Original Research Paper

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"Comparative Evaluation of Microleakage in Zirconia Crowns Cemented With Bioactive, Conventional Gic and Dual Cure Resin Luting Cements - An in Vitro Study"

Abstract:

Purpose: The objective of this study was to evaluate and compare the microleakage in Zirconia crowns cemented with Bioactive, Conventional GIC, and Dual Cure Resin Luting Cements.

Materials and Methods: 45 Freshly extracted permanent molars were randomly equally divided. Group 1- Bioactive Cement, Group 2: Conventional GIC and Group 3: Dual Cure Resin Cement. Teeth were embedded in resin blocks 1 mm cervical to CEJ and prepared according to the standardized protocols, zirconia crowns were fabricated using CAD CAM technology andcemented onto the respective tooth preparations according to the manufactures instructions andexcess cement was removed. After cementation all restored teeth were placed in buffered saline solution at 37 degrees centigrade for 1 day. Samples of each group were divided into 3 subgroups i.e. A, B and C, (5 samples each) and for aging subgroup B and C of all groups were placed in a thermocycler for 6000 and 10,000 cycles alternating between 5 degrees centigrade and 55 degrees centigrade to simulate aging at 6 months and 12 months respectively. All samples were painted with acrylic varnish to within 1 mm of crown margin and were placed in 2 % basic fuchsin dye solution. After 24 hrs. they were sectioned buccolingually,and were examined under a stereomicroscope at 30 X magnification for microleakage and scored.

Results: Based on results obtained by statistical analysis of the readings recorded from stereomicroscope for microleakage it was concluded that the microleakage score of group 1 samples was significantly less than that of samples in group 2 (p value-0.001*) and in group 3 (p value-0.007*). There was no significant difference in the microleakage score of groups 2 and 3 samples (p value-0.061).

Conclusions: The research revealed that the Bioactive luting agent exhibited lower microleakage than Conventional GIC, and Dual Cure Resin Luting Cement. Therefore, the null hypothesis was rejected.

Key-words: Zirconia crowns, Luting cements, Bioactive cement, Microleakage.

Introduction:

All ceramic offer esthetically pleasing restorations even for long span FPDs; however, their use has made luting procedures more challenging.

One hundred years ago this decision was easy with the availability of essentially only one luting agent, zinc phosphate cement. In fact, today we still have the longest experience of this cement.

Currently, a plethora of luting agents is available. Now the choice of the optimal luting agent can be confusing, even for the most experienced clinician.[1]

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The process of cementation integrates the restoration with the dental hard tissues, especially with the dentin, supplying marginal sealing, retention, and esthetics. However, the cementation of indirect restorations produces a vulnerable interface between the restoration and dentin surface, which is prone to a myriad of complications ranging from minor

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staining to formation of micro/nano size gaps resulting in plaque accumulation, sensitivity, and secondary caries.[3]

Microleakage is the penetration of substances, such as bacteria, oral fluids, molecules and /or ions, into a gap or a structural defect that is naturally present or that occurs between restorative materials and tooth structure. It is a concern because of the effect bacteria may have on the remaining tooth structure and pulpal tissues and can affect the tooth-cement interface associated with a crown restoration as well as the tooth-foundation interface.[4]

Formation of a hermetic seal at the margins to prevent leakage of contaminants is a prerequisite that restorative luting agents should demonstrate.

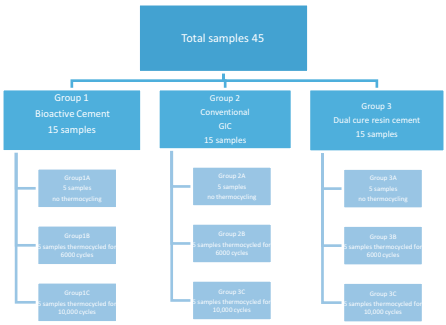
Zinc phosphate does not chemically bond to any substrate and provides a retentive seal by mechanical means only. Zinc polycarboxylate cement exhibits significantly greater plastic deformation than zinc phosphatethus, it is not well suited for use in regions of high masticatory stress or in cementation of long-span prosthesis.[6] Glass ionomer cements is associated with the occurrence of tooth sensitivity after restoration delivery and high early solubility.[8] Commonly used resin luting agents (polymerization reaction) show excellent translucency, controlled setting, low cement film thickness, resistance to post-polymerization solubility, and mechanical strength.[3]

Within the last two to three decades, a new class of dental materials has emerged. This group of materials shares three characteristics (1) they contain comparably high levels of calcium, (2) they display a pH in the alkaline range, and (3) they are bioactive.[9] When used as luting agents these materials associate with oral fluids and show recharge and renewal of restorative material constituents, have the potential to reduce bacterial microleakage and enhance marginal integrity.

The primary objective of this study is to explore whether this relativity new class of dental materials (bioactive luting cements) could prevent microleakage as compared with Conventional GIC, and Dual Cure Resin Luting Cements as there is no single ideal luting agent that fulfills the requirements and thus, studies comparing various luting agents are of much help to a clinician.

Materials and Methods:

45 Freshly extracted, caries free, intact, permanent human molars were collected, cleaned, and were stored in 0.1 % thymol solution and randomly divided into 3 groups.



All teeth were mounted in self-cure acrylic resin(clear) blocks 1 mm cervical to CEJ and prepared with NSK Europe GmBh Airoter for dentin-bonded monolithic zirconia crowns with 1.7 mm occlusal, 1.5 mm axial reductions, 1 mm heavy chamfer (0.5 mm above CEJ), 4.5 mm height with diamond burs.Zirconia crowns were fabricated using CAD CAM technology. Prepared samples were directly scanned using extraoral scanner (Medit Identica Blue). Restorations were designed on a computer monitor using CAD software based on the digitized data as a virtual wax up. Finally, restorations were processed by a computer assisted processing machine, using a milling machine.

A cement space of 0.02 mm at 2mm from the prepared margin was incorporated. The inner surface of all zirconia crowns was etched with 5% buffered HF acid (CeraEtch porcelain Etching Gel) for 90 seconds. (Fig: 1a,1b)

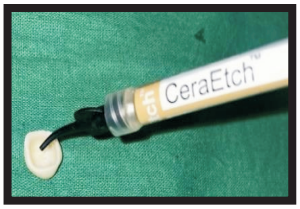


Fig:1aApplication of etchant

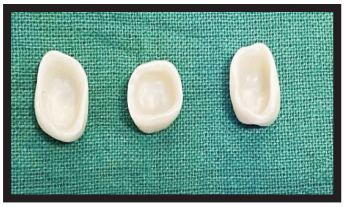


Fig:1bEtched crowns

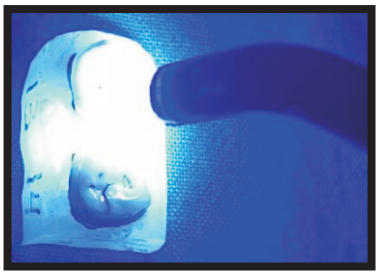


Fig:2Application of bonding agent

Bonding agent was applied to all teeth with the applicator tips for 20 secs, dried with air (5 sec) and photopolymerized each surface (occlusal, buccal, lingual, mesial, and distal) for 20 secs.(Fig: 2). Each crown was cemented to the corresponding tooth preparation with the assigned cement following manufacturer's instructions. Equal amount of cement was dispensed in each crown and smeared with the walls and the crowns were cemented on tooth preparation.Excess cement

was removed using a sickle scaler. For specimens in Group-1 (Bioactive),(Fig 3a, 3b) tooth preparation was dried with air for 5 sec and crowns cemented followed by removal of the excess cement and photo-polymerization like Group-3 (dual cure resin) specimens(Fig 4).

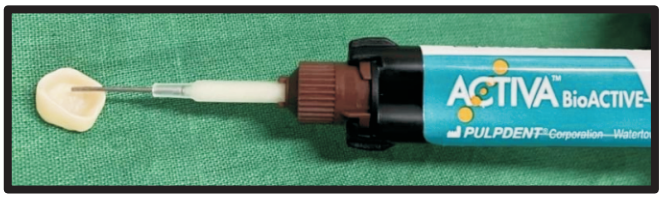


Fig:3a: Loading bioactive cement

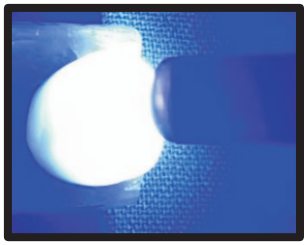


Fig:3b: photopolymerization

Fig:4: Application of dual cure luting cement

In the specimens cemented with GIC (group 2), cementation followed the standard protocol however, a thin layer of petroleum jelly was applied to the margin to prevent water dissolution or absorption during cement setting (Fig 5).

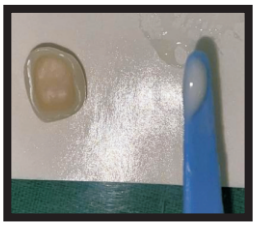


Fig:5: Application of glass ionomer cement

After cementation all restored teeth were placed in buffered saline solution at 37 degrees centigrade for 1 day. Samples of each group were divided into 3 subgroups i.e. A, B and C, (5 samples each) and for aging subgroup B and C of all groups were placed in a thermocycler (5 degree centigrade: LG Model: 051SA, 55degree centigrade: Mahavir India) for 6000 and 10,000 cycles alternating between 5 degrees centigrade and 55 degrees centigrade to simulate aging at 6 months and 12 months respectively(Fig:6).

Fig:6: Placement of samples in thermocycler

All the restored teeth were painted with acrylic varnish to within 1 mm of crown margin.

Then all the restored teeth were placed in 2 % basic fuchsin dye solution for 24 hrs. (Fig:7).

Fig:7: Immersion in dye

After 24 hrs. the restored teeth were sectioned using diamond disc under running water buccolingually. The sections were examined under a stereo microscope (Wuzhou New found, Model: XTL3400E) at 30 X magnification and MAGNUS TZM6, OLYMPUS OPTO SYSTEM, INDIA software was used to transfer into the laptop and analysis of image data for microleakage and scored from zero to four based on the amount of staining toward the pulp (Table 1). A score of zero represented microleakage at the crown margins only, while a score of four represented microleakage throughout the tooth and into the pulp.

TABLE: 1	SCORING CRITERIA
0	Microleakage at crown margins only
1	Microleakage at crown margins and around cement
2	Microleakage at crown margins and throughout cement
3	Microleakage to 1/3 of tooth structure
4	Microleakage throughout tooth structure and pulp

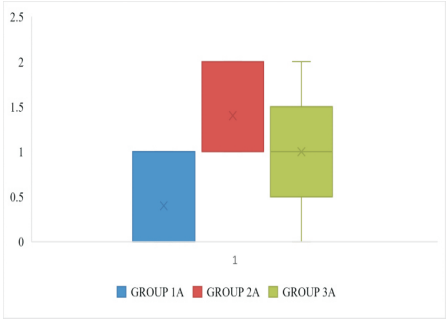
Data was analyzed using SPSS (Statistical Package for Social Sciences) 21.0 version, IBM, Chicago. Descriptive statistics was performed. Inter-group comparison was performed using Kruskal-Walli's test and Chi-square test. Pair-wise comparison was done using Post Hoc analysis.

Results :

All samples in this study had microleakage. The median microleakage score in group 1 sample was 1.0 (0.0-1.0). There was no significant difference in the microleakage score of the samples belonging to group 1A, 1B and 1C (p value >.05). The median microleakage score in group 2 was 2.0 (1.0-2.0). There was no significant difference in the microleakage score of the samples belonging to group 2A, 2B and 2C (p value >.05). The median microleakage score in group 3 was 1.0 (1.0-2.0). There was no significant difference in the microleakage score of the samples belonging to group 3A, 3B and 3C (p value >.05). The microleakage score of the samples of group 1A, 2A and 3A was significantly different (p value <.05) (Table2,3).The microleakage score of the samples of group 1B, 2B and 3B was significantly different (p value <.05)(Table 4,5). The microleakage score of the samples of group 1C, 2C and 3C was significantly different (p value <.05)(table 6,7).The microleakage score was significantly different between the samples of group 1, 2 and 3 (p value <.05) (Table 8,9) graph

Table2: Comparison of microleakage score insamples of group 1A, 2A and 3A.

	Median	Inter-quartile range	Chi-square value	P value$^{\Omega}$
Group 1A	0.0	0.0-1.0	4.641	.031*
Group 2A	1.0	1.0-2.0		
Group 3A	1.0	0.5-1.5		



Graph 1. Microleakage score in samples of group 1A, 2A and 3A

$^{\Omega}$Kruskal-Walli's test. *p value<.05 was considered statistically significant.

The microleakage score of the samples of group 1A, 2A and 3A was significantly different (p value <.05).

Table 3. Post hoc analysis (Group 1A, 2A and 3A)

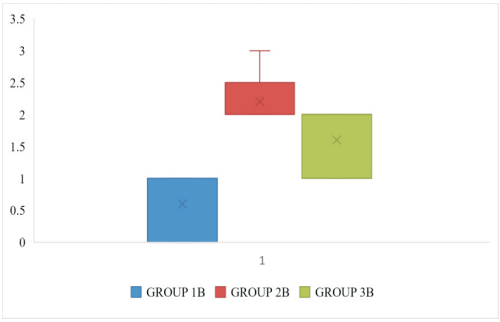
Pair-wise	P value
Group 1A vs 2A	.031*
Group 1A vs 3A	.166
Group 2A vs 3A	.339

*p value<.05 was considered statistically significant.

Pair-wise comparison revealed that microleakage score in group 1A samples was significantly less than that of group 2A samples. There was no significant difference in the microleakage score of the samples of group 1A and 3A, and group 2A and 3A (p value >.05).

Table 4. Comparison of microleakage score in samples of group 1B, 2B and 3B

	Median	Inter-quatile range	Chi-square value	P value$^{\Omega}$
Group 1B	1.0	0.0-1.0	7.500	.006*
Group 2B	2.0	2.0-2.5		
Group 3B	2.0	1.0-2.0		



Graph 2. Microleakage score in samples of group 1B, 2B and 3B.

$^{\Omega}$Kruskal-walli's test. *p value <.05 was considered statistically significant.

The microleakage score of the samples of group 1B, 2B and 3B was significantly different (p value <.05).

Table 5. Post hoc analysis (1B, 2B, 3B).

Pair-wise	P value
Group 1B vs 2B	.002*
Group 1B vs 3B	.057
Group 2B vs 3B	.223

Pair-wise comparison revealed that microleakage score in group 1 samples was significantly less than that of group 2 samples. There was no significant difference in the microleakage score of the samples of group 1B and 3B, and group 2B and 3B (p value >.05).

Table 6. Comparison of microleakage score in samples of group 1C, 2C and 3C.

	Median	Inter-quartile range	Chi-square value	P value$^{\Omega}$
Group 1C	1.0	0.0-1.0	5.808	.016*
Group 2C	2.0	1.5-3.0		
Group 3C	1.0	1.0-2.0		

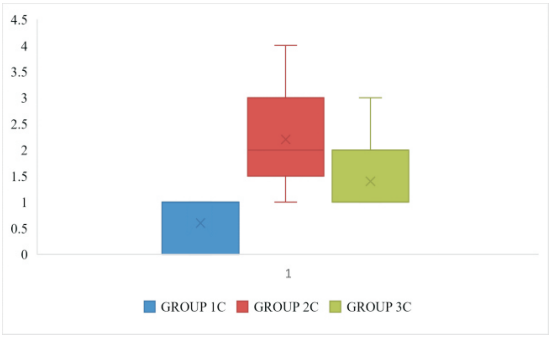
$^{\Omega}$Kruskal-wallis test. *p value<.05 was considered statistically significant.

The microleakage score of the samples of group 1C, 2C and 3C was significantly different (p value <.05).

Table 7. Post hoc analysis (1C, 2C and 3C).

Pair-wise	P value
Group 1C vs 2C	.007*
Group 1C vs 3C	.177
Group2C vs 3C	.177

*p value<.05 was considered statistically significant.

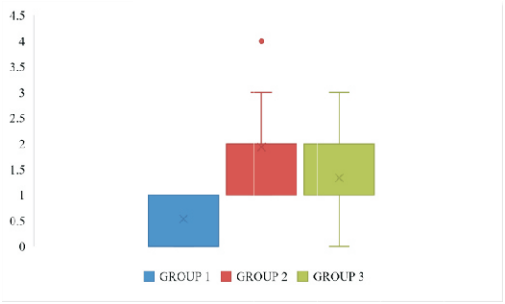


Graph 3. Microleakage score in samples of group 1C, 2C and 3C.

Pair-wise comparison revealed that microleakage score in group 1C samples was significantly less than that in group 2C samples. There was no significant difference in the microleakage score of the samples of group 1C and 3C, and group 2C and 3C (p value >.05).

Table 8. Comparison of microleakage score in samples of group 1, 2 and 3 samples.

	Median	Inter-quartile range	Chi-square value	P value$^{\Omega}$
Group 1	1.0	0.0-1.0	17.856	.001*
Group 2	2.0	1.0-2.0		
Group 3	1.0	1.0-2.0		



Graph 4. Microleakage score in samples of group 1, 2 and 3.

$^{\Omega}$Kruskal-wallistest. *p value<.05 was considered statistically significant.

The microleakage score was significantly different between the samples of group 1, 2 and 3 (p value <.05).

Table 9. Post hoc analysis (group 1, 2 and 3)

Pair-wise	P value
Group 1 vs 2	.001*
Group 1 vs 3	.007*
Group 2 vs 3	.061

*p value<.05 was considered statistically significant.

The microleakage score of group 1 samples was significantly less than that of samples in group 2 and 3. There was no significant difference in the microleakage score of groups 2 and 3 samples (p value >.05).

Discussion:

The advancement of restorative materials and techniques continues to enhance the clinical success of numerous restorative procedures. Despite these new innovations, microleakage persists as one of the main causes of restoration failure.

Microleakage assays provide useful information on the performance of restorative materials. It is typically evaluated with in vitro methods rather than in vivo methods, which can be qualitative as well as quantitative.[2] The clinical performance of any new dental restorative material can only be tested first using in vitro models. In vitro results can be generalized to oral circumstances and are valuable for gathering preliminary data, but they have limits.[5] Microleakage tests can be subdivided into old and contemporary methods. Old methods were used to test the presence of gaps and the sealing ability of different restorative materials. These methods included air pressure, fluid filtration, electrochemistry, neutron activation, bacteria, and artificial caries. However, these techniques were found to be nonrepresentative of leakage and thus have been replaced by more contemporary methods such as Radioisotope method, Acetate peel technique, Dye penetration, Three-dimensional methods, Micro computed tomography, Confocal laser scanning microscopy, Optical coherence tomography.[7]

The staining of microleakage and nano leakage using colored agents is the most commonly used technique. Dye penetration method involves the use of contrasting dyes as an immersion solution to stain the areas of microleakage, and then the tooth–restoration interface is examined for evidence of staining. Notably, the most commonly used solutions are 0.5% basic fuchsin, 2% methylene blue, and 50% silver nitrate.[7]

The dye penetration assay has many advantages over other techniques. First, no reactive chemicals are used along with no radiation.[10] Second, different dye solutions are available; therefore, the technique is highly feasible and easily reproducible. We utilized a chemical marker like 0.5% Basic Fuchsin to test the imperviousness of sealing and bonding solutions. The oral environment can be replicated by water storage and thermocycling of samples. The use of thermocycling as a simulation of clinical aging is a common artificial aging technique.

The rmocycling is intended to simulate the thermal stress to which the restorative materials and the teeth would be exposed to by consuming drinks and food to get years of aging for the specimens in a short period of time.

There are disagreeing opinions about the influence of the rmocycling on microleakage. Some authors reported the absence of any influence of thermocycling on microleakage,[11] while others show an increase of microleakage at the cementum-dentin-restoration interface after thermal stressing.[5]

In this study, Stereomicroscope, Basic Fuschin dye and Thermocycler were used to evaluate sealing ability of various cements like Bioactive cement, Conventional GIC and Dual Cure Resin cement. Microleakage was selected to be tested by stereomicroscope and analyzed by **MAGNUS TZM6, OLYMPUS OPTO SYSTEM, INDIA** because it is ideal for evaluating microleakage and has advantages such as repeatability, sensitivity and objectivity.

On the basis of results obtained by statistical analysis of the readings recorded from stereomicroscope for microleakage it was concluded that the microleakage score of group 1 samples was significantly less than that of samples in group 2 (p value-0.001*). The microleakage score of group 1 samples was significantly less than that of samples in group 3 (p value-0.007*). There was no significant difference in the microleakage score of groups 2 and 3 samples (p value-0.061).

The microleakage score of the samples of group 1A, 2A and 3A was significantly different (p value - 0.031*). The microleakage score of the samples of group 1B, 2B and 3B was significantly different (p value.006*). The microleakage score of the samples of group 1C, 2C and 3C was significantly different (p value-0.016*). The microleakage with bioactive cement was less than that of GIC and Dual cure resin cement at day 1 and after 10,000 cycles (Fig:8).

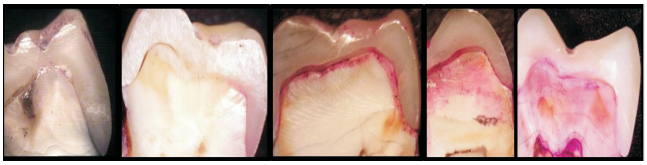


Fig:8 Microleakage of each crown-cement combination. (A) Microleakage with Bioactive cement, score of 0; (B) Microleakage with Dual cure resin cement with a score of 1;

(C) Microleakage with a score of 2 (D) Microleakage with glass ionomer cement with a score of 3; (E) Microleakage with a score of 4.

The present study was based on the hypothesis that there is no significant difference in microleakage in zirconia crowns cemented with Bioactive, Conventional GIC, and Dual Cure Resin Luting Cements. The research revealed that the Bioactive luting agent exhibited lower microleakage than Conventional GIC, and Dual Cure Resin Luting Cement. Therefore, the null hypothesis was rejected.The explanations for these findings include chemical compositions of the materials and their interaction with tooth dentin.

Conventional acid–base cement such as glass ionomer cement (GIC)) shows high solubility and low mechanical resistance in the presence of bioactivity and fluoride release.[3] Commonly used resin luting agents (polymerization reaction) show excellent translucency, controlled setting, low cement film thickness, resistance to solubility post-polymerization, and mechanical strength.[12] However, resin cements are sensitive to moisture, undergo dimensional changes (polymerization and thermal), show minimum bacterial resistance, and lack dentin remineralization potential.

Bioactive cement is based on the ionic resin matrix responsible for the chemical bond between the material and the dentin. In the presence of water, ionization causes the replacement of hydroxyl groups in phosphate acid of the matrix with the calcium in dentin, resulting in a chemical bond.[13] This ionic exchange results in binding of the bioactive luting agent to the tooth structure, forming a hydroxyapatite complex and a marginal seal.[3]

This is explored by **Steven R. Jefferies et al** whether bioactive dental cements have the ability to seal marginal gaps as compared with other classes of dental cements. The analysis of gap closure for the various materials indicated a complete lack of any changes in the artificial margin gaps created for the glass ionomer, resin-modified glass ionomer, or self-adhesive resin cements at any time point in the evaluation. In contrast, both the calcium silicate-Portland cement-type cement and the calcium aluminate-glass ionomer cement clearly demonstrated mineral deposits and partial/total occlusion of the artificial marginal gaps created in their specimens. Furthermore, all bioactive cement specimens (both the calcium silicate/Portland cement-type and the calcium aluminate/glass ionomer) clearly demonstrated complete gap closure in gaps ranging from 50 to 120 μm in initial dimensions.[14]

The results of our study are in agreement with the research done by **Fahim Vohra et al**. They have concluded that microleakage was significantly lower in crowns luted with bioactive (0.381 ± 0.134) cement compared to GIC (1.057 ± 0.399 mm3) ($p < 0.01$) and resin (0.734 ± 0.166 mm3) ($p = 0.014$) cemented crowns. The type of luting agent had a significant influence on the microleakage of crowns and bond strength to dentin ($p < 0.05$).[3]**Fahad Alkhudhairy and Zeeshan H Ahmad** have compared the shear bond strength and microleakage properties of Activa restorative with other bulk-fill restorative materials surefil (SDR), Biodentine, ever X posterior. They have concluded that SDR (surefil) showed better shear bond strength and better microleakage properties compared with the other test materials ($F = 186.7157$, $p<0.05$). It is due to the difference in the testing materials they have used surefil (SDR), Biodentine, ever X posterior and Activa restorative which are bulk fill materials. But we have used Activa bioactive, conventional GIC and dual cure resin cement which are luting materials. Hence there is difference in the result.[15]

This study was an in vitro study some of the limitations include are the methods employed in the assessment of microleakage are not standardized and comparisons of outcomes observed to other studies is not justified. In addition, the in vitro study assessed a clinical in vivo phenomenon, with limitations of not having an intra-oral environment. Although we used a well-established protocol to simulate the oral environment, the real clinical scenario is too complex and difficult to reproduce by means of laboratory experiments. The preliminary findings of this initial study suggest that the Bioactive cement shows the least amount of microleakage when compared with Conventional GIC and Dual Cure luting cements. Further study and evaluation are necessary to corroborate and develop additional information with respect to the findings of this study. If substantiated, the capability of a bioactive reactive restorative material to reseal and close marginal gaps and defects could potentially add a new useful additional protective function to restorations in dentistry.

Conclusions:

Based on this in vitro investigation's results, it was concluded that the microleakage in the zirconia crowns cemented with bioactive luting cements was significantly less than that of the zirconia crowns cemented with Dual cure resin luting cement and glass ionomer cement.

References:

1. M u t l u ö z c a n, Luting cements for dental applications, Woodhead Publishing Limited, 2013.
2. Jacker-Guhr S, Ibarra G, Oppermann LS, Lührs AK, Rahman A, Geurtsen W, et al. Evaluation of microleakage in Class V composite restorations using dye penetration and micro-CT. Clin Oral Investig 2016;20:1709-18.
3. Fahim Vohra et al, Bond integrity and microleakage of dentin-bonded crowns cemented with bioactive cement in comparison to resin cements: in vitro study, Journal of Applied Biomaterials & Functional Materials,2020, 1–8.
4. Lindquist and Connolly, In vitro microleakage of luting cements and crown foundation material, The Journal of Prosthetic Dentistry, march 2001, volume 85 number 3.
5. Andrea Fabianelli, The relevance of micro-leakage studies, international dentistry sa vol. 9, NO. 3.
6. Komal Ladha and Mahesh Verma, Conventional and Contemporary Luting Cements: An Overview, J Indian Prosthodont Soc (Apr-June 2010) 10(2):79–88.
7. Yavuz I, Tumen EC, Kaya CA, Dogan MS, Gunay A, Unal M, et al. The reliability of microleakage studies using dog and bovine primary teeth instead of human primary teeth. Eur J Pediatric Dent 2013; 14:42-6.
8. EE Hill, J Lott, A clinically focused discussion of luting materials, Australian Dental Journal 2011; 56:(1 Suppl): 67–76.
9. Steven R. Jefferies et al, Preliminary Evidence That Bioactive Cements Occlude Artificial Marginal Gaps, J Esthet Restor Den, 2015 27:155–166.
10. Subramaniam P, Pandey A. Assessment of microleakage of a composite resin restoration in primary teeth following Class III cavity preparation using Er, Cr: YSGG laser: An in vitro study. J Lasers Med Sci 2016; 7:172-6.
11. Doerr CL, Hilton TJ, Hermesch CB. Effect of thermocycling on the microleakage of conventional and resin modified glass ionomer. Am J Dent 1996; 9: 19-21.
12. Pameijer CH. A review of luting agents. Int J Dent 2012; 12: 32–37.
13. Naorungroj S, Wei HH, Arnold RR, et al. Antibacterial surface properties of fluoride-containing resin-based sealants. J Dent 2010; 38: 387–391.
14. Jefferies et al, Preliminary Evidence That Bioactive Cements Occlude Artificial Marginal Gaps, Journal of Esthetics and Restorative Dentistry, 2015 Vol 27 No 3, 155–166.
15. Fahad I Alkhudhairy and Zeeshan H Ahmad, Comparison of Shear Bond Strength and Microleakage of Various Bulk-fill Bioactive Dentin substitutes: An in vitro Study, The Journal of Contemporary Dental Practice, December 2016;17(12):997-1002.