surfaces.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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