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AN EVALUATION OF MICRO LEAKAGE UNDER COMPLETE METAL CROWNS USING 3 DIFFERENT LUTING AGENTS – AN INVITRO STUDY

Original Research Paper

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ABSTRACT- To evaluate the microleakage at tooth cement surface and cement metal interface.

Aim : To evaluate the microleakage under complete metal crowns using three different commercially available luting agents

Setting and Design: A total of 60 samples were prepared of these 20 samples were prepared to evaluate the microleakage under complete metal crowns using Glass Ionomer cement (3M ESPETMKetacCem), another 20 for resin modified glass ionomer cement (GC India) and remaining 20 samples for resin cement (3M ESPETMRelyX U200).

Material and Method: 60 intact extracted human premolars of similar dimensions were prepared (1mm) with chamfer finish line and a flat occlusal surface. The samples were randomly divided into 3 groups. Grouping was based on the different cements for luting used. Each group was also randomly subdivided into two subgroups depending upon interface interfacei.e.teeth cement and metal cement interface. One hour after cementation, all the samples were for 24 hrs in water at room temperature, followed by thermocycling.Eachthermocycling consisted of alternate immersion of sample in waterbath maintained at 5° and 55° C. The samples were immersed in 5% solution of indigo carmine dye for 72hours. The sample were sectioned and were studied under Optical Microscope at 100x magnification. The extent of microleakage was indicated by the dye penetration on both the interface i.e. metal cement (MC) surface and tooth cement (TC) interface.

Statistical Analysisused: Kruskal Wallis test and Mann Whitney U test.

Result : Range of microleakage score of Group I was from 2 to 4.Range of microleakage score of Group II was from 1 to 3. Range of microleakage score of Group III was from 0 to 3.

Conclusion: The present in vitro study was conducted and on the basis of results, observations and statistical analysis, the following conclusions were drawn that between three groups, Glass ionomer cement recorded maximum combined microleakage amongst three cements irrespective of the interfaces.

Key words :
tooth cement interface, metal cement interface, luting agent, stereomicroscope.

Conflict of interest: Nil
No conflicts of interest : Nil

INTRODUCTION: Fixed prosthodontics treatment involves the replacement of teeth by artificial substitutes that are not readily removable from mouth. The ultimate goal of any prosthetic treatment is to provide the patient with a precisely fabricated restoration which preserves the long term integrity of natural abutments of fixed partial dentures and their pulpal vitality[1]

Luting cements must exhibit a sufficiently low viscosity to flow along the interfaces between hard tissue and a fixed prosthesis, and they must be capable of wetting both surfaces to hold the prosthesis in place. If optimal performance is to be attained, the physical and biological properties and the handling characteristics such as working time, setting time, consistency and ease of removal of excess material must be considered when selecting a luting cement.

Fixed prosthesis can be retained by mechanical or chemical means or by combination of the two. Both surfaces are rough and the cement fills the irregular crevices along both surfaces.

The cement-prosthesis and cement-tooth interfacial regions then exhibit a void-free sealed continuum, and the cement layer can resist shear stress acting along the interface. This represents the principle of mechanical retention.

The strength of retention depends upon the strength of the luting agent to resist applied forces, which may dislodge the prosthesis.

Fussayamaet al.[2] (1963) in their study found that marginal adaptation of cemented crowns is never perfect and the cast restoration usually display a marginal discrepancy.

So there is an increased dependence on marginal seal considering the physical and mechanical properties of luting cements for successful outcome of fixed restoration.

An important requirement of dental cements is that they should be resistant to solubility and disintegration in the oral cavity by fluids.

Although the establishment of optimal resistance and retention forms in the tooth preparation are of primary importance, a dental cement must be used to act as a barrier against microbial leakage, sealing the interface between the tooth and restoration and holding them together through some of the surface attachment. The attachment may be mechanical chemical or combination of both methods.[3, 4]

There is no universally accepted technique to determine marginal permeability at the interface between the tooth and the restoration. Use of dyes radioactive isotopes, air pressure, bacteria, neutron activation analysis, and artificial caries has been documented1, [5-6].

All the previous studies performed regarding the assessment of microleakage showed that microleakage is evident in different cements up to some extent but they did not gave conclusive result regarding the extent of microleakage on both the tooth cement interface and metal cement interface individually

Hence, this study was undertaken to evaluate marginal leakage under complete metal crowns at tooth cement and metal cement interface individually using three different commercially available luting agents, which included glass ionomer cement, Resin modified glass ionomer cement and resin cements and an attempt to quantify the extent of microleakage.

Aims : To evaluate the microleakage under complete metal crowns using commercially available luting agents

Objectives:

- To evaluate microleakage under complete metal crown using three adhesive cements i.e. Glass Ionomer Cement Type I, Resin modified GIC, dual cure resin luting cement.
- To access the microleakage between tooth cement interface and metal cement interface between the three different luting cements.
- To access the microleakage on tooth cement interfaces and metal cement interfaces within individual cement.
- To quantify the extent of microleakage on both the tooth cement and metal cement interface.

Methodology : A total of 60 samples were prepared. Of these, 20 samples were prepared to evaluate the microleakage under complete metal crowns using Glass Ionomer cement (3M ESPETMKetacCem), another 20 for resin modified glass ionomer cement (GC India) and remaining 20 samples for resin cement (3M ESPETMRelyX U200).

The following steps were involved in the preparation of the sample:-

1. 60 intact extracted human premolars of similar dimensions were stored in artificial saliva at room temperature till the time of their preparation for complete metal crowns.
2. Teeth were individually mounted on the wax block made of modelling wax.
3. The coronal portion of each tooth was prepared (1mm) with chamfer finish line and a flat occlusal surface using a diamond point and aerotor. Parallel preparation was used for maintaining the uniform taper of axial wall preparation.
4. Wax patterns were made using blue inlay wax after applying 2 layers of die spacer on all surfaces except around 1 mm of prepared margin of the crown and the die separator was applied for easy retrieval of the pattern.
5. Sprue former was attached while the pattern was still on the die and was then be invested in phosphate bonded investment. After completing the casting, the crowns were adjusted polished and fitted on the prepared teeth.
6. The samples were randomly divided into 3 groups. Grouping was based on the different cements for luting. Each group was also randomly subdivided into two subgroups depending upon the interface i.e. tooth cement surface and metal cement interface.

Table 1 Distribution of Study Sample

Group 1 – Glass Ionomer Cement (3M ESPE™KetacCem)	Group 1A - Metal Cement Interface Group 1B - Teeth Cement Interface
Group 2 – Resin Modified GIC (GC India)	Group 2A - Metal Cement Interface Group 2B - Tooth Cement Interface
Group 3 – Dual Cure Resin Luting cement (3M ESPE™RelyX U200).	Group 3A - Metal Cement Interface Group 3B - Teeth Cement Interface

7. One hour after cementation, all the samples in each group were mounted in plaster base and then stored for 24 hrs in

water at room temperature, followed by thermocycling.

8. Each thermocycling consisted of alternate immersion of sample in waterbath maintained at 5° and 55° C. 500 cycles were performed in each water-bath with 30sec dwell time and 5sec transition time.
9. After thermocycling, the samples were immersed in 5% solution of indigo carmine dye for 72hours. The sample were then washed to remove superficial stains.
10. Each sample was sectioned with diamond wheel with water cooling.

LABORATORY METHOD

1. After the samples were sectioned they were studied under Optical Microscope (Reflected Binocular Metallurgical Microscope) at 100x magnification.
2. The samples were mounted on the specimen holder and was placed on the stage of optical microscope. The magnification was then set at 100x for studying the extent of microleakage.
3. The extent of microleakage was indicated by the dye penetration on both the interface i.e. metal cement (MC) surface and tooth cement (TC) interface.

The extent of dye penetration was quantified on a scale17as:-

0 – No dye penetration

1- Dye penetration less than 1/3rd the axial wall

2- Dye penetration more than 1/3rd but less than 2/3rd the axial wall

3- Dye penetration all along the axial wall

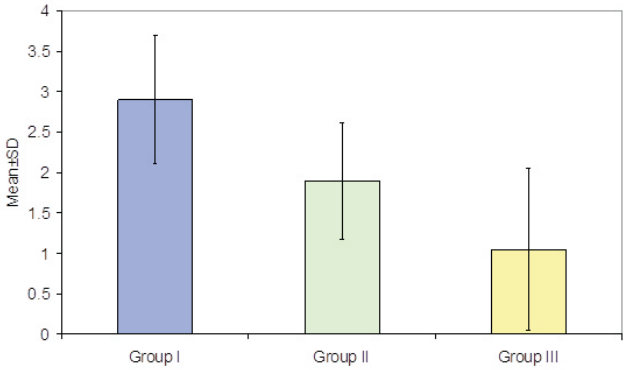
4- Dye penetration on occlusal surface

The observations were tabulated and subjected to statistical analysis.

Result

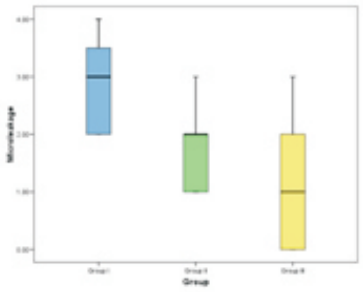
Table 2: Microleakage Score for different groups for both metal-cement and tooth-cement interface

Score	Group I		Group II		Group III	
	No.	%	No.	%	No.	%
0	0	0.0	0	0.0	7	35.0
1	0	0.0	6	30.0	7	35.0
2	7	35.0	10	50.0	4	20.0
3	8	40.0	4	20.0	2	10.0
4	5	25.0	0	0.0	0	0.0
Mean Score	2.90		1.90		1.05	
SD	0.79		0.72		1.00	
Median	3.00		2.00		1.00	



Group	N	Mean Rank
Group I	20	44.75
Group II	20	29.40
Group III	20	17.35
Total	60	

Table 3: Intergroup Comparison (Kruskal Wallis H test)



Graph 2: Intergroup Comparison (Kruskal Wallis H Test) for both Metal Cement and Tooth Cement Interface

Comparison	Z	p
I vs II	3.467	<0.001
I vs III	4.548	<0.001
II vs III	2.800	0.007

From Table 3 and above box plot it was found that rank of Group I was found to be higher than Group II and Group III and a partial overlap in interquartile values between Group II and Group III was found. This shows a statistically significant difference in microleakage scores among the three groups ($p<0.001$).

Table 4: Between Group Comparisons (Mann-Whitney U test)

On comparing the order of microleakage score of luting agents was found to be:

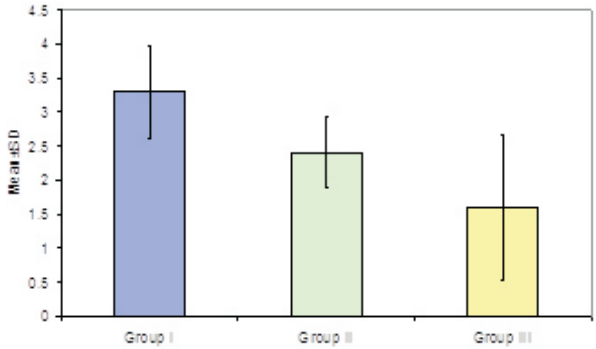
Group I (GIC) > Group II (RMG) > Group III (Resin Cement)

Table 5a: Microleakage Score for different groups for metal-cement interface

Subgroup A

Score	Group IA		Group IIA		Group IIIA	
	No.	%	No.	%	No.	%
0	0	0.0	0	0.0	2	20.0
1	0	0.0	0	0.0	2	20.0
2	1	10.0	6	60.0	4	40.0
3	5	50.0	4	40.0	2	20.0
4	4	40.0	0	0.0	0	0.0
Mean Score	3.30		2.40		1.60	
SD	0.68		0.52		1.07	
Median	3.00		2.00		2.00	

Graph 3: Microleakage Score for Different Groups for Metal-Cement Interface



Range of microleakage score of metal-cement interface of Group IA was from 2 to 4 and 3 was the most common score (50.0%) in Group IA. Mean microleakage score of Group IA was found to be 3.30+0.68 and median microleakage score of Group IA was found to be [3].

Range of microleakage score of metal-cement interface of Group IIA was from 2 to 3and 2 was the most common score (60.0%) in Group IIA. Mean microleakage score of Group IIA was found to be 2.40+0.52 and median microleakage score of Group IIA was found to be [2].

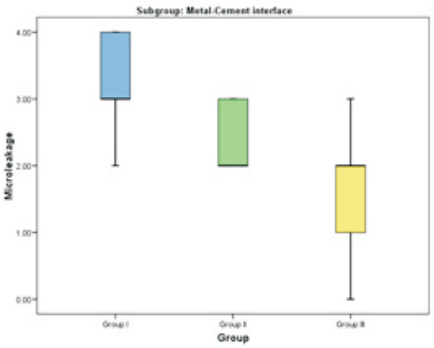
Range of microleakage score of metal-cement interface of Group IIIB was from 0 to 3 and 2 was the most common score (40.0% each) in Group III. Mean microleakage score of Group III was found to be 1.60+1.07 and median microleakage score of Group III was found to be [2].

Table 5b: Intergroup Comparison (Kruskal Wallis test)

Group	N	Mean Rank
Group IA	10	22.90
Group IIA	10	14.40
Group IIIA	10	9.20
Total	30	

H=13.723; p<0.001 (Significant)

Graph 4: Intergroup Comparison (Kruskal Wallis test) Metal Cement Interface



From Table 5 and above box plot it was found that Group IA was ranked higher than Group IIA and Group IIIA. No overlap in interquartile values of microleakage was found among the groups. This shows that difference in microleakage of above three groups was found to be statistically significant (p<0.001).

Table 5c: Between Group Comparisons (Mann-Whitney U test)

Comparison	Z	p
IA vs IIA	2.690	0.011
IA vs IIIA	3.207	0.001
IIA vs IIIA	1.806	0.105 (NS)

On comparing the difference of microleakage score between groups it was found that between group difference in microleakage of Group IA Vs. IIA, Group IA Vs. IIIA were found to be statistically significant while difference between and Group IIA Vs. IIIA was not found to be statistically significant. Hence, order of microleakage score of luting agents was found to be:

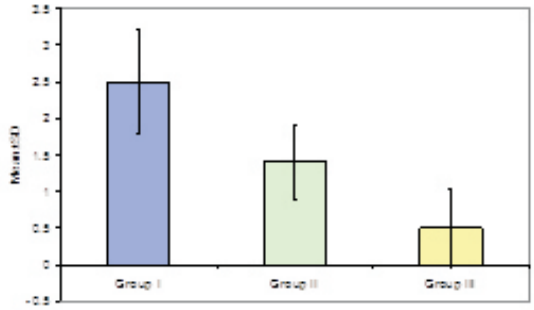
Group IA (GIC) > Group IIA (RMG) Group IIIA (Resin Cement)

Table 6a: Microleakage Score for different groups for tooth-cement interface

Subgroup B

Score	Group IB		Group IIB		Group IIIB	
	No.	%	No.	%	No.	%
0	0	0.0	0	0.0	5	50.0
1	0	0.0	6	60.0	5	50.0
2	6	60.0	4	40.0	0	0.0
3	3	30.0	0	0.0	0	0.0
4	1	10.0	0	0.0	0	0.0
Mean Score	2.50		1.40		0.50	
SD	0.71		0.52		0.53	
Median	2.00		1.00		0.50	

Graph 5: Microleakage Score for Different Groups for Tooth Cement Interface



Range of microleakage score of tooth-cement interface of Group IB was from 2 to 4. Mean microleakage score of Group IA was found to be 2.50+0.71 and median microleakage score of Group IA was found to be [2].

Range of microleakage score of tooth-cement interface of Group IIB was from 2 to 3. Mean microleakage score of Group IIB was found to be 1.40+0.52 and median microleakage score of Group IIA was found to be [1].

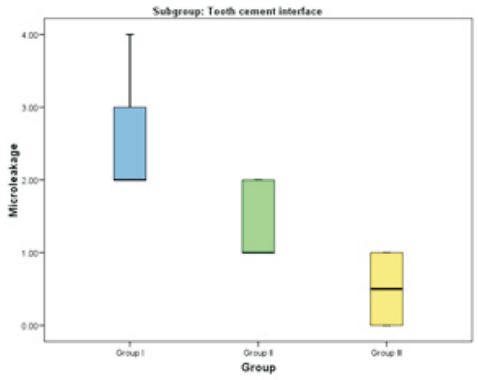
Range of microleakage score of metal-cement interface of Group IIIB was from 0 to 1. Mean microleakage score of Group III was found to be 0.50+0.53 and median microleakage score of Group III was found to be 0.50.

Table 6b: Intergroup Comparison (Kruskal Wallis test)

Group	N	Mean Rank
Group IB	10	24.30
Group IIB	10	15.20
Group IIIB	10	7.00
Total	30	

H=21.261; p<0.001 (Significant)

Graph 6: Intergroup Comparison (Kruskal Wallis test) for Tooth-Cement Interface



From Table 8 and above box plot it was found that Group IB was ranked higher than Group IIB and Group IIIB. This shows that difference in microleakage of above three groups was found to be statistically significant (p<0.001).

Table 6c: Between Group Comparisons (Mann-Whitney U test)

Comparison	Z	p
IB vs IIB	3.122	0.003
IB vs IIIB	3.897	0.001
IIB vs IIIB	2.936	0.007

On comparing the difference of microleakage score between groups it was found that between group differences in microleakage of Group IB vs. IIB, Group IB Vs. IIIB and between Group IIB Vs. IIIB was found to be statistically significant. Hence, order of microleakage score of luting agents was found to be:

Group IB (GIC) > Group IIB (RMG) > Group IIIB (Resin Cement)

Table 7: Comparison of Microleakage between Subgroup A and B (Mann-Whitney U test)

Comparison	Z	P
IA vs IB	2.297	0.029
IIA vs IIB	3.130	0.003
IIIA vs IIIB	2.381	0.023

On comparing with in Group difference in microleakage of teeth-cement interface and metal-cement interface. In all the three groups, microleakage at teeth cement interface was

found to be higher than that at metal-interface of that group, and difference between teeth-cement interface microleakage and metal-cement interface microleakage was found to be statistically. Hence, order of microleakage score in all the groups was:

Teeth-cement interface > Metal-cement interface

DISCUSSION : Marginal leakage around the dental restoration is the cause for the recurrence of caries at that site7. A space always exists between the casting and the tooth at the margins before and after cementation. Microleakage is caused by the difference in coefficient of thermal expansion of restorative material and tooth structure[8].

Cement with high modulus of elasticity is important to prevent microleakage[9, 10-12]. Powers and Sakaguchi[13]. suggested protection for 24 h at the margin and use of acid conditioner followed by aqueous solution of ferric chloride on dentin, while sandblasting and tin plating the castings have been advocated by Graver, Vallittu, Hotz and Hondrum[14, 15] to improve glass ionomers bond strength with both the tooth and restoration. Glass ionomer cement is the most susceptible to dissolution during and immediately after initial set due to its prolonged setting reaction in progressive, multiple and overlapping stages. Its modulus of elasticity increases over time and the cement might mature over a period of 24 h to 1 year.[9, 12-13].

In the current study, samples were stored in artificial saliva after 1 h of the cementation. The effect is dramatically shown in the results by the relatively high leakage with glass ionomer cement due to the presence of excess saliva during the growth of the hydrated silica phase[16].

A study by Tjan AH (1992)[17] stated that crowns cemented with resin cement exhibited substantially less microleakage than those cemented with zinc phosphate cement. But there was no difference observed between 30-day and 90-day water immersion of crowns cemented with resin cement.

Many studies have examined various cements in terms of microleakage by using dye penetration and radio permeability techniques (Mondelli and Galan (1987)[18]; Myers et al. (1983)[19]; Gordon et al. (1985)[20]; Shen and Herrin (1986)[21]. Dye penetration studies examine the permeability of the margin to a dye, after which an assessment of the linear amount of penetration is made (Crim and Shay (1987)[22]; Kanca (1987)[23]; Gordon et al. (1986)[24]. Radio permeability studies do not require direct identification of leakage by the investigator in terms of penetration, as the measurement is determined by the scintillation counting device. The scintillation counting device quantitatively measures the amount of radioactivity in a solution which has traversed a margin or junction (Herrin and Shen 1985)[25].

The method used to perform the qualitative assessment of microleakage in this study is in accordance with that proposed by Anthony H.L et al.[17]. The criteria was modified and the extent of dye penetration was assessed.

The results of this study indicate that when in vitro testing is used to evaluate microleakage of restorations, the rmocycling is the more effective procedure. Those studies which have examined the penetration of an isotope or dye solution at a constant temperature are useful to the extent that leakage has been demonstrated many times even under these relatively passive laboratory conditions. However, they did not take into consideration the difference that exists between the coefficients of thermal expansion for tooth structure and restorative materials. To better correlate thermocycling testing with in-vivo conditions, the system used in this study used short exposure time to the extreme temperatures with an adequate intervening period for the specimen to return to body temperature.

All the previous studies performed regarding the assessment of microleakage showed that microleakage is evident in different cements up to some extent but they did not gave conclusive result regarding the extent of microleakage on both the tooth cement interface and metal cement interface individually. Also the studies gave statistically insignificant difference.

So, the present study was performed to assess the microleakage between the routinely used luting agents i.e. glass ionomer cement, resin modified glass ionomer cement and resin cement. The microleakage was assessed at both tooth cement interface and metal cement interface individually. The extent of microleakage was compared with in individual cement at both interface and also between each other. The study revealed statistically significant difference in micro leakage scores. The need of such study was to justify as to which cement is most suitable for luting purpose and in which situations.

The better performance of adhesive resin cement can also be explained through the role of filler particles that improve the marginal wear resistance. Resin cement also demonstrate good bond strength to sand-blasted metal as a result of mechanical retention. Also the resin cement forms a micromechanical bond with the partially demineralized dentin. The resin cement interlocks in the hydroxyapatite crystals and rods of etched enamel.

CONCLUSION : The present in vitro study was conducted and on the basis of results, observations and statistical analysis, the following conclusions were drawn.Between three groups, Glass ionomer cement recorded maximum combined microleakage amongst three cements irrespective of the interfaces. Within group, glass ionomer shows more microleakage at metal cement interfaces than at tooth cement interface. Result was statistically significant only for glass ionomer cement. Within group, the level of microleakage was almost statistically comparable for resin modified glass ionomer and resin cement. Between three groups, metal crowns cemented with resin cement showed least microleakage. The result was statistically significant both at tooth cement and metal cement interface in comparison to the other two cements. On comparing within group differences in microleakage of teeth-cement interface and metal-cement interface. In all the three groups, microleakage at teeth cement interface was found to be higher than that at metal-interface of that group, and difference between teeth-cement interface microleakage and metal-cement interface microleakage was found to be statistically significant. Stereomicroscopic study also supplemented that the samples luted with glass ionomer cement showed higher microleakage score at both the teeth cement interface and metal cement interface than other cements when examined visually.

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