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Original Research Article

An in-Vitro Study to Evaluate the Microleakage of Metallic Copings Luted with Three Different Commercially Available Luting Cements: A Comparative Study

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Abstract

Aim: The aim of the present study was to evaluate the microleakage of metallic copings luted with three different commercially available luting cements.

Methods: The study was conducted at Department of Dentistry. 24 replicas of abutment analog having length 5 mm, width of platform 4.8 mm, taper 6°, broad chamfer finish line and three anti-rotation grooves over it which end 1 mm above finish line were milled from titanium rods.

Results: The result showed microleakage scores for specimens cemented with zinc oxide non-eugenol, zinc polycarboxylate and zinc phosphate luting cements, respectively. All specimens exhibited microleakage to different degrees. Mean microleakage score was least for Zinc Phosphate cement (1.078±0.32), followed by Zinc Polycarboxylate cement (1.6±0.84) and most for zinc oxide non-eugenol (2.3±0.87). On subjecting the values of mean microleakage scores to Kruskal–Wallis ANOVA followed by Chi-square test, the value of $P = 0.001$ indicating that there was significant difference in mean microleakage scores of the groups tested ($P < 0.05$).

Conclusion: Within the limitations of the study, it was found that all cements exhibited certain amount of microleakage. Zinc Phosphate cement exhibited a mean microleakage score that was significantly lower than Zinc Oxide Non Eugenol cement and Zinc Polycarboxylate cement. When microleakage scores of Zinc Oxide Non Eugenol cement and Zinc Polycarboxylate cement were compared, the difference was found to be insignificant indicating that microleakage in these cements was similar.

Keywords: Cement solubility, implant abutments, luting cements, microleakage

Introduction

The ultimate goal of any prosthetic treatment is providing 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] An extra coronal restoration that has been completed precisely with attention to detail on a sound foundation has the best and most predictable prognosis. [2] Despite the material advancements and precise laboratory techniques, cement lines are inevitable in fixed prosthodontics and some degree of marginal discrepancy is always expected. [3] Zinc phosphate cement is one of the most popular cements, which has been in use for many years. The success of this material has been attributed to high retentive and fatigue strength as well as its minimal film thickness of <25 μ. [4,5]

Polycarboxylate cement and glass ionomer cement have attracted attention due to their ability to bond chemically with various restorative materials and to tooth structure. According to some studies, glass ionomer cement seems to have higher retentive and compressive strength than other luting cements. [4,6] Certain disadvantages of these cements, such as low retentive values despite several advancements, have led scientists to develop methods in an attempt to improve the essential properties of luting cements. Resin cement is particularly attractive because of its high retention, low solubility in oral fluids, and its ability to adhere to different materials. [4-6] Even though a definitive restoration may be placed as quickly as 2 weeks after tooth preparation, the provisional restorations must satisfy important needs of the patient and dentist. Materials used to fabricate provisional restorations can be classified as acrylics or resin composites. [7,8] Multiple factors affect the success of fixed prosthodontic restorations with preparation design, oral hygiene/microflora, mechanical forces and restorative materials being some of them. However, the key to success is the choice of proper luting cement and cementation procedure. The word "LUTING" is derived from a Latin word lutum‑which means mud. Dental luting agents provide a link between the restoration and the prepared tooth, bonding them together through some form of attachment, which may be mechanical, micro‑mechanical, chemical or combination. [9]

Cement dissolution can cause microleakage, but other possible causes include lack of adhesion between luting cement and tooth structure, shrinkage of luting agent on setting and mechanical failure of the luting agent. The location of margins, whether sub‑gingival or supra‑gingival may also influence the leakage by exposure to different quantities of oral fluids and microflora. The marginal accuracy of provisional crowns is due to a combination of factors that include: Material properties, fabrication techniques and dynamic loading factors. Any marginal gap combined with inherently weak provisional cement will provide an ideal site for microleakage to occur.

The aim of the present study was to evaluate the microleakage of metallic copings luted with three different commercially available luting cements.

Materials and Methods

The study was conducted at Department of Dentistry Anugrah Narayan Magadh Medical College and Hospital, Gaya, Bihar, India from February 2021 to Jan 2022 . 24 replicas of abutment analog having length 5 mm, width of platform 4.8 mm, taper 6°, broad chamfer finish line and three anti‑rotation grooves over it which end 1 mm above finish line were milled from titanium rods.

Fabrication of metal copings

Each abutment analog was mounted in dental plaster along the long axis for stabilization. Two layers of die spacer were applied on abutments analogs 1mm short of margin. Two different colored die spacers were used to ensure even thickness of the die spacer on the abutment. A die lubricant was applied over abutments to help easy separation of the pattern. Wax pattern was prepared using type II inlay wax having uniform thickness of 0.5 mm. For even thickness of wax pattern for other abutment analogs, a putty index was prepared from this wax pattern. The remaining wax patterns were prepared using the putty index. Wax near the margin was scraped off and readapted for marginal refinement. A sprue former was made of wax, and a reservoir was attached to the sprue. The length of the sprue was adjusted so that the wax pattern was approximately ¼ inch from the casting ring. A non ‑asbestos ring liner was applied inside the casting ring. Wetting agent was applied over the wax pattern to prevent any bubble formation. Wax patterns were invested into phosphate bonded investment, burnout procedure was carried out, and casting was done using Ni‑Cr alloy in induction casting machine. Castings were divested, desprued and sandblasted with aluminum oxide particles of 110–125 micron under 2 bar pressure to remove residual investment material. Nodules were removed from the fitting surface with the help of rotary instrument. Copings were finished and polished using polishing burs. Each coping was checked under optical microscope for marginal discrepancy and the specimens with marginal discrepancy <40 µm were selected for the study.

Cementation

The copings with their respective abutment analog were randomly divided into three groups having 8 samples in each. Cementation was done with three luting agents commonly used in cementation of implant‑supported prosthesis. The cements were:

I. Zinc oxide non‑eugenol luting cement (3M)

II. Zinc polycarboxylate cement (Dentsply)

III. Zinc phosphate luting cement (GC).

Cementation was done in accordance with the manufacturer's instructions for mixing time, mixing conditions, and powder: liquid ratio. Luting agent was applied completely on all internal walls of copings and was then seated onto abutment analog with firm figure pressure for 10 s followed by 2 kg axial load for 5 min with the help of the customized holding device. For equal distribution of load on metallic coping, the customized holding device was designed in such a way that the circumference of the head of weight was 1 mm short of circumference of occlusal surface of coping. After setting, excess cement was removed with the help of hollenback carver. Specimens were examined visually to confirm complete seating of copings onto abutment analogs and allowed to set for 24 h.

Thermocycling

After 24 h, the cemented specimens were removed from plaster blocks and subjected to 5000 cycles of thermocycling between 5° and 55° C with dwell time of 10 s and transfer time of 5 s in the thermocycling unit.

Dye Penetration

After thermocycling, cemented specimens were placed into 0.5% aqueous solution of basic fuchsin solution for 24 h for dye penetration.

Evaluation of Microleakage

Microleakage was evaluated by using multiple surface scoring methods for each specimen. After keeping the cemented specimen in dye solution for 24 h, the specimens were sectioned longitudinally in bucco‑lingual axis with the help of carborundum disc. Microleakage score was recorded at two abutment‑coping interfaces of each section, thus making a total of four scores for each specimen. Two markings were made on the axial walls, which were at 1/3rd and 2/3rd of the length of abutment analog. The sectioned specimens were placed under stereomicroscope under ×40 for the evaluation of microleakage. Microleakage was scored by the method used by Tjan et al. Microleakage scores used were:

0 No microleakage seen on the axial wall of the sectioned specimen

1 Microleakage seen up to 1/3rd the length on the axial wall of the sectioned specimen

2 Microleakage seen up to 2/3rd the length on the axial wall of the sectioned specimen

3 Microleakage seen along the full length of the axial wall of the sectioned specimen

4 Microleakage seen on the occlusal surface of the sectioned specimen.

Statistical Analysis

Microleakage scores were recorded for each group. Data were tabulated and analyzed using Kruskal–Wallis analysis of variance (ANOVA) followed by Chi‑square test. Pairwise comparison of groups was made with Mann–Whitney U‑test. Statistical significance was set at $P < 0.05$.

Results

Table 1: Microleakage scores in specimens cemented with zinc oxide noneugenol luting cement (Group I)

Number	Buccal 1	Microleakage scores Buccal 2 Lingual 1		Lingual 2	Mean score
1	1	2	1	1	1.55
2	2	2	1	2	1.30
3	1	1	1	1	1.55
4	2	1	4	4	2.55
5	4	3	2	2	2.80
6	2	2	1	1	1.60
7	4	4	3	3	2.55
8	1	1	2	2	1.55
Total mean score		2.3±0.87			

Table 2: Microleakage scores in specimens cemented with zinc polycarboxylate luting cement (Group II)

Number	Buccal 1	Microleakage scores Buccal 2 Lingual 1		Lingual 2	Mean score
1	1	1	1	2	1.55
2	2	1	2	1	1.80
3	2	2	2	2	1.80
4	2	2	1	1	2.00
5	2	2	2	2	2.00
6	1	1	2	2	1.60
7	2	1	1	1	1.55
8	1	2	2	2	2.00
Total mean score			1.6±0.84		

Table 3: Microleakage scores in specimens cemented with zinc phosphate luting cement (Group III)

Number	Buccal 1	Microleakage scores Buccal 2 Lingual 1		Lingual 2	Mean score
1	1	2	1	1	1.25
2	1	1	2	2	1.50
3	1	1	0	0	0.50
4	1	1	1	1	1.00
5	0	0	1	1	0.50
6	2	2	1	1	1.50
7	1	1	2	2	1.50
8	1	1	1	1	1.00
Total mean score			1.078±0.32		

Tables 1-3 show microleakage scores for specimens cemented with zinc oxide non-eugenol, zinc polycarboxylate and zinc phosphate luting cements, respectively. All specimens exhibited microleakage to different degrees. Mean microleakage score was least for Zinc Phosphate cement (1.078±0.32), followed by Zinc Polycarboxylate cement (1.6±0.84) and most for zinc oxide non-eugenol (2.3±0.87).

Table 4: Descriptive statistics and Statistical analysis for microleakage with all luting cements using Kruskal–Wallis test

	NPar tests n		Mean	SD Minimum Maximum	
Total	24	1.6490	0.67009	0.50	4.00
Cement	24	2.00	0.844	1	3
Cement			n	Mean rank	
Group I			8	18.92	
Group II			8	19.71	
Group III			8	6.94	
Total			24		

On subjecting the values of mean microleakage scores to Kruskal–Wallis ANOVA followed by Chi-square test, the value of $P = 0.001$ indicating that there was significant difference in mean microleakage scores of the groups tested ($P < 0.05$).

Discussion

Microleakage is determined today by many in vitro techniques [10] and according to Van Meerbeek et al., (2003), methods of assessing microleakage can be divided into qualitative, semiquantitaive or true quantitative measurements of sealing effectiveness. In vitro studies evaluating the microleakage of provisional restorations cemented with various temporary luting cements have been reported. Luting cements were chosen because there are very few studies related to evaluation of microleakage of provisional crowns cemented with luting cements which is important as leakage occurring at the tooth-cement interface has greater biological significance since it causes dentinal sensitivity, secondary caries formation, corrosion or dissolution of dental materials, discoloration of dental materials and surrounding tooth structure, and percolation of fluid and if leakage is severe it may lead to the irritation of pulp and inflammatory pulpal lesions. Microleakage is related to dimensional changes of provisional crown materials due to polymerization shrinkage, thermal contraction, absorption of water and mechanical stress [11] and any marginal gap combined with an inherently weak provisional cement will provide an ideal site for microleakage to occur. [12]

The result showed microleakage scores for specimens cemented with zinc oxide non-eugenol, zinc polycarboxylate and zinc phosphate luting cements, respectively. All specimens exhibited microleakage to different degrees. Mean microleakage score was least for Zinc Phosphate cement (1.078±0.32), followed by Zinc Polycarboxylate cement (1.6±0.84) and most for zinc oxide non-eugenol (2.3±0.87). Hooshmand T et al [13] evaluated the microleakage and marginal gap of two self-adhesive resin cements with that of other types of adhesive luting cements for noble alloy full cast crowns. Fifty noncarious human premolars and molars were prepared in a standardized manner for full cast crown restorations. The Rely X Unicem (with or with no pretreatment) exhibited the smallest degree of microleakage at both tooth-cement and cement-crown interfaces. The greatest amount of microleakage was found for Panavia F 2.0 resin cement followed by GC Fuji Plus at both interfaces. No statistically significant difference in the marginal gap values was found between the cementing agents evaluated. Various principles, including biological, chemical, electrical, physical, or radioactive components, have been utilized by contemporary methods to evaluate microleakage. These include the use of dyes, bacteria, neuron activation analysis, radioactive isotopes, artificial caries, air pressure, scanning electron microscope, and calcium hydroxide. [14]

In the present study, zinc phosphate cement exhibited the least microleakage. This can be attributed to its high compressive and tensile strengths coupled with excellent retention properties. The mean microleakage score in zinc polycarboxylate cement was less than zinc oxide noneugenol cement. Although both the cements have similar compressive strengths, the difference in microleakage can be attributed to better retentive properties of polycarboxylate cement. The difference in the microleakage for these two cements was insignificant. In the present study, Zinc oxide non-eugenol cement was selected because zinc oxide non-eugenol cement showed less microleakage than Zinc oxide eugenol cement. [Therefore, a number of improved eugenol-free cements have been introduced that contain polyorganic acid, polycarboxylate, etc. Advantages of these cements are they do not interfere with definitive cementation and also have low film thickness. They have the characteristics of being compatible with resin provisional materials, with permanent resin cements and show greater retention compared to ZOE cements. [16]

The tensile strength of zinc polycarboxylate cement is higher than zinc phosphate cement, but it is not commonly used as definitive cement in implant dentistry. This can be attributed to its inferior compressive strength and retentive properties. This cement is commonly used in cases with the presence of less than six abutments, no cantilever or offset loads are present and soft access cement is desired. Zinc polycarboxylate cement can also be used as provisional cement when zinc oxide eugenol cement appears insufficient. [17] In vitro microleakage tests carried out with dyes are more sensitive than those carried out in oral cavity. This is probably because the dye is more easily diffused than bacteria and their by‑products and secondly, the build‑up of proteins and debris that calcify in the marginal opening may improve the seal. [18] On subjecting the values of mean microleakage scores to Kruskal–Wallis ANOVA followed by Chi ‑square test, the value of $P = 0.001$ indicating that there was significant difference in mean microleakage scores of the groups tested ($P < 0.05$).

Conclusion

Within the limitations of the study, it was found that all cements exhibited certain amount of microleakage. Zinc Phosphate cement exhibited a mean microleakage score that was significantly lower than Zinc Oxide Non Eugenol cement and Zinc Polycarboxylate cement. When microleakage scores of Zinc Oxide Non Eugenol cement and Zinc Polycarboxylate cement were compared, the difference was found to be insignificant indicating that microleakage in these cements was similar.

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