ORIGINAL ARTICLE

Comparative Evaluation of Microleakage of Amalgam, High Viscosity and Resin-Modified Glass Ionomers as Restorative Materials in Primary Molars

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ABSTRACT

***Background and Objective*:** One of the major requisites of an ideal restorative material is excellent marginal seal. Microleakage has been identified as a significant clinical problem with filling materials. The objective of the study was to evaluate and compare the degree of microleakage of amalgam, high viscosity glass ionomer and resin-modified glass ionomer in primary molars.

***Methods*:** A total of 99 human non-carious primary molars that were liable to exfoliate within the next six months were selected. Standardized Class I cavities were prepared on occlusal surfaces of molars and randomly filled with either Amalgam (Aristaloy 21), High Viscosity Glass Ionomer (Ketac Molar) or Resin-Modified Glass Ionomer (GC Fuji II LC). The teeth were divided into nine groups (n=11 each) on the basis of filling material used and time of restored tooth extraction viz. one week, six weeks and twelve weeks. After immersion in a 2% methylene blue dye solution for 24 hours, the teeth were sectioned buccolingually in an occluso-apical direction through the middle of the restoration. The specimens were then examined under stereomicroscope at 30X magnification. Statistical analyses were performed with ANOVA and Tukey's test at 5% level of significance.

Results: Amalgam restorations had significantly less microleakage as compared to the high-viscosity glass ionomer and resin-modified glass ionomer restorations. High-viscosity glass ionomer restorations were superior in resisting microleakage than resin-modified glass ionomers. The restorative materials used can be arranged in their sealing ability from least to severe microleakage as: Amalgam <High-viscosity glass ionomer <Resin-modified glass ionomer.

Conclusion: Amalgam restorations showed less microleakage as compared to high-viscosity and resin-modified glass ionomer restorations. Amalgam may preferably be used as a restorative material of choice for primary molars.

KEYWORDS: Microleakage, Amalgam, Resin-modified glass ionomer, High-viscosity glass ionomer.

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INTRODUCTION

Dental caries continues to be one of the major dental health problems among all age groups and especially in children. The removal of dental caries and restoration of tooth should be done as early as possible to avoid large scale tooth destruction and successive pulp involvement. The ideal goal of restorative treatment in primary dentition is to preserve arch length, protect masticatory function and prevent infection in the oral cavity.[1]

Restorative materials mostly used in posterior primary teeth include amalgam, composite resin, GICs, and resin-modified GICs (RMGICs).[2] Dental amalgam has long been employed as the standard restorative material in pediatric dentistry, despite of the great advancement of new products.[3]

Glass ionomer cements are the most frequently employed alternative to dental amalgam for restoring deciduous teeth.[4] The main features are the capability to chemically adhere to enamel as well as dentine, thermal expansion coefficient comparable to the tooth structure, less volumetric setting contraction, biocompatibility and fluoride release giving a cariostatic action.[5]

Since the launch of glass ionomer cement (GIC), several changes have been done to its powder and liquid constituents to enhance the handling as well as physical characteristics of the set material. One such improvement was the resin-modified glass ionomer cements (RMGICs) in 1980s to overcome the drawbacks of conventional glass ionomer cements, i.e. sensitivity to moisture and inferior physical properties (mainly their initial physical strength). The resin-modified glass ionomer cements also have the advantage of conventional glass ionomers, for example the chemical bonding and fluoride release.[6]

One of the main factors which determine the longevity of dental restorations is the presence or absence of gap at tooth-restoration interface. Microleakage due to the inability of filling materials to fully bond to the enamel and dentin is one of the most significant problems of the restorative dentistry today.[7] Even though glass ionomer (GIC) is the most popular restorative material used for children, but very technique sensitive. Analysis reveals that moisture control is indispensable for the success of the restoration. Manufacturers of high viscosity glass ionomers claim improved early physical properties and resistance to dissolution over conventional glass ionomers, due to the reduction in the size of glass particles.[8] The resin component in resin-modified glass ionomers may produce polymerization shrinkage which could adversely affect marginal adaptation.[9] Most of the studies on microleakage have been carried out on *in vitro* models but the conditions are different in the oral cavity. So there was a need to conduct a study where the selected restorative materials undergo intra-oral thermal changes and functional stresses before the degree of microleakage can be evaluated. Therefore, the current study was designed to compare the degree of microleakage of the three different restorative materials in primary molars namely: Amalgam (Aristaloy 21, Cookson, United Kingdom); High Viscosity Glass Ionomer (Ketac Molar, 3M ESPE, Germany) and Resin-modified Glass Ionomer (Fuji II LC, GC Corporation, Tokyo, Japan).The null hypothesis was that no statistically significant differences were present among the materials used.

METHODS

A total of thirty-three children aged 9 to 11 years old were selected from the outpatient department of Pediatric Dentistry Department, de 'Montmorency College of Dentistry, Lahore. Ethical approval for the study was granted by the Ethical Review Committee of Post Graduate Medical Institute, Lahore, Pakistan. The sample size was calculated at 80% power of study and 95% confidence level. Parallel group allocation (1:1), with each selected child by non-probability purposive sampling technique had at least three non-carious primary molars. The teeth were without any cracks or restorations and liable to exfoliate within the next six months, as was determined by the preoperative radiograph i.e. close to Nolla stages 7 and 8. Each selected tooth had an antagonist tooth. Written informed consent was achieved from the patient's parents after clarifying them about the research in detail. The availability of the patient for the follow up was also insured.

Standardized Class I cavities were prepared on the occlusal surfaces of the selected primary molars using diamond burs (BR-45 round bur, SF-11 straight fissure bur, SI-48 inverted cone bur, Mani Dia-Burs, Mani Inc., Tochigi, Japan) with contra-angle high speed air-rotor hand piece with constant water spray. The depth of the cavities was standardized at 1.5 mm with the help of a premeasured and marked SF-11 straight fissure bur. All the preparations were non-beveled. The completed preparations were randomly assigned to one of nine study groups (total teeth 99), each containing eleven cavities. The prepared cavities were thoroughly cleaned with water and gently air dried. The cavities were then filled with either high viscosity glass ionomer (Ketac Molar), amalgam (Aristaloy 21) or resin-modified glass ionomer (Fuji II LC), according to the manufacturer's instructions. The restored teeth were scheduled to be extracted at three different periods of time viz. one week after filling, six weeks after filling, and twelve weeks after filling. Because of longer interval between the check-up appointments, bottles of formal saline solution (10%) were given to the patient's parent, who was requested to write the date and store the tooth, in the case of spontaneous exfoliation.

To test for microleakage, all the surfaces of the tooth except the restoration and a 1 mm zone adjacent to its margins were immediately covered with two coats of nail polish. The root apices of the teeth, if any, were sealed with sticky wax to prevent dye leakage. The nail polish was left to dry for one hour. The coated samples were then immersed in 2% methylene blue dye for 24 hours at room temperature. After removal from the dye, specimens were thoroughly washed below tap water for ten minutes. Nail polish coating was stripped by peeling and scraping and wax removed. The specimens were washed again in tap water until the dye was removed from all the surfaces. The specimens were then dried, embedded in self-cure acrylic resin and allowed to set.

The teeth were then sectioned buccolingually in an occluso-apical direction through the middle of the restoration with a slow speed diamond disk under water spray. Each section was then examined under stereomicroscope (Olympus Corporation, Tokyo, Japan) at 30X magnification by two independent examiners to measure the depth of dye penetration. The degree of dye penetration was analyzed using the following 0-3 scale scoring system, previously used by Alptekin et al.[16] in their study. From both the sections of a specimen, whichever score was higher was considered as the microleakage score for that specimen. Any discrepancies in the scores of two examiners were re-evaluated by both until a consensus value was reached.

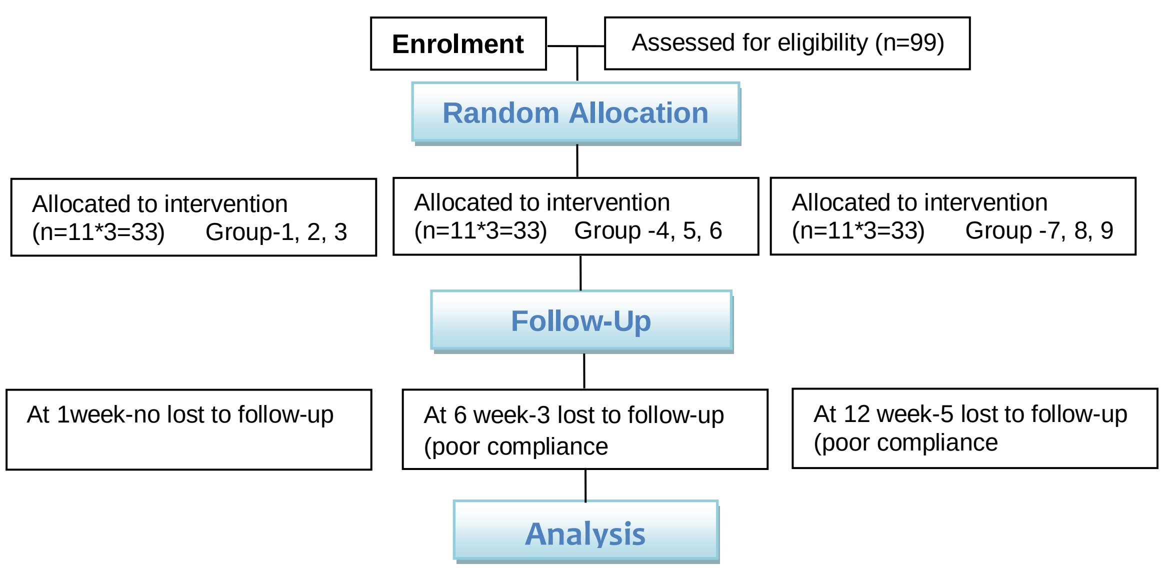

Fig.1: Diagrammatic flow showing the research work.

Scoring System used to Evaluate Dye Penetration

Score 0: No dye penetration into the enamel.

Score-1: Dye penetration limited to the enamel of axial wall.

Score-2: Dye penetration past the enamel up to the dentin of the axial wall.

Score-3: Dye penetration past the axial wall involving the floor of the cavity.

STATISTICAL ANALYSIS

The data was analyzed using commercially available statistical software package. (SPSS 20.0, SPSS Inc.). Mean ± S.D was calculated for descriptive statistics. Analysis of variance (ANOVA) was used for mean comparison at each follow up in between different groups. For pair-wise comparison, Tukey's test was applied. Repeated measure ANOVA was used for the comparison within group (comparisons within follow ups). A p-value ≤ 0.05 was considered as statistically significant. Descriptive statistics of microleakage in all groups is given in table 4.

RESULTS

The three restorative materials used (Aristaloy 21, Ketac Molar and GC Fuji II LC) showed varying degree of dye penetration. The total number of each score in each group was determined and is summarized below in Tables 1-3.

Table-1: Microleakage Scores of Restorative Materials after One Week.

Restorative Materials	No. of Samples	Microleakage Scores			
		Score 0	Score 1	Score 2	Score 3
Aristaloy 21 (Group 1)	11	9	1	1	0
Ketac Molar (Group 2)	11	5	3	2	1
GC Fuji II LC (Group 3)	11	4	3	3	1

On applying ANOVA, a significant difference in mean microleakage *(P=0.004)* was found. On applying Tukey's test, significant difference was observed in pairs like Group 1 vs. Group 3, Group 5, Group 6 and Group 9, *(P<0.05)*. There was significant difference of Group 2 with Group 7 only, *(P=0.05)*. Group 3 was significantly different with Group 4 and Group 7, *(P<0.05)*. Group 4 was significant with Group 6 and Group 9, *(P<0.05)*. Group 5 was significantly different with Group 7 only, *(P<0.05)*. Group 6 was significantly different with Group 7, *(P<0.05)*. We also found significant difference in Group 7 versus Group 8 and Group 9 *(P<0.05)*.

Table-2: Microleakage Scores of Restorative Materials after Six Weeks.

Restorative Materials	No. of Samples	Microleakage Scores			
		Score 0	Score 1	Score 2	Score 3
Aristaloy 21 (Group 4)	9	8	0	1	0
Ketac Molar (Group 5)	11	5	2	3	1
GC Fuji II LC (Group 6)	10	3	2	4	1

Table-3: Microleakage Scores of Restorative Materials after Twelve Weeks.

Restorative Materials	No. of Samples	Microleakage Scores			
		Score 0	Score 1	Score 2	Score 3
Aristaloy 21 (Group 4)	10	9	1	0	0
Ketac Molar (Group 5)	9	4	2	2	1
GC Fuji II LC (Group 6)	9	2	2	3	2

Table-4: Descriptive Statistics of Microleakage in all Groups.

Groups	N	Mean	S.D	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Group 1	11	0.18	0.40	-0.09	0.45
Group 2	11	0.91	1.04	0.21	1.61
Group 3	11	1.09	1.04	0.39	1.79
Group 4	9	0.22	0.67	-0.29	0.73
Group 5	11	1.00	1.10	0.26	1.74
Group 6	10	1.30	1.06	0.54	2.06
Group 7	10	0.10	0.32	-0.13	0.33
Group 8	9	1.00	1.12	0.14	1.86
Group 9	9	1.56	1.13	0.69	2.42

DISCUSSION

The current study evaluated the microleakage of three filling materials in primary molars using the dye penetration method. Various other methods have been used to investigate microleakage, for example, radioactive isotopes, scanning electron microscopy, neutron activation analysis, chemical tracers, electrochemical method, fluid filtration and air pressure method. However, dye penetration method is the most commonly used because of its sensitivity, ease of application and convenience.[10]

Amalgam restorations showed significantly lower microleakage as compared to high-viscosity glass ionomer and resin-modified glass ionomer restorations. This finding is similar to the findings of Bashar et al.[11] and Alperstein et al.[12] but varies from the findings of Murray et al.[13]

Amalgam is much less technique sensitive in addition to being more operators friendly as compared to the other restorative materials. The discrepancy between the quality and the physical properties of composite resins performed under laboratory conditions and those placed in the patient's mouth is much greater than with amalgam. Small deviations from the manufacturer's instructions can compromise the final outcome of the composite rein restoration, while amalgams are less affected.[14]Lower microleakage scores in amalgam restorations may be due to the use of cavity varnish.

Mahler et al.[15] in a study concluded that the existence of zinc in dental amalgam alloy results in the development of zinc corrosion products, which leads to more rapid sealing. They evaluated the microleakage weekly and found that the margins of the amalgam restorations are virtually sealed at eight weeks. Hence the low leakage scores in amalgam restorations in the current study may be related to the corrosion sealing of zinc containing amalgam alloys. Alptekin et al.[16] found no considerable differences in the microleakage scores between the lined and unlined Class I dental amalgam restorations. It was confirmed from the in vivo and in vitro assessments that microleakage was higher in composite resin restorations as compared to amalgam.

Among both the glass ionomers compared in this study, high-viscosity glass ionomer showed significantly lower microleakage when compared to resin-modified glass ionomer. This possibly is related to the fact that high-viscosity glass ionomers have comparable coefficient of thermal expansion to that of tooth substrate whereas resin-modified glass ionomers have quite high coefficient of thermal expansion as compared to that of tooth.

Resin-modified glass ionomer materials additionally have resin monomers in liquid (HEMA) along with the initiators and activators in contrast to the conventional glass ionomer cements. On mixing powder and liquid, acid-base reaction of conventional glass ionomer plus polymerization reaction of resin constituents occurs resulting in the generation of two different matrices, i.e. metal polyacrylate matrix and poly HEMA matrix. High level of water sorption increases the unwanted consequences on restorative materials. The materials that show high water sorption exhibits greater degree of expansion and they are readily colored by hydrophilic pigments, water acting as a medium for dye-penetration. Light-cured glass ionomer cement has higher affinity for water which explains its poor performance as water degrades it.[17]

GC Fuji II LC showed greater microleakage than Ketac Molar restorations. This finding is similar to the result of Masih et al.[18] andGerdolle.[19] In an in vivo study, Masih et al.[18] reported that marginal sealing of both GC Fuji II LC (Improved) and GC Fuji IX GP was similar in primary molars on the basis of the mean value of dye-penetration. However, GC Fuji IX GP revealed slightly better results, although the conclusions were statistically not significant.

Bryant and Mahler[20] found that the mix with the maximum powder: liquid ratio illustrated least contraction. According to them, this possibly showed a significantly higher proportion of each powder particle remaining unreacted in the high viscosity material mix, with a smaller amount of contracting matrix component. In tooth-colored restorations, polymerization contraction is known to be accountable for many clinical problems. The probable reason for greater microleakage of Fuji II LC in dentin could also be the complexity in bonding to dentin due to the intricate histological organization and inconsistent composition of dentin. Dentin on average is only 45% inorganic hydroxyapatite by volume while enamel is 92% inorganic. Dentinal hydroxyapatite is haphazardly organized in an organic matrix whereas the hydroxyapatite crystals in enamel have regular arrangement. Moreover due to the seepage of fluid out of the dentinal tubules and capillary pressure, the resin infiltration is not far.[20]

The present study finding of more

microleakage with resin-modified glass ionomers than high-viscosity glass ionomer is however, inconsistent with studies. This may be due to the fact that the above studies were carried out in in-vitro conditions where different experimental conditions may have contributed to the difference of results. A study compared the marginal property of Class II composite resin restorations under *in vitro* and in vivo conditions. Results revealed that microleakage was observed in all in vivo samples, but only in 60% of the *i*n vitro samples. Thus, significantly more microleakage was observed in restorations placed in vivo in contrast to in vitro.[21]

Though amalgam restorations demonstrated less microleakage than both high-viscosity glass ionomer and resin-modified glass ionomer, some samples in both the high-viscosity glass ionomer and resin-modified glass ionomer restorations showed no microleakage, which implies that they were actually capable of decreasing bacterial penetration. Another benefit of glass ionomer is the fluoride ion release which plays a major role in controlling caries in children. It has been shown that the mechanical cycling could increase the amount of deformation of the restored tooth either permanently or temporarily when the tooth was under stress. Masticatory stresses may decrease long-term survival of dentinal bonded restorations in vivo as load cycling can induce bond failures.[10] Since both the glass ionomer cements were unable to stop micro leakage completely, more improvement in the characteristics of these cements is required so that their marginal integrity is maintained until time the filled deciduous tooth is there in the mouth.

CONCLUSION

Significant difference was found in the mean microleakage between amalgam, high-viscosity glass ionomer and resin-modified glass ionomer restorations in primary molars. Amongst all the restorative materials compared, amalgam showed the least microleakage which makes it a material of choice for sealing ability in primary molars.

LIMITIONS OF STUDY

The limitations of the present study were that microleakage of selected restorative materials was compared for shorter period of time. Future studies may be conducted to examine the microleakage for longer period of time. Secondly all the cavities prepared were class one, so different cavity designs might give different results. Thirdly the results obtained were based on two-dimensional interpretation of microleakage which was actually a three-dimensional entity. The dye penetration was scored after cutting longitudinal sections at the tooth and restoration interface. The drawback of longitudinal sections of a specimen was that just the sectioned portion of the filled preparation could be investigated. So to evaluate the long-term effects of the restorative materials in oral cavity, further studies utilizing advanced techniques like X-ray microtomography/micro-XCT can be used to assess interfacial gap for microleakage.

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CONFLICT OF INTEREST

None to declare.

FINANCIAL DISCLOSURE

None to disclose.

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Author's Contribution

MAH: Substantial contributions to conception design, acquisition, analysis and interpretation of data.

SN: Drafting the article and revising it critically for important intellectual content.

SR: Acquisition of data.

SAK: Conception and design of study.

ALL AUHTORS: Final approval of the version to be published.