IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 8 Ser.13 (August. 2020), PP 25-31
www.iosrjournals.org

"Microleakage Interpretation in Open and Closed Laminate Techniques in Class V Cavities."

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Abstract:
Aim: *To evaluate the microleakage of class V cavities extended below cementoenamel junction (CEJ) restored with open and closed sandwich techniques using resin-modified glass ionomer cement (RMGIC) as a liner by dye penetration method.*
Materials and Methods: *Class V cavities were prepared 1mm below CEJ on both the buccal and lingual surfaces of 20 freshly extracted sound human molars, which were randomized into two groups. In group I (n=20), the open sandwich technique, RMGIC liner was applied on the axial wall and cavity floor extending to the cavosurface margin. In group II (n=20), the closed sandwich technique, RMGIC liner was applied only on the axial wall without extending to the cavosurface margin. After curing RMGIC, samples were restored with composite resin. Later, the samples were immersed in 2% basic fuchsin dye for 24 hours. After copious water irrigation, they were sectioned longitudinally in buccolingual direction, resulting in 1/4th tooth as one specimen, while 40 specimens for each group and evaluated under a stereomicroscope to determine the microleakage.*
Results: *Data was statistically analyzed using the Chi-square test. In the open and closed sandwich technique, there was a significant difference in the gingival microleakage (P<0.045). In the open sandwich technique, there was no significant difference between occlusal and gingival microleakage (P>0.683).*
Conclusion: *The open sandwich technique with RMGIC showed significantly lower microleakage (p<0.05) as compared to the closed sandwich technique.*
Keywords: *Open and closed sandwich technique, microleakage, laminate technique resin-modified glassionomer cement, class V cavities, below CEJ(Cemento Enamel Junction).*

Date of Submission: 11-08-2020 Date of Acceptance: 27-08-2020

I. Introduction:

Cervical lesions are driving interest in day to day practice in clinical dentistry because of their increasing prevalence.[1] Restoring these lesions is technique sensitive, due to a variety of factors like poor isolation, cusp movement during occlusion or adhesion to different substrates (enamel and dentin/ cementum),[2] bacterial, liquid and molecular penetration through the cavity-material interface, resulting in marginal staining, post-operative sensitivity, secondary caries ,pulp pathosis and finally, failure of the restoration.[3]

A variety of materials are available for restoring class V lesions, of which, the most popular restorative material is a composite resin.[4] Due to its growing demand for aesthetic and conservative cavity preparations, it has attracted renewed interest in restoring posterior and cervical cavity lesions.[5] Apart from aesthetics, the longevity of the restoration is also essential, which depends on multiple factors, such as the capability to adapt well to a cavitywall, bonding of restoration to the tooth, cavity preparation with the proper position of cavosurface margins and isolation during the procedure.[6]

In class V lesions, despite proper cavity preparation and isolation, adhesive failure of restorative materials is noticed when cavity preparations were below CEJ, resulting in poor adaptability because of the contraction stresses magnitude, while due to high configuration factor resulting in v-shaped micro-gap (10-15μm) between tooth(cementum) and restoration interface.[7] Weak bonding of composite resin to cementum is mainly due to its hypo mineralized and hyper-organic structure, which does not provide micro retention for the adhesive materials even after acid etching.[8] Apart from cementum bonding, the main drawback of composite resins is the polymerization shrinkage at the tooth–restoration interface.[9] Thus microleakage is inevitable in resin restorations, and hence, evaluation of the success of restoration depends on the assessment of microleakage, which is major criteria in composite restorations.

Many approaches are advocated to minimize the polymerization shrinkage, like incremental placement technique,[10] soft-start polymerization,[11] low shrinkage composites,[12] semi-direct and indirect

restoration,[13] and placement of stress-relieving liners referred to as sandwich technique. According to Dionysopoulos 2014**,** polymerization shrinkage can be controlled by material properties and restoration techniques.[14**]**

The laminate technique was implemented in the present study, which is layering of various restorative materials to create the optimal combination of desired properties, like to reduce polymerization shrinkage and stress induced bonding failure at cementum and restoration interface. Sandwich technique with liners can be performed in two different methods based on their extension to the oral environment. They are the open[15] and closed sandwich technique[16]where glass-ionomer cement (GIC) was used as a liner and left exposed at the cervical margin to protect the surrounding tooth structure and to allow the release of fluoride. In the closed sandwich technique, dentin (axial wall) was covered with the liner prior to etching and bonding of remaining walls, followed by composite resins.[17] Later, the use of other materials with this technique, like resin-modified glassionomer cement (RMGIC) was advocated.[18]

The microleakage assay provides useful information on the performance of the restorative materials. Different techniques are developed for assessing microleakage, among which the dye penetration technique using coloring agents is among the most commonly used techniques.[19]

Today, studies comparing open and closed below CEJ was documented in class II[20]and with class V cavities, restored either with open or closed sandwich technique below CEJ were published, however, a study comparing both open and closed in the class V cavities extending below CEJ bonding specially to cementum on buccal or lingual surfaces which has high c-factor[21] and restored with RMGIC liner were not yet documented.[22][23][24]

The rationale behind this study was to evaluate the microleakage in class V cavities comparing open and closed laminate techniques using composite resins and RMGIC. The null hypothesis stated that there is no significant difference between open and closed laminate techniques restoring class V cavities extended below CEJ with RMGIC as liner.

II. Materials And Methodology:

Twenty freshly extracted sound human molars were selected and examined for any cracks and fissures under a stereomicroscope at 10x magnification. They were stored in 0.5% Chloramin T at 4^0c for 24 hours and then stored in distilled water at room temperature, untilexperimented.[25] Class V cavities were prepared using no. 245 carbide bur (SS White) under copious water coolant using a high-speed standardized handpiece. The digital caliper for width and a periodontal probe for depth were used to measure the prepared dimensions of 4mm mesiodistally, 2mm axial depth, and 3mm occlusogingival height were prepared on buccal and lingual surfaces of 20 teeth. To ensure that there is no pulpal exposure and enamel cracks at the cavosurface margins, the preparations were re-evaluated at 10x magnification under the stereomicroscope. Forty cavities (2 cavities in each tooth) were randomly divided into two groups of 10 teeth each (20 cavities in each group). Thus, atotal of 40 cavities were prepared with occlusal margins in enamel and gingival margin 1mmbelow CEJ. Tooth preparation on both the buccal and lingual surfaces were etched with 37% phosphoric acid(Scotch bond Etchant, 3M ESPE), rinsed and blot dried. Bond ingagent was applied using a small brush, along with low-pressure air spray cured for 20seconds uniformly. In the open sandwich technique, the full length of the gingival floor wasrestored with RMGIC (FUJI II LC glass ionomer (GC America, Alsip III) as per themanufacturer's instructions) and cured for 20 seconds, whereas in closed sandwich technique along with axial wall, gingival floor till dentin was restored with RMGIC as a liner and cured for 20 sec. Finally, micro-hybrid resin composite (Z100, 3M ESPE) of shade A2 was used and light cured (light intensity of 550 mW/cm2) for 40 seconds at a curing distance of 0.5 mm for each increment of 1mm and restored cavities in two increments, continually closely monitored.

After 24hrs, all restorations were finished to contour. The cavosurface margins with a no. 7901carbide finishing bur (SS White, Lakewood, N.J.) with air and water spray in a high-speed handpiece (Star Dental, Lancaster, Pa.) as well as polished with Sof-Lex discs (Polishing Discs, 3M-ESPE, St. Paul, MN, USA).Each tooth was coated with two layers of nail varnish, leaving 2mm rim around restorative margins to allow the contact of tracing agents with the margins of restorations.Thermocycling was performed for 20 teeth, 1000 cycles at 5^0 and $55^0 \pm 1^0$C with dwelling time of 30 seconds.[21] The specimens were immersed in 2% basic fuchsin dye for 24hrs. After 24hrs, the specimens were washed, and the nail varnish was removed. Using water-cooled slow-speed diamond saw (Cir-Saw, Confident Dental Co.,India), 20 teeth with 40 restorations were sectioned through the centre bucco-lingually with aprecision, resulted in 80 specimens. Then the restorations were analyzed under a stereomicroscope at 40X magnification and scored for degree of dye penetration along the occlusal and gingival walls by two individual examiners.

SCORES: The scoring method of dye penetration, according to Alavi et al.[26]
0 = No dye penetration.

1 = Dye penetration at the 1/3 first side of the cavity wall.
2 = Dye penetration at the 2/3 middle side of the cavity wall.
3 = Dye penetration at the 1/3 last side of the cavity wall.
4 = Dye penetration at the axial wall.
From obtained data, statistical analysis was done by the **chi-square test** for group wise comparisons at a significance level of $p \leq 0.05$.

III. Results:

SPSS software version 20 was used for statistical analysis of the data and chi-square test was performed for group-wise comparisons at a significance level of $p \leq 0.05$

Table 1: Group 1- Open Sandwich Technique

Scores		Group 1		Total
		Occlusal	Gingival	
.00	Count	19	22	41
	%	43.2%	50.0%	46.6%
1.00	Count	23	18	41
	%	52.3%	40.9%	46.6%
2.00	Count	1	2	3
	%	2.3%	4.5%	3.4%
3.00	Count	1	2	3
	%	2.3%	4.5%	3.4%
Total	Count	44	44	88
	%	100.0%	100.0%	100.0%
Chi Square value = 1.496, P value = 0.683 (Not Significant)				

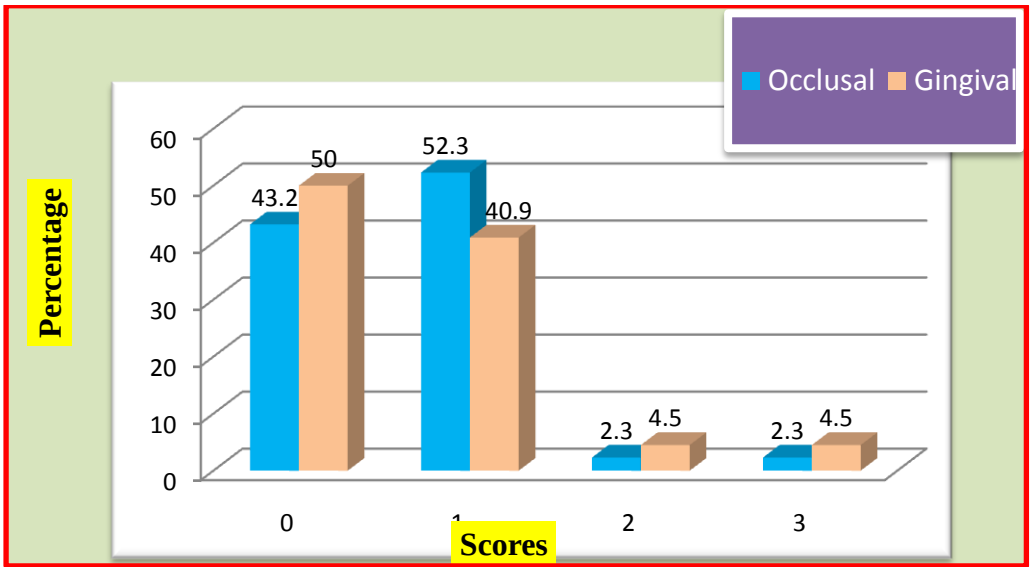

Table 1:To the base line data, chi-square test was performed which showed no significant difference in occlusal and gingival margins of class V cavities when extended below CEJ and restored with open sandwich technique using RMGIC as liner with p-value ($p < 0.683$).

Table 2: Group 2 - The Closed Sandwich Technique

Scores		Group 2		Total
		Occlusal	Gingival	
.00	Count	20	10	30
	%	45.5%	22.7%	34.1%
1.00	Count	24	24	48
	%	54.5%	54.5%	54.5%
2.00	Count	0	3	3

	%	0.0%	6.8%	3.4%
3.00	Count	0	3	3
	%	0.0%	6.8%	3.4%
4.00	Count	0	4	4
	%	0.0%	9.1%	4.5%
Total	Count	44	44	88
	%	100.0%	100.0%	100.0%
Chi Square value = 13.333, **P value = 0.01 (Significant)**				

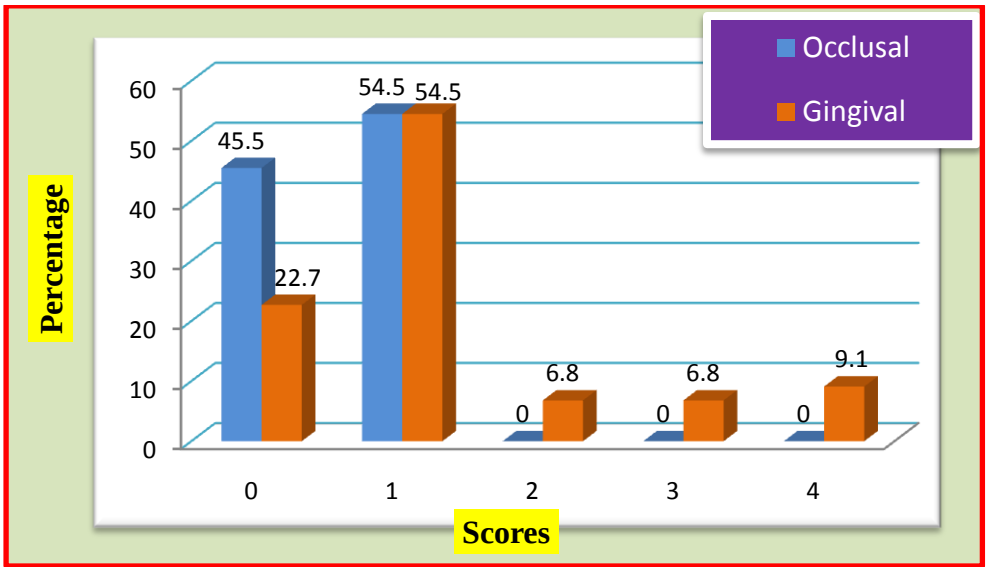

Table2:For baseline data, the chi-square test was performed, which showed significant difference in occlusal and gingival margins of class v cavities when extended below CEJ and restored with open sandwich technique using RMGIC as liner with p-value (p< 0.01)

Table 3: Gingival leakage in open and closed

Scores		**Groups**		**Total**
		Open (Group 1)	**Closed (Group 2)**	
.00	Count	22	10	32
	%	50.0%	22.7%	36.4%
1.00	Count	18	24	42
	%	40.9%	54.5%	47.7%
2.00	Count	2	3	5
	%	4.5%	6.8%	5.7%
3.00	Count	2	3	5
	%	4.5%	6.8%	5.7%
4.00	Count	0	4	4
	%	0.0%	9.1%	4.5%
Total	Count	44	44	88
	%	100.0%	100.0%	100.0%
Chi Square value = 9.757, **P value = 0.045 (Significant)**				

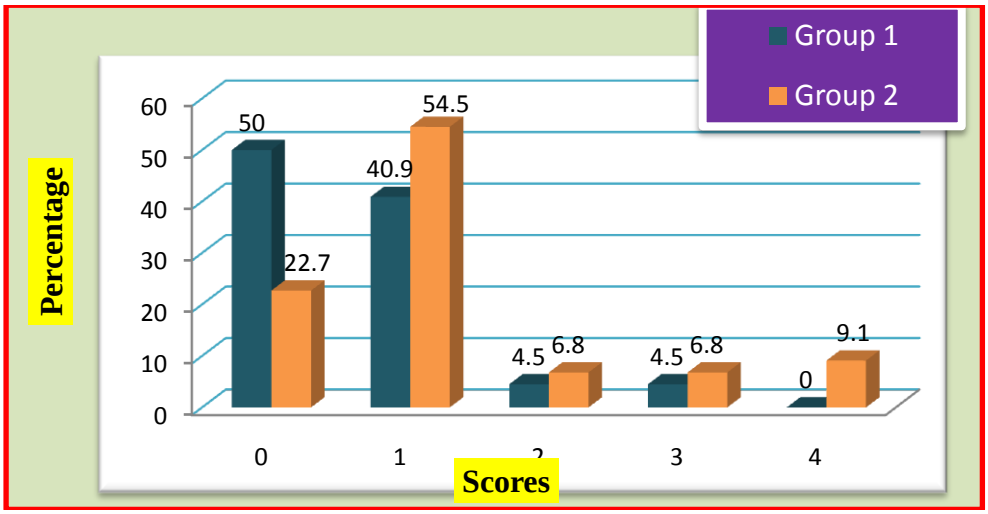

Table3:For baseline data, chi-square test was performed, which showed significant difference in gingival margins of class v cavities in both groups when extended below CEJ and restored with open and closed sandwich technique using RMGIC as liner with p-value (p< 0.045).

IV. Discussion:

Microleakage between cavity wall and restorative material is one of the main causes of post-operative sensitivity, recurrent caries and pulpal pathosis.[27,28] Location and restoration of Class V cavities, presents a special challenge to the clinician.[29,30] Despite several improvements in adhesive systems, the adaptation and bonding of these adhesive systems to cementum and dentin is less predictable. The cyclic flexure of tooth in these cervical areas along with polymerization shrinkage of adhesive material may also lead to loss of marginal adaptation.[31,32]

The sandwich technique using RMGIC as liner was used in the present study as, it reduced the bulk of the composite resin restoration and also reported to relieve polymerization contraction stresses by 20%–50%, the volumetric contraction by 41%[21] along with other properties like a fluoride release (found in original glass ionomers), true adhesion, decreasing microleakage, low water solubility coefficient and fluid absorption, increased working time, fracture toughness, improved mechanical and chemical properties (its ion exchange between dentine and RMGIC), HEMA in RMGIC showed improved bond strength, better longevity, does not require dentin conditioning,[33] low modulus of elasticity compared to flowable composite.[34]

Many previous studies have compared the microleakage in the open and closed sandwich techniques with different liner materials in class II restorations[20] and few studies evaluated microleakage in class V restorations using either open[35] or closed sandwich technique[23] independently. In present study, interest is focused on the difference in microleakage when cavities with gingival floor extended to cementum and bonding of composite or RMGIC(explained as closed and open laminate technique), which bond better to cementum with their respective properties.

Considering the properties of RMGIC based on solubility and microleakage compared to conventional resin composites and the extension of the cavity below CEJ, RMGIC, as a liner was encouraged to compare the microleakage in both the groups.

In-vitro evaluation tests are done to predict the clinical performance of the restoration.[36] Various methods for detection of marginal adaptation of restorative material include dye and bacterial leakage studies, chemical and radioactive tracers and Scanning Electron Microscopy (SEM).[32] Bond failure between the tooth and restoration interface are commonly assessed with microleakage dye penetration tests,[27,36] as there is no reactive chemical, no radiation, highly feasible and readily available, reproducible,[37] very economical (materials and associated equipment are relatively inexpensive), a rapid inspection of large areas and volumes as well as high sensitivity (small discontinuities can be detected) method is suitable for complex anatomical morphologies, various types of materials can be inspected such as metallic and non-metallic, magnetic and non-magnetic, conductive and non-conductive materials, portable, indications are produced directly on the surface of the part and constitute a visual representation of the flaw.[19]

From the statistical analysis, there is no significant difference between occlusal and gingival leakage in open sandwich technique (p> 0.683). This was in accordance with Khadim et al[38] and Pouyanfar et al.[39]This could be due to fact that enamel has high mineral content, uniform structural formulation with the acceptable and reliable substrate for micromechanical bond to composite.[39] In the

gingival area, dentin is the most challenging substrate for bonding. The lining materials can act as "elastic buffers" since they have sufficient flexibility to resist polymerization shrinkage stress and favorably dissipate stress produced by thermal variations, water absorption and occlusal loads across theinterface.[40]Also, the dual setting mechanism of RMGIC ensuring a more complete hardening ofthe material and higher fracture toughness when compared with conventional GIC along with instant set property which prevents pull back of the material due to polymerization shrinkage.[41]

The gingival microleakage was significantly higher than occlusal microleakage in the closed sandwich technique (p= 0.01) which was in accordance with Nematollahiet al,[23] in closed sandwich technique, composite bonding to cementum at the gingival margin restricting RMGIC to the dentin. The probable causes of microleakage are polymerization shrinkage, high coefficient of thermal expansion leading to dimensional changes[38] and extending to cementum resulting shrinkage induces stresses at the tooth as well as restorative interface failed to bond-forming v shape gap (10–15 μm) with a microleakage high in the gingival margin.[13]

The results showed gingival microleakage was significantly less in the open sandwich technique compared to the closed sandwich technique when cavity extended below CEJ. (p = 0.045) in accordance with Liebenberg et al.[33] and Khan et al.[42] This was mainly becauseof the intermediate layer RMGIC with low elastic modulus when restored by the opensandwich technique, when bonded with one surface to the dentin and cementum of the tooth, whileother surfaces with the resin composite, acted as an elastic buffer which shows flexibilityand minimal shrinkage by dissipating stresses.[40] In the closed sandwich technique of present study, RMGICwas bonded only to dentin but not cementum as it was not extended to the cavosurface margin and direct resin composite was bonded to cementum instead of RMGIC. This gave asignificant difference as the bonding of RMGIC was better than the conventional compositesresins.

Null hypothesis is rejected from the results which showed there was significant difference between open and closed laminate techniques with RMGIC liner in class V cavities when extended below CEJ. The purpose of this study was satisfied with less microleakage in open sandwich technique than closed sandwich techniques when bonded to cementum in class V cavities.

Limitations of this in-vitro studies were compromised as there is no stimulation of the dynamic intraoral thermal changes induced by routine eating and drinking, thermocycling is often employed in laboratory experiments to simulate stresses in the oralcavity, absence of outward flow of the dentinal fluid, completely altered dentinal surface by extraction and only ideal cavities were prepared – resulting poor correlation between in-vivoand in-vitro conditions. However, these invitro microleakage studies were the basis for any in-vivo studies as they provide initial information to overcome negative results to compare different new restorative materials and techniques.

V. Conclusion:

Class V cavities with a margin extending to cementum restored with the open sandwich technique using RMGIC as liner exposing to cavosurface margin showed less microleakage compared to the closed sandwich technique.

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