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Research Article

A COMPARATIVE EVALUATION OF MICROLEAKAGE AND MARGINAL GAP FORMATION WITH GLASS IONOMER CEMENT, SILVER AMALGAM AND COMPOSITE RESIN RESTORATIONS (AN *IN-VITRO* STUDY)

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ABSTRACT

This study was envisaged to find out a material, which can ideally adhere to tooth surface and eliminate or at least minimize the gap at the tooth-restoration interface, a prime etiological factor of microleakage and resultant secondary dental caries leading to failure of the restorations with three dental restorative materials viz. Glass ionomer cement, silver amalgam and light curable composite resin. This was accomplished by evaluating and comparing microleakage and marginal gap formation in seventy-five human permanent posterior teeth using these three dental restorative materials. The tooth samples were divided into three groups each having twenty-five teeth and restored with one of the three materials. They were thermo-cycled and submerged in methylene blue dye then sectioned to test microleakage and marginal gap formation. The data thus obtained were subjected to statistical analysis. The scores were calculated using ANOVA test and statistical data were compared cross-sectionally. Results showed microleakage at tooth-restoration inter phase with all the materials. They were found in the following decreasing order: group B (SA) > group C (CR) > group A (GIC). Hence, GIC was found best followed by CR and SA

INTRODUCTION

The increasing trend of much sticky and refined sugars and curtailment of fibrous foods in the diet have largely contributed to the incidence and prevalence of dental caries. Simultaneously, a number of dental restorative materials have globally been investigated to fill into the formed cavity but none of them has been proved 'ideal' which can absolutely adhere to the tooth surface without exhibiting any micro leakage. Three properties of the restorative materials that contribute significantly to microleakage are; coefficient of thermal expansion, polymerization shrinkage and adhesion. A good marginal adaptation of the restorative materials decreases considerably the microleakage, the post-operative sensitivity and the secondary caries occurrence; therefore, improving the longevity of the fillings (Yoshikawa T *et al*., 2001)

and failure to prevent microleakage may contribute to post operative pain, sensitivity, recurrent caries, marginal staining and possible pulpal pathology (Berry FA and Tjan AHL, 1994) jeopardizing the clinical longevity of restoration. Therefore, marginal seal of the restorative material to the cavity wall is the crucial factor for long-term performance of any restoration. The prevent *in-vitro* study has been designed to evaluate and compare microleakage and marginal gap formation in seventy five human permanent posterior teeth with three dental restorative materials *viz*. silver amalgam (SA), glass ionomer cement (GIC) and light cured composite resin (LCCR) routinely used in pediatric dental practice in an effort to find out a material showing no or minimal microleakage.

MATERIALS AND METHOD

Seventy five permanent posterior teeth were collected for the study from paedodontic and exodontic clinics of faculty of dental sciences, King George's Medical College, Lucknow that were extracted for their periodontal afflictions, fixed orthodontic problems that required extractions and oro-surgical

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problems that necessitated extractions. Care was taken to select sound teeth without any carious lesions, fractures or existing restorations. The apices of the roots were hermetically sealed with silver amalgam prior to preparation of the cavities.

The tooth samples were thoroughly cleansed under running tap water to remove any necrotic debris saliva or blood etc. and stored in normal saline at room temperature. Class -I cavities were prepared in the tooth samples. They were then divided into three experimental groups containing twenty-five samples in each group. All the samples of each group were restored with one of the three experimental dental restorative materials according to manufacturer's recommendations.

The experimental groups were divided as follows:

Group A: Teeth restored with GIC. (Shofu FX Inc. Japan)
Group B: Teeth having SA restorations. (Heraeus Kulzer Dental India Pvt. Ltd.)
Group C: Teeth having LCCR restorations. (Super composite, Germany)

After restoration with different materials, the teeth were placed in separate test tubes and thermocycled. In each case, they were separately soaked in water bath at 5^0C and 55^0C using a dwell time of forty seconds. A total of three hundred cycles were used for all tooth specimens. The root surfaces and adjacent enamel of each sample were coated with nail varnish excluding the restoration and approximately two millimeters of the periphery of the restoration. The samples were then submerged in one percent methylene blue dye for twenty-four hours at room temperature. After removal from the dye, the samples were thoroughly cleansed and rinsed with tap water. Each crown was sectioned bucco-lingually with diamond cutting disc (0976, SS White) mounted on a slow speed handpiece. The sections were stored in hundred percent humidity before being examined under binocular microscope for dye penetration. The samples were then prepared for scanning electron microscopic study (Leo model-430, Gold plating device- Polaron SC 7640) to evaluate marginal gap formation.

Microleakage and marginal gap formation were evaluated according to the criteria given below and data were subjected to statistical analysis.

Microleakage

Score 0 - No dye penetration along tooth-restoration interface.
Score 1 - Dye penetration up to the half of the tooth-restoration interface.
Score 2 - Dye penetration more than half but less than full length of the tooth-restoration interface.
Score 3 - Dye penetration reached full length of the tooth-restoration interface.
Score 4 - Dye penetration reached the bases of the prepared cavity.

Marginal gap formation: Marginal gap formation was measured according to the criteria of scanning electron microscope.

Statistical analysis of the available data was carried out to ascertain the level of significance of various observations. Mean and standard deviation were first calculated and then to test quality of more than two mean scores, Analysis of Variance (ANOVA) test was used and to see the relation between two variables, the correlation coefficient was calculated.

RESULTS

All the groups showed microleakage (Table-1) and marginal gap formation with least in the group A (samples restored with GIC) and most in group B (samples restored with SA). They were found in the following increasing order:
group A<group C< group B

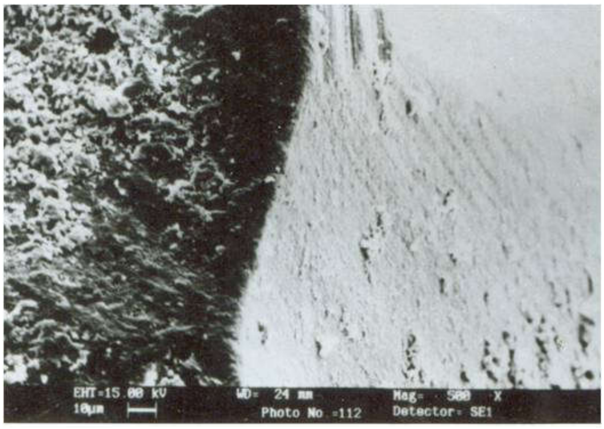


Fig 1 SEM microphotograph showing GIC restoration- tooth interface with no marginal gap formation at 500X magnification

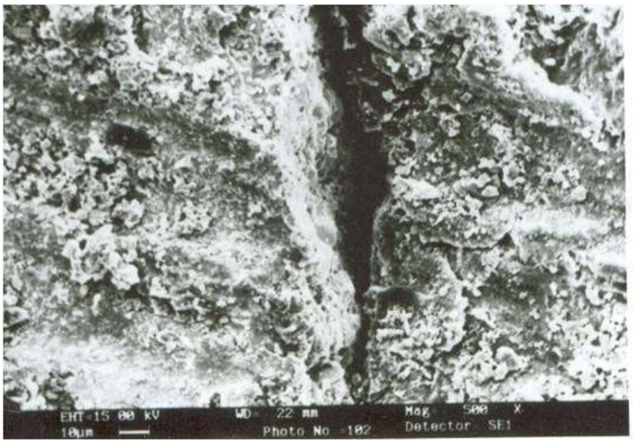


Fig 2 SEM microphotograph showing silver amalgam restoration-tooth interface with marginal gap formation at 500X magnification

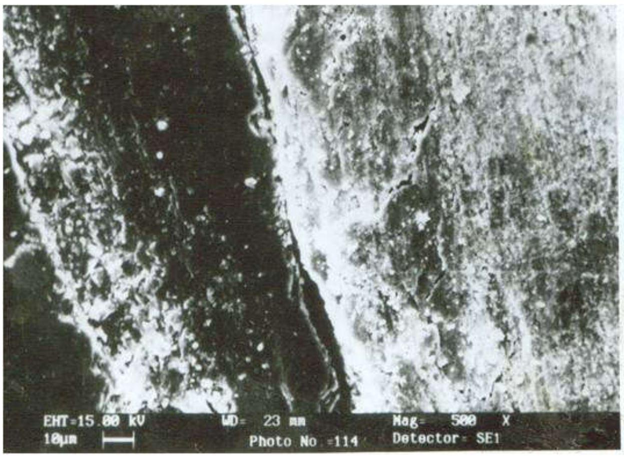


Fig 3 SEM microphotograph showing composite resin restoration- tooth interface with little marginal gap formation at 500X magnification

Table 1 Microleakage in the samples as per scores given

Group	S-0	S-1	S-2	S-3	S-4
Group-A GIC	21	2	2	0	0
Group-B SA	10	9	5	1	0
Group-C LCCR	18	4	3	0	0

Table 2 Analysis of microleakage/marginal gap (in µ) in various groups

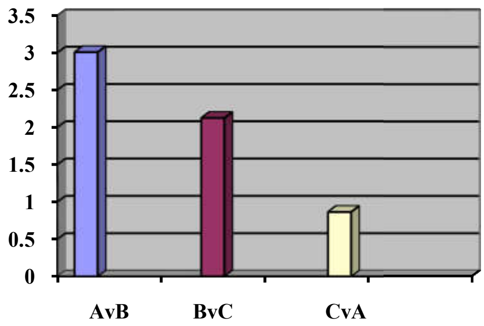
Group	A	B	C
N	25	25	25
Mean	0.2400/0.6400	0.8800/2.0800	0.4000/0.6800
S.D.	0.5972/1.6299	0.8813/2.7677	0.1091/1.7729
S.E.	0.1194/0.3259	0.1763/0.5535	0.1414/0.3545

N= Number of samples SD = Standard deviation S.E = Standard error

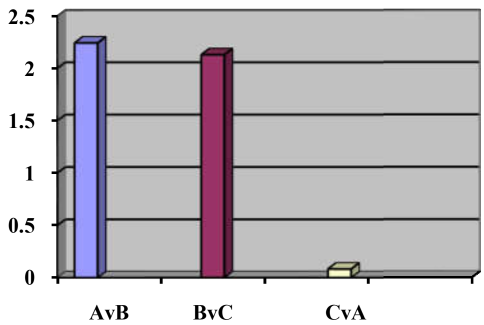
Table 3 Comparison of microleakage/marginal gap (in µ) in various groups

Comparison	't'	'p'
AvB	3.0059/2.2416	p<.01/p<0.05
BvC	2.1241/2.1297	p<0.05/ p<0.05
CvA	0.8643/0.0830	NS/NS

t= Student 't' test, p= probability factor, NS = not significant, p<0.01 = Significant



Comparison of microleakage in different groups



Comparison of marginal gap in different groups

DISCUSSION

The present study was undertaken to evaluate microleakage and marginal gap formation with three dental restorative materials generally used in pediatric dentistry *viz.* GIC, SA and LCCR. GICs are materials that combine characteristics such as adhesiveness to the dental structure, biocompatibility, and antimicrobial and anti-cariogenic potential through constant fluoride release (Crisp S, 1976; Donavan TE and Daftary F, 1987) but their strength is the disadvantage, which precludes its use in load bearing areas. The silver amalgam has excellent physical properties and is most extensively used restorative material in dental practice but it is unesthetic and amalgam affords no adhesion to the walls of the cavity preparation (Andrews JT and Hembree JH, 1975; Derkson GD *et al*, 1986). The use of posterior composite restorations is increasing because of esthetic demands by the general public (Bala O *et al*, 2003) despite their higher costs and shorter longevity in comparison with amalgam and gold (Yip KH *et al*, 2003). One of the major disadvantages of restoring posterior teeth with composite resins is the lack of adaptation of the material to tooth structure, particularly at the gingival margin (Sadeghi M, 2007).

In the present study, the class I cavity was prepared in the posterior teeth because in children aged 5-17, 56-70% of all dental lesions are occlusal caries (Pardi A *et al*., 2006). The tooth samples were subjected to thermo-cycling, which is defined as *in- vitro* process of subjecting a restoration and teeth to temperature extremes that conform to those found in the oral cavity (Alani AH and Toh CG, 1997) to simulate aging process in restorations *in-vivo.* A total of three hundred cycles between 5º and 55ºC water baths using a dwell time of forty seconds were used. Fraser CJ in 1929 (12) suggested the possible importance of variation in temperature on marginal adaptation of restorative materials but according to Doerr *et al*. thermo-cycling does not affect dye penetration (Doerr *et al*., 1996). In the present study methylene blue in one percent aqueous solution was used to demonstrate the microleakage around various materials since the use of dyes to measure shrinkage dates back to as early as 1895, when Fletcher used them to study the shrinkage of amalgam (Blackwell RE,1955). The penetration of a dye, although not an absolute measure, can indicate the lack of a perfect seal (V. Srinivasan C and Deery Z, 2005). Ahlberg *et al* in1995 compared methylene blue to Indian ink dye and reported superiority of methylene blue as a tracer of microspaces and as an accurate method of leakage measurement when used in passive dye penetration (1). Methylene blue has a smaller molecular weight than bacteria, which may not simulate the clinical situation (Kersten HW and Moorer WR, 1989). The specimens were soaked in the dye for twenty-four hours as affirmed by Roger Smales RJ in 1997 (21). Prati *et al* in 1989 reported that dentin/enamel chemical pretreatments is an important step for all composite resin and GIC restorations to prevent marginal microleakage as it removes the smear layer and other debris, thereby, providing a cleaner surface for stronger bond between the material and the restorative surface (18). In the present study, to attain clean and smooth surfaces each crown was sectioned bucco-lingually with diamond cutting disc mounted on a slow speed hand piece. The diamond-cutting disc provides smooth sections without chipping off the restorative material from the tooth surface. A slow speed handpiece was used to get a better control over the sectioning and preventing any vibrations as well as desiccation of the specimens as seen with high speed. Moreover, ten percent polyacrylic acid was used as a conditioner prior to GIC restorations while both etchant and bonding agent were used before the restoration of tooth samples with composite resin to achieve stronger bond between the material and restorative surfaces.

In this study, all groups evaluated showed microleakage as seen in Table 1. This finding was in accordance with those reported by Theodoridou-Pahini *et al*. in 1996 (22), Gladys *et al*. in 1998 (13) and Mali P *et al*. in 2006 (16) who stated that microleakage can be expected with all restorative materials.

Khan *et al* in 1998 (15) studied to investigate microleakage at class I cavities filled with amalgam, composite resin, or glass ionomer and assessed microleakage at the restored cavities by the dye penetration method and scanning electron microscopy (SEM). The results showed that minimal or moderate leakage was evident at most of the composites resin or GI restorations, whereas moderate or severe leakage was observed at most of the amalgam restorations. This study is in agreement with the present study in which glass ionomer cement and light cured composite resin showed less leakage than silver amalgam. Salama FS *et al*. in1995 (20) carried out a study to compare microleakage and marginal gap formation of three light cured glass ionomer cements (LCGI). In their study, marginal gap formation was found only in one light cured glass ionomer cement. This study again showed an agreement with the present study in which marginal gap was seen in very few teeth restored with glass ionomer cement.

It must be recognized, however, that application of the restorative materials *in-vivo* is more difficult than their application *in-vitro* on extracted teeth. Since a dry enamel surface is necessary to achieve good adhesion, an adequate seal *in-vivo* is unquestionably difficult to attain as contamination during swallowing and tongue movement is possible (Bodur H *et al*., 1999) and *in-vitro* conditions can not be simulated to *in-vivo* conditions despite all efforts that too vary greatly patient-to-patient, time to time and diet to diet. There are many diverse methods of demonstrating the microleakage of restorative materials with each technique having its own pros and cons, however, the consequence of such a large choice of methods leads to lack of standardization between workers. Therefore, attempts are being made at developing standard scoring systems for assessment of microleakage, but these continue to be quite subjective. Hence, long-term clinical investigations are recommended to arrive at results that are more fruitful.

CONCLUSION

All the restorative materials showed microleakage and marginal gap formation. GIC showed least followed by composite resin and silver amalgam. They were found in the following decreasing order:
group B> group C> group A

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