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Research Article

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Comparative Evaluation of Microleakage in Three Core Materials with Conventional and Unconventional Placement of Crown Margins-An *In-vitro* Study

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ABSTRACT

Aims: *To compare microleakage in three core materials (Multicore Flow, Fuji IX and Ketac Silver) with conventional and unconventional placement of crown margins.* ***Methods and Material:*** *Sixty extracted human premolars were selected for the study. The teeth were divided into three main groups of 20 each for three materials tested. A large class II cavity extending up to the cemento-enamel junction were prepared on the teeth and then restored with the core materials respectively. Then each tooth was prepared to receive a PFM crown of which 10 samples in each group were prepared with conventional placement of crown margins and in the other 10 samples the margins were placed on the core material. Later the crowns were cemented with Rely X U 200 luting cement. The cemented samples were subjected to mechanical loading and thermocycling followed by the immersion of the samples in 0.5% aqueous Basic Fuschin solution for 8 hours for three days. Later the samples were sectioned mesio-distally using a diamond disc and then the samples were assessed for microleakage under the stereomicroscope. The extent of dye penetration was recorded using an ordinal scale.* ***Statistical analysis used:*** *Chi-Square and Mann Whitney U tests.* ***Results:*** *The results showed that there was no significant difference in the microleakage among the two different materials being used and when compared, it was found that Multicore Flow had the least amount of microleakage among the three materials making it the material of choice among the three.* ***Conclusions:*** *Microleakage were comparable among the samples with gingival margins placed on the tooth and on the core structure Hence it was concluded that margin placement can be done even on the core material and there by preserve the remaining tooth structure to improve the retention and resistance form of the final tooth preparation.*

Keywords: Microleakage; Marginal gap; Marginal fit; Core build-up materials; Composite resins; Glass ionomer cements; Dye penetration

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INTRODUCTION

Success of a full crown restoration depends on many factors of which marginal integrity plays a crucial role. Inadequate marginal integrity results into microleakage, secondary caries, pulpitis and pulp necrosis. For the purpose of study, microleakage can be considered as a marker for marginal integrity. Placement of the gingival margin plays an important role in deciding the marginal integrity. Literature confirms that gingival margins need to be placed on natural tooth structure for better prognosis. However, in everyday practice, we come across a large number of situations with defects / decay extending beyond the cemento enamel junction (CEJ). These teeth may require root canal treatment followed by core build up and an extra-coronal restoration (crown). In these cases, the core build up will also extend beyond the CEJ. And the conventional crown preparation will require the gingival margins to be placed beyond the core restoration in order to locate the margins on the natural tooth. This would mean compromising on the retention and resistance form due to need of increasing the taper for appropriate tooth preparation. Accessibility and visibility are also compromised in situations where posterior teeth need treatment. Ideally, it is required to do so. However, many clinicians place margins on the restorative material rather than on the tooth structure beyond CEJ due to above mentioned reasons. The possible outcomes of this unconventional margin placement on the core material are - microleakage and marginal fracture. This study was carried out with the aim to assess the microleakage of three commonly used core materials - Multicore Flow ™[Ivoclar, Vivadent], Fuji IX™[GC Gold Label]and Ketac Silver™ [3M ESPE], by placing margins on the core material during the crown preparation. This was compared with the microleakage under the conventional crown preparations.

MATERIALS AND METHODS

Sixty intact extracted human premolars were collected and were divided into three major groups of 20 each for the three different core materials being used in the study (Figure 1).

Figure 1: Extracted human premolars

A large class II cavity was prepared extending up to the cemento- enamel junction of the tooth (Figure 2).

Figure 2: Class II cavity prepared

The prepared cavities were restored with the three different core materials. Tooth preparation using the standard protocol, were carried out on 30 premolars to receive porcelain fused to metal crowns (Figure 3).

Figure 3: Tooth preparation and PFM crowns

The other 30 were prepared with gingival margins of the preparation on the core material. Crowns were cemented over the teeth with resin luting cement (Rely X ™ 3M ESPE). The crowned samples were then subjected to mechanical cyclic loading [1] of 400 N at the rate of 5 cycles per second up to 36,000 cycles in order to provide artificial aging of samples and later followed by thermo cycling [1], maintaining 700 cycles between 5ºC-55ºC. The immersion time of each specimen was 30 seconds with a transition time of 15 seconds [1]. After thermo cycling, the specimens were immersed in 0.5% aqueous solution of Basic Fuschin for 8 hours, for three days [1-3] (Figure 4).

Figure 4: Mechanical loading, thermocycling of samples and immersion in in 0.5% aqueous solution of basic fuschin

Then, each tooth was longitudinally sectioned in mesio-distal direction with the help of a diamond disc along with copious water irrigation through a three-way syringe in order to prevent the effect of heat generated during sectioning [2] (Figure 5).

Figure 5: Sectioning of specimen

The sectioned samples were evaluated for the extent of dye penetration using a stereomicroscope [1]. The extent of dye penetration on the sectioned samples was assessed and graded as depicted in the picture and according to the ordinal scale presented in the Table 1 (Figure 6).

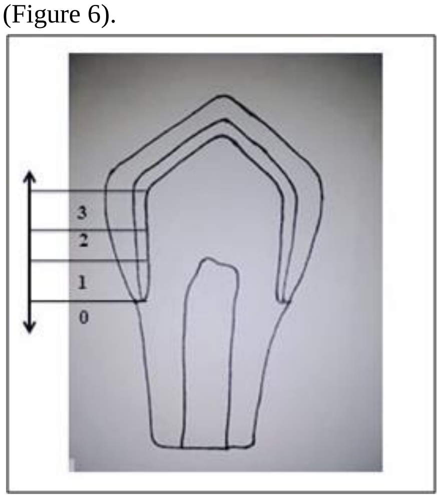


Figure 6: Assessment dye penetration on sectioned samples

Table 1: Scale for assessing extent of dye penetration

Grade For Microleakage	Extent of Dye Penetration
0	No Dye Penetration
1	Dye Penetration Up To One Third Of Axial Wall
2	Dye Penetration Up To Middle Third Of Axial Wall
3	Dye Penetration Up To Full Length Of Axial Wall

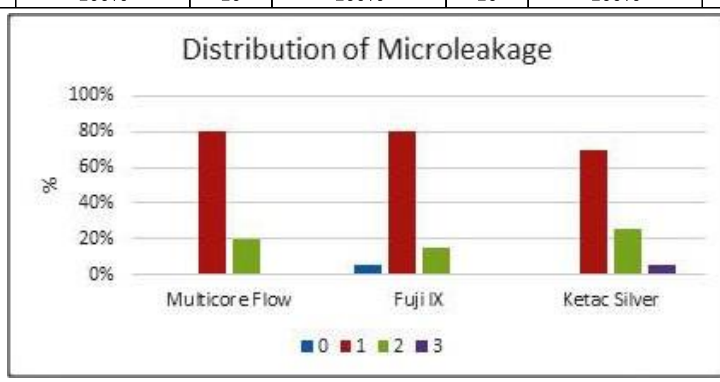
The statistical analysis was carried out using the non-parametric Chi-square and Mann- Whitney U test.

RESULTS

When the three tested materials were compared for microleakage for the conventional method of margin placement, it was found that there was no statistically significant difference among them (Table 2 and Graph 1).

Table 2: Comparison of microleakage among 3 materials with conventional margin placement

Microleakage	Multicore Flow		Fuji IX		Ketac Silver		χ^2	P-Value
	n	%	N	%	N	%		
0	0	0%	1	10%	0	0%	2.4	0.663
1	8	80%	8	80%	8	80%		
2	2	20%	1	10%	2	20%		
Total	10	100%	10	100%	10	100%		

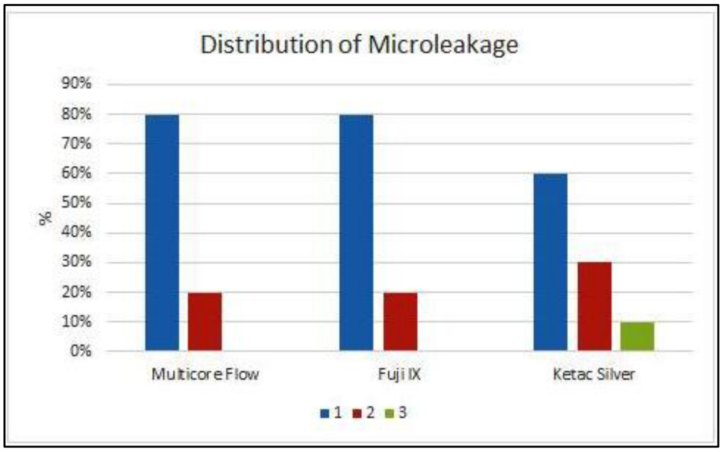


Graph 1: Distribution of microleakage

Out of the materials tested Multicore flow had the least amount of microleakage followed by Fuji IX and then Ketac Silver. When the three tested materials were compared for microleakage for the un-conventional method of margin placement, it was found that there was no statistically significant difference among them (Table 3 and Graph 2).

Table 3: Comparison of microleakage among 3 materials in un-conventional margin placement for crowns

Microleakage	Multicore Flow		Fuji IX		Ketac Silver		χ^2	P-Value
	N	%	N	%	n	%		
1	8	80%	8	80%	6	60%	2.649	0.618
2	2	20%	2	20%	3	30%		
3	0	0%	0	0%	1	10%		
Total	10	100%	10	100%	10	100%		

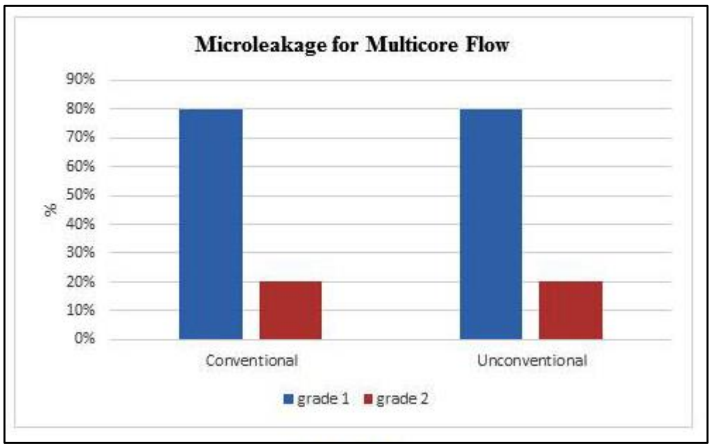


Graph 2: Distribution of microleakage

In the unconventional group Multicore Flow had the least amount of microleakage and then followed by Fuji IX and Ketac Silver. When the conventional and unconventional methods were compared with Multicore Flow as the restorative material it was found to have no statistically significant difference in the amount of microleakage (Table 4 and Graph 3).

Table 4: Comparison of microleakage for multicore flow

Tooth Preparation	Mean	Std Dev.	SE of Mean	Mean Difference	Z	P-Value
Conventional	1.2	0.422	0.133	0	0	1
Unconventional	1.2	0.422	0.133			

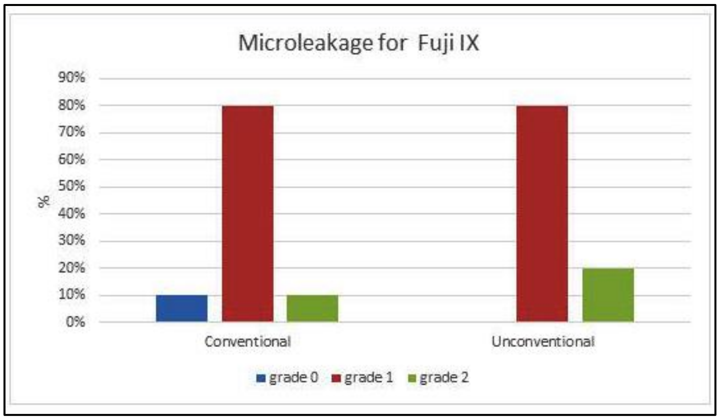


Graph 3: Microleakage for multicore flow

Similarly when the conventional and unconventional methods were compared with FUJI IX as the restorative material it was found to have no statistically significant difference in the amount of microleakage (Table 5 and Graph 4).

Table 5: Comparison of microleakage for Fuji IX

Tooth Preparation	Mean	Std Dev.	SE of Mean	Mean Difference	Z	P-Value
Conventional	1	0.471	0.149	-0.2	-0.976	0.329
Unconventional	1.2	0.422	0.133			

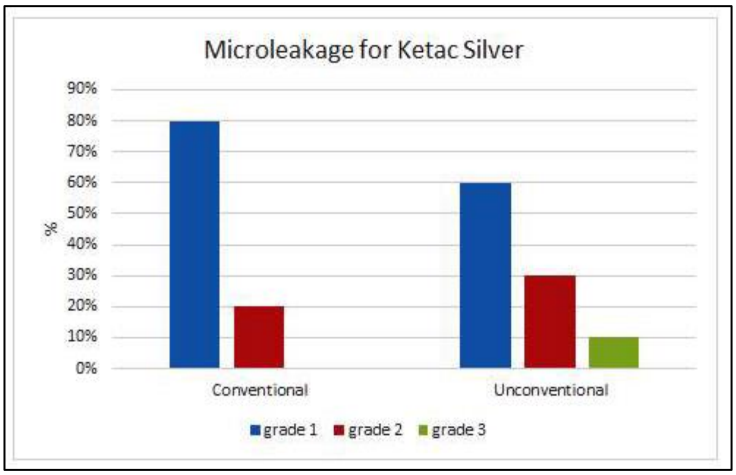


Graph 4: Microleakage for Fuji IX

When the conventional and unconventional methods were compared with Ketac Silver as the restorative material it was found to have no statistically significant difference in the amount of microleakage (Table 6 and Graph 5).

Table 6: Comparison of microleakage for Ketac silver

Tooth Preparation	Mean	Std Dev.	SE of Mean	Mean Difference	Z	P-Value
Conventional	1.2	0.422	0.133	-0.3	-1.037	0.3
Unconventional	1.5	0.707	0.224			



Graph 5: Microleakage for Ketac silver

DISCUSSION

The problem of marginal gap and leakage has challenged the profession for decades. Microleakage phenomenon is one which cannot be avoided in clinical situations. It can even happen with an intact bond between the tooth and the restoration. The need to obtain an adequate thickness of the restoration that maintains dental anatomy causes exposure of millions of dentinal tubules. These tubules are potential channels for the diffusion and colonization of the bacteria to the pulp [2,3]. Normally, there is a balance between the rate of diffusion of bacterial products permeating dentin due to microleakage and the rate at which they are removed by the pulpal circulation [4]. Exposure of more dentin surface during tooth preparation combined with decreased pulpal blood flow increases the potential for greater microleakage and can permit increased concentration of these products, resulting in inflammation Another important factor which influence the leakage is luting agent which is soluble and do not provide continuous impermeability at tooth-cement interface. This may potentially act as major reason for microleakage under the crowns. In addition, any marginal gap can cause cement dissolution and microleakage allowing saliva with its bacterial components to penetrate the gap and gain access to circum-pulpal dentin from where bacteria and their products easily diffuse to the pulp. This is a major cause of postoperative sensitivity, secondary caries and pulpal necrosis, ultimately leading to clinical failure of the treatment provided. The goal of a successful prosthetic treatment of a severely decayed tooth has two aspects. The first one being effective replacement of natural tooth structure by giving a core; second protecting the exposed dentine against bacteria and their toxins by preventing microleakage under an extra coronal restoration [5]. Core build up is the first step to restore a severely damaged, fractured, and extensively decayed or root canal treated tooth [6]. Core materials differ in terms of strength, stiffness, elasticity and other properties like sealing ability to microleakage that may influence the marginal integrity as well as the durability before final restoration [6,7]. There are several core build up materials available in market. For the present study three materials - Multicore Flow, Fuji IX and Ketac Silver were selected because of the better properties exhibited by them.

The study was done to understand whether the gingival margin can be located on the core restorative material instead of the natural tooth structure in a severely decayed tooth restored by three different core build up materials. It was found that there was no significant statistical difference in the microleakage among the different groups.

In a flowable composite like the Multicore Flow, microleakage might be because of the difference in the amount of filler loading and the size of the filler particles. High filler loading results in a high degree of stiffness, which can lead to high shrinkage stress. Also, smaller-sized particles cause scattering of light and decrease its absorption thereby reducing the overall polymerization and increasing the microleakage in the material. The low-molecular weight methacrylate molecules and resultant high number of double bonds per unit weight create a high degree of cross linking; creating a rigid resin with a relatively high shrinkage [8,9]. This could be the reason for microleakage in the samples restored with Multicore Flow material. However, the amount of microleakage was comparatively less than the other two core build up materials. It has been believed that GICs would be able to prevent microleakage as a result of its chemical bonding to tooth substances [8]. Many studies have consistently shown that marginal sealing of GICs to tooth structure was not sufficient enough to prevent dye leakage into the tooth-restoration interface [9-11]. Other studies reported that microleakage of resin-modified GICs was slightly less than that of chemically-cured GICs. Similarly, another study comparing microleakage of self-cured GICs with third generation dentin bonding agents/resin-based composite, reported no differences in microleakage among groups at one week, 6 months, and one year and that microleakage at one year was more severe than at one week [12-15]. Another comparable study using the same dentin bonding agents on Class V cavities concluded that GICs demonstrated less leakage than that of dentin bonding agents [15]. The cohesive strength of glass ionomer cement is found to be lower than adhesive strength. The porous nature of the material may be an important factor that enhances potential for microleakage in GIC core material, Fuji IX [10].

Ketac Silver is metal-modified glass ionomer cement. The idea was to increase the toughness of the GIC, by acting as a stress-absorber, to improve its wear characteristics, and to render the restoration sufficiently opaque. Weakening occurs with Ketac Silver when stored in water. This may be the result of the plasticizing effect of water diffusion through the specimen, resulting in a reduction of their properties. The contacting solution partly dissolves material components with a consequently altered network of the glass-ionomer cement. Authors have attributed to this property of core build up material because of the increased solubility of glass-ionomer materials, and the hydro-gel phase increasing water sorption of the set materials, with the higher degree of hydration resulting in lower mechanical properties. Other studies also showed that metal-modified glass-ionomers showed properties not different to those of the other conventional glass-ionomers tested, with no improvement in its sealing properties, as stated by several authors [16-19]. When the three core build up materials were assessed for microleakage it was concluded that all of them showed minimal amount of microleakage irrespective of the different tooth preparation configurations being used. Two among the samples being restored with Ketac silver under the unconventional method of tooth preparation showed greater amount of dye penetration along the axial walls than Multicore flow and Fuji IX. But when compared with the total number of the samples tested this was found to be of not much significance. As there was no much significant difference in the amount of microleakage when the margins were placed on the core material, it can be advised to place the margin in such a way so as to enhance the retention and preserve the remaining tooth structure. Given a specific condition out of the three core build up materials being tested it is advisable to use Multicore Flow for a core build up as it showed least microleakage. In the various studies conducted to assess the microleakage of the core material placed under the crowns it was concluded that there is still an amount of leakage occurring which may or may not be visible and symptomatic clinically. It is the property of the material to resist the forces and thereby prevent the micro-gap formation and hence reduce the leakage. For this, the core build up material chosen should always have the properties equal to that of the tooth structure. When a crown with a good clinically acceptable marginal fit is cemented with a luting agent of least amount of dissolution it can result in minimum formation of marginal gap for the passage of the fluids and thereby reducing the microleakage to a considerably good extent and hence increasing the life and prognosis of the treatment/ restoration [8,20].

CONCLUSION

From the current study we were able to conclude that the dye penetration/microleakage was comparable among the samples with gingival margins placed on the tooth and on the core structure. Margins placed on Ketac Silver core material allowed greater amount of dye penetration followed by Fuji IX and finally Multicore Flow. Since there was no significant difference in the microleakage among all the samples , it can be concluded that the margin placement can be done even on the core material and there by preserve the remaining tooth structure to improve the retention and resistance form of the final tooth preparation.

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