Original Article

Comparative Evaluation of Microleakage of Metallic Copings Luted with Three Different Commercially Available Luting Cements: An *In vitro* Study

Samrat Mankar*, Sonika Mankar, Ashwin Aidasani, Abhay Narayane, Ranjeet Gandagule, Rahul Kothari

Department of Prosthodontics, Dr. Hegdewar Smruti Rugna Seva Mandals Dental College and Hospital, Hingoli, Maharashtra, India.

Abstract

Background: In the mainstream, dental implants play a significant role. Today's dentistry focuses on restoring esthetics, shape, occlusion, function, comfort, speech, and overall health. Microleakage at the tooth prosthesis contact has been the subject of numerous investigations in the past. Microleakage at the implant abutment prosthesis contact has received very little attention in the literature. As a result, a study was carried out to assess microleakage at the implant abutment and prosthesis interface in cemented implant-supported prostheses cemented with three different commercially available luting cements. **Materials and Methods:** It was an *in vitro* comparative evaluation research. A total of 45 abutment analogue replicas were machined and divided into three groups. The marginal gap was measured with an optical microscope and luted with zinc oxide non-eugenol cement, zinc polycarboxylate cement, and zinc phosphate cement. Cemented specimens were immersed in a 0.5% aqueous solution of basic fuchsin solution for 24 h after thermocycling to allow dye penetration. Copings were sectioned longitudinally and microleakage scores were calculated. The Chi-square test was used after the Kruskal–Wallis analysis of variance. The Mann–Whitney U-test was used to compare groups pairwise. **Results:** Mean microleakage score was least for zinc phosphate cement (1.064 ± 0.43) followed by zinc polycarboxylate cement (1.76 ± 0.41) and most for zinc oxide non-eugenol (2.31 ± 0.76). The results of the study were statistically significant, $P < 0.05$. **Conclusions:** It was discovered that all cements had some degree of microleakage. Zinc phosphate cement had a considerably lower mean microleakage score than zinc oxide non-eugenol cement or zinc polycarboxylate cement. When the microleakage scores of zinc oxide non-eugenol and zinc polycarboxylate cements were examined, the difference was found to be minor, indicating that microleakage is equivalent in both cements.

Keywords: Cement solubility, Implant abutments, Luting cements, Microleakage.

Introduction

In the mainstream dentistry, dental implants play a significant role. Today's dentistry focuses on restoring esthetics, shape, occlusion, function, comfort, speech, and overall health. There was a considerable predilection for screw-retained restorations from the 1980s to the early 1990s, which thereafter gave way to cement-retained restorations. Fastening screws are the most common type of retention in screw-retained restorations, as they secure the prosthesis to the abutment and, as a result, the abutment to the implant.[1,2] These are primarily advised in circumstances when the interarch space is limited, limiting the specified height of the axial wall for cement-retained prosthesis retention. The advantages of a screw-retained prosthesis include good crown retention, a cement-free gingival sulcus area, and the ability to retrieve the crown. Abutment screw loosening, fastening screw fracture, ideal location of the access hole for exact placement, ceramic chip off around access hole, abutment fracture, and other difficulties can occur. According to an analysis of 17 research, abutment screw loosening occurs in 2%–45% of instances.[3,4] The survival rate of implants has increased dramatically from 50% to 90% because to recent advancements in methods. The issue of retrievability has not been clinically significant due to the enhanced survival rate.[5,6]

Because achieving a passive fit coping for screw-retained implant prostheses can be difficult, cement-retained prostheses have grown in favor. The cement space between the abutment

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2021.12.6.82

Address for correspondence: Dr. Samrat Mankar, Department of Prosthodontics, Dr. Hegdewar Smruti Rugna Seva Mandals Dental College and Hospital, Hingoli, Maharashtra, India. E-mail: mankarsdentalclinic@gmail.com

Received: 01 Aug, 2021; **Accepted:** 27 Aug, 2021; **Published:** 28 Sep, 2021

How to cite this article: Mankar S, Mankar S, Aidasani A, Narayane A, Gandagule R, Kothari R. Comparative Evaluation of Microleakage of Metallic Copings Luted with Three Different Commercially Available Luting Cements: An *In vitro* Study. J Res Adv Dent 2021;12(6):354-358.

and the prosthesis can be used to correct for minor variations in prosthesis fit. Cement-retained implant prostheses offer optimal occlusion, esthetics, reduced ceramic fracture, easier axial loading, the ability to use traditional prosthetic techniques, less appointments, and lower costs.[7,8] The fundamental disadvantage of cement-retained prostheses is retrievability. The desire for retrievability, the estimated amount of retention required, and the simplicity of cement removal should all be considered when choosing a cement for an implant assisted restoration. According to the literature, zinc oxide eugenol with or without ethoxy benzoic acid, zinc phosphate cement, and zinc polycarboxylate cement are the most often used cements in implant dentistry for luting the final prosthesis. Because of its stickiness, removing the residual glass ionomer cement from the abutment becomes very difficult when the prosthesis is removed. The composite resin cement's strong tensile strength makes retrieving the prosthesis challenging.[9,10]

Dead spaces created by luting cement disintegration cause microleakage. Peri-implantitis can develop, particularly in subgingival locations, when toxins build up in these dead spaces, causing bone loss surrounding the implants. This bone loss could be caused by stress, microorganisms, or a combination of the two. When bone loss due to stress and germs deepens the sulcular fissure, oxygen tension decreases. In addition, anaerobic bacteria operate as key promoters of continuing bone loss, which leads to implant failure. Keller *et al*. hypothesized that the effect was due to the marginal gap width and cement's failure to prevent leaking at the interface.[11,12]

As a result, an optimal cement for implant-supported restorations should have low microleakage, good retention, and be easy to remove. Microleakage at the tooth prosthesis contact has been the subject of numerous investigations in the past. Microleakage at the implant abutment prosthesis contact has received very little attention in the literature.[13,14] As a result, a study was carried out to assess microleakage at the implant abutment and prosthesis interface in cemented implant-supported prostheses cemented with three different commercially available luting cements.

Materials and Methods

The Institutional Review Board has given its approval to the study. Titanium rods were milled into 45 replicas of an abutment analogue with a length of 5 mm, a platform width of 4.8 mm, a taper of 6, a broad chamfer finish line, and three anti-rotation grooves that end 1 mm above the finish line.

Fabrication of metal copings

For stability, each abutment analog was fixed in dental plaster along the long axis. On abutments analogs that were 1 mm short of the margin, two layers of die spacer were placed. To guarantee that the die spacer on the abutment was the same thickness, two different colored die spacers were employed. A die lubricant was added to the abutments to aid in pattern separation. Type II inlay wax with a uniform thickness of 0.5 mm was used to create the wax design. A putty index was made from this wax pattern to ensure a uniform thickness of wax pattern for subsequent abutment analogues. The putty index was used to create the remaining wax patterns. Wax was scraped off along the margin and readapted for marginal refining.

A wax sprue forming was used, and the sprue was linked to a reservoir. The sprue length was adjusted so that the wax pattern was about 14 inches away from the casting ring. Inside the casting ring, a non-asbestos ring liner was put. To avoid the production of bubbles, a wetting agent was applied to the wax pattern. Wax patterns were invested in phosphate-bonded investment, burnout was performed, and casting was done in an induction casting machine utilizing NiCr alloy. To remove leftover investment material, castings were divested, desprued, and sandblasted with aluminum oxide particles of 110–125 micron under 2 bar pressure. A rotary instrument was used to remove nodules from the fitting surface. Polishing burs were used to complete and polish the copings. Under an optical microscope, each coping was examined for marginal disagreement, and specimens with a marginal discrepancy of less than 40 m were chosen for the investigation.

Cementation

The copings and their corresponding abutment analogs were sorted into three groups, each with 15 samples. Three luting agents frequently utilized in the cementation of implant supported prostheses were used. The cements were:

1. Zinc oxide noneugenol luting cement (3M)
2. II. Zinc polycarboxylate cement (Dentsply)
3. III. Zinc phosphate luting cement (GC).

The manufacturer's directions for mixing time, mixing conditions, and powder: liquid ratio were followed during cementing. With the help of the tailored holding device, luting agent was applied fully to all internal walls of copings and then seated onto abutment analogue with hard figure pressure for 10 s followed by 2 kg axial load for 5 min. The bespoke holding mechanism was created to ensure that the load on the metallic coping was distributed evenly. 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

The cemented specimens were removed from plaster blocks after 24 h and thermocycled in the thermocycling equipment for 5000 cycles between 5° and 55°C with a dwell duration of 10 s and a transfer time of 5 s.

Dye penetration

Cemented specimens were immersed in a 0.5% aqueous solution of basic fuchsin solution for 24 h after thermocycling to allow dye penetration.

Evaluation of microleakage

For each specimen, microleakage was assessed using a variety of surface scoring methods. The specimens were sectioned longitudinally in the buccolingual axis with the use of a carborundum disc after being immersed in dye solution for 24 h. At each section's two abutment coping interfaces, the microleakage score was recorded. 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:

1. No microleakage seen on the axial wall of the sectioned specimen
2. Microleakage seen up to 1/3rd the length on the axial wall of the sectioned specimen
3. Microleakage seen up to 2/3rd the length on the axial wall of the sectioned specimen
4. Microleakage seen along the full length of the axial wall of the sectioned specimen
5. Microleakage seen on the occlusal surface of the sectioned specimen.

Results

Each group's microleakage scores were recorded. The Kruskal–Wallis analysis of variance (ANOVA) was used to tabulate and evaluate the data, which was followed by the Chi-square test. The Mann–Whitney U-test was used to compare groups pairwise. The threshold for statistical significance was fixed at $P = 0.05$.

Microleakage scores for specimens cemented with zinc oxide non-eugenol, zinc polycarboxylate, and zinc phosphate luting cements are shown in Table 1. Microleakage was present in all specimens to varying degrees. Zinc phosphate cement had the lowest mean microleakage score (1.064 ± 0.43) followed by zinc polycarboxylate cement (1.76 ± 0.41) and zinc oxide non-eugenol (2.31 ± 0.76).

When the mean microleakage scores were subjected to Kruskal–Wallis ANOVA followed by the Chi-square test, the result of $P = 0.001$ was obtained, suggesting that there was a significant difference in mean microleakage scores between the groups tested ($P = 0.05$) (Table 2). The Mann–Whitney U-test was used to compare the microleakage scores of the three cements pairwise. When the microleakage scores of zinc oxide non-eugenol luting cement and zinc polycarboxylate luting cement were compared, $P = 0.796$ (>0.05) was found, showing that the difference in the mean microleakage scores of both cements is insignificant. When the microleakage scores of zinc polycarboxylate luting cement and zinc phosphate luting cement were compared, $P = 0.000$ ($P = 0.05$) was found, showing that the difference in the mean microleakage scores of both cements is significant. When the microleakage scores of zinc oxide non-eugenol luting cement and phosphate luting cement were compared, $P = 0.001$ ($P \leq 0.05$) was found, showing that the difference in the mean microleakage scores of both cements is significant. Tables 3 and 4 show the results.

Table 1: Microleakage scores in specimens cemented with three cements

Cement	No. of specimens	Total mean score	*P*-value
Group 1	15	2.31±0.76	0.003
Group 2	15	1.76±0.41	
Group 3	15	1.064±0.43	

Table 2: Statistical analysis for microleakage with all luting cements using Kruskal–Wallis test

Ranks		
Cement	**n**	**Mean rank**
Group I	15	19.81
Group II	15	19.82
Group III	15	6.89
Total	45	
Test statistics	**Difference_score**	
χ^2	15.022	
df	2	
Asymptotic significant	0.001	

Table 3: Pairwise comparison of Group I (zinc oxide non-eugenol luting cement) and Group II (zinc polycarboxylate luting cement) using Mann–Whitney U-test

Ranks			
Cement	**n**	**Mean rank**	**Sum of ranks**
Group I	15	10.85	108.50
Group II	15	10.15	101.50
Total	30		
Test statistics	**Difference_score**		
Mann–Whitney U	46.500		
Wilcoxon W	101.500		
Z	−0.274		
Exact significant (two×[onetailed significant])	0.796		
Asymptotic significant	0.001		

Discussion

Instead of the tooth adhering to the metal as in traditional fixed prosthodontics, there is adhesion between two metallic components in implant dentistry. As a result, luting cements come in a wider range of colors and textures than actual teeth. Furthermore, implant abutments have a considerably better resistance and retention form than normal tooth preparations.[15,16] This enables for the use of lower strength cements in implant-supported restorations while still allowing for retrieval if necessary. Microleakage is the most common issue with cement-retained implant prostheses. The migration of germs, fluid molecules, or ions between the abutment and the prosthesis is known as microleakage.[17,18]

It is generally known that luting agents do not produce a perfect seal between the abutment and the prosthesis, and that there are countless microgaps that allow solutes and solvents to flow through, allowing bacteria and their byproducts to proliferate.

Table 4: Pairwise comparison of Group II (zinc polycarboxylate luting cement) and Group III (zinc phosphate luting cement) using Mann–Whitney U-test

Ranks			
Cement	**n**	**Mean rank**	**Sum of ranks**
Group II	15	15.05	150.50
Group III	15	5.95	59.50
Total	30		
Test statistics	**Difference_score**		
Mann–Whitney U	4.500		
Wilcoxon W	59.500		
Z	−3.530		
Exact significant (two×[onetailed significant])	0.000		
Asymptotic significant	0.000		

As a result, peri-implantitis develops, resulting in bone loss and the possibility of implant failure. Contemporary methods have used a variety of principles to assess microleakage, including biological, chemical, electrical, physical, and radioactive components. Dyes, bacteria, neuron activation analysis, radioactive isotopes, artificial caries, air pressure, scanning electron microscope, and calcium hydroxide are some of the methods used.[19,20]

Organic dyes are frequently used and are one of the oldest and most used ways for determining microleakage. Basic fuchsin, methylene blue, eosin, aniline blue, crystal violet, and erythrosine B are examples of organic dyes. Basic fuchsin (0.5–2%) is the most widely utilized of these dyes.[21,22] Wenner *et al*. discovered that when only one section of a microleakage study is reviewed, there is 33% chance of obtaining a false negative. As a result, in microleakage research, multiple surface scoring methods are recommended. In microleakage research, non-parametric scoring systems are commonly utilized. The relevance of linear dye penetration stated in millimeters varies. The best method to evaluate microleakage is non-parametric scoring method in fixed prosthesis.[23,24]

In this study, zinc phosphate cement had the least amount of microleakage. This is due to its strong compressive and tensile strengths, as well as its good retention characteristics. Zinc polycarboxylate cement had a lower mean microleakage score than zinc oxide non-eugenol cement. Although both cements have equal compressive strengths, the difference in microleakage can be attributable to the polycarboxylate cement's stronger retentive characteristics. The microleakage difference between these two cements was negligible. Zinc oxide non-eugenol cement was used for this study because it demonstrated fewer microleakage than zinc oxide eugenol cement.[25,26]

When choosing luting cements for fixed prostheses, solubility is a crucial factor to consider. Microleakage can be caused by cement disintegration. Water sorption and solubility can promote further cement degradation, resulting in the creation of microgaps. Bacteria and their byproducts infiltrate the microgaps produced inside the established matrix.[27] In comparison to zinc polycarboxylate cement (0.06 wt percent) and zinc phosphate cement (0.06 wt percent), zinc oxide non-eugenol set cement has a higher solubility (0.4 wt percent). When zinc polycarboxylate cement is exposed to organic acids with a pH of 4.5, its solubility increases dramatically.[28]

Due to the leaching of unreacted zinc and magnesium particles during dissolution, residual voids form in the matrix of both zinc phosphate and zinc polycarboxylate cements, resulting in an increase in microleakage. The diameter of these unreacted particles in the matrix is about 2–8 m.[29] The amount of marginal space between the abutment and the prosthesis is another important element in microleakage. If the marginal distance surpasses 75 m, according to several researches, the rate of cement disintegration increases.[30] The rate of cement disintegration due to diffusion is independent of the degree of exposed luting cement, according to Fick's law. Jacobs and Windeler evaluated that marginal gap of more than 150 µm demonstrated slight but statistically significant increase in cement dissolution.[28]

Mechanical and temperature changes cause stresses in luting agents, which, when they surpass the material's cohesive and adhesive strength, cause microcracks to develop and microleakage to occur. The expansion and contraction of luting agents in response to temperature cycling cause mechanical stresses in the cement, resulting in the production of microcracks and microleakage in *in vitro* tests. Zinc oxide eugenol with oethoxybenzoic acid is the most popular soft access cement used in implant dentistry (EBA). Manufacturers claim that eugenol-free cement has a stronger bonding capacity than other traditional interim agents.[13]

The inclusion of EBA modifier increases compressive strength to a level comparable to zinc polycarboxylate cement but lower than zinc phosphate cement. As a result, the prosthesis can be removed quickly but remains in place during typical activities.[11] Although zinc polycarboxylate cement has a better tensile strength than zinc phosphate cement, it is not widely employed as a definitive cement in implant dentistry. This is due to the material's low compressive strength and retentive characteristics. When there are less than six abutments, no cantilever or offset loads, and soft access cement is desired, this cement is frequently employed. The selection of each cement depends on its various properties. It is important for the clinician to selfanalyze the selection of the certain type of cement based on various clinical conditions.[18]

In vitro microleakage testing using dyes is more sensitive than oral cavity microleakage tests. This is likely due to the dye's ease of diffusion compared to bacteria and their byproducts, and the buildup of proteins and detritus that calcify in the marginal aperture may help to improve the seal. Many other factors, such as saliva, changing pH of the oral environment, masticatory load, and so on, can affect *in vivo* outcomes.[31]

This research was undertaken to provide data on microleakage in cemented copings on implant abutments, which could be useful in forecasting their values in the oral environment. Further research would be necessary in the form of a long-term clinical trial**.**

Conclusions

The following conclusions can be drawn within the restrictions of this study:

1. When utilized as a luting agent for metallic copings in cement-retained implant prostheses, zinc phosphate cement showed the least microleakage, with a statistically significant difference between zinc polycarboxylate cement and zinc oxide non-eugenol cement
2. The mineral zinc although polycarboxylate cement had less microleakage than zinc oxide non-eugenol cement, the difference was not statistically significant.

As a result, cementing the cement-retained implant prosthesis should be done in stages. In the event that provisional cement fails, definitive cement should be considered.

References

1. Misch CE. Dental Implant Prosthetics. 1st ed. Philadelphia, PA: Elsevier Mosby; 2005.
2. Uludamar A, Ozkan YK. Cement selection of cemented implant supported restorations. Cumhuriyet Dent J 2012;15:16674.
3. Hebel KS, Gajjar RC. Cementretained versus screwretained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. J Prosthet Dent 1997;77:2835.
4. Goodacre CJ, Kan JY, Rungcharassaeng K. Clinical complications of Osseo integrated implants. J Prosthet Dent 1999;81:53752.
5. Becker W, Becker BE. Replacement of maxillary and mandibular molars with single endosseous implant restorations: A retrospective study. J Prosthet Dent 1995;74:515.
6. Michalakis KX, Pissiotis AL, Hirayama H. Cement failure loads of 4 provisional luting agents used for the cementation of implantsupported fixed partial dentures. Int J Oral Maxillofac Implants 2000;15:5459.
7. Michalakis KX, Hirayama H, Garefis PD. Cementretained versus screwretained implant restorations: A critical review. Int J Oral Maxillofac Implants 2003;18:71928.
8. Jokstad A. Osseointegration and Dental Implants. Hoboken: Wiley-Blackwell Publication; 2008.
9. Keller W, Bragger U, Mombelli A. Periimplant micro flora of implants with cemented and screw retained suprastructures. Clin Oral Impl Res 1998;9:20917.
10. Bhatnagar V, Sardar CS, Ram SM, Mehta A. An evaluation of microleakage of metallic copings cemented with three luting agents: A stereomicroscopic study. J Indian Prosthodont Soc 2007;7:814.
11. Baldissara P, Comin G, Scotti FM. Comparative study of the marginal microleakage of six cements in fixed provisional crowns. J Prosthet Dent 1998;80:41722.
12. Yüksel E, Zaimoğlu A. Influence of marginal fit and cement types on microleakage of allceramic crown systems. Braz Oral Res 2011;25:2616.
13. Shiva Kumar K, Boris Bhim A, Shankar S. Microleakage of two systems of glass ionomer luting agents-*in vitro* study. JIADS 2010;1:14.
14. Rossetti PH, Do Valle AL, De Carvalho RM, De Goes MF, Pegoraro LF. Correlation between marginal fit and microleakage in complete crowns cemented with three luting agents. J Appl Oral Sci 2008;16:649.
15. Pan YH, Ramp LC, Lin CK, Liu PR. Retention and leakage of implantsupported restorations luted with provisional cement: A pilot study. J Oral Rehabil 2007;34:20612.
16. Pan YH, Ramp LC, Lin CK, Liu PR. Comparison of 7 luting protocols and their effect on the retention and marginal leakage of a cementretained dental implant restoration. Int J Oral Maxillofac Implants 2006;21:58792.
17. Oyague RC, Turrion AS, Lozano JF, SuarezGarcia MJ. Vertical discrepancy and microleakage of laser sintered and vacuum cast implant supported structures luted with different cements. J Dent 2012;40:12330.
18. Bhandari S, Aras M, Chitre V. An *in vitro* evaluation of the microleakage under complete metal crowns using three adhesive luting cements. J Indian Prosthodont Soc 2012;12:6571.
19. Piwowarczyk A, Lauer HC, Sorensen JA. Microleakage of various cementing agents for full cast crowns. Dent Mater 2005;21:44553.
20. Nascimento CD, Barbosa RE, Issa JP, Watanabe E, Ito IY, Albuquerque RF. Bacterial leakage along the implant abutment interface of premachined or cast components. Int J Oral Maxillofac Implants 2008;37:17780.
21. Gonzalez NA, Kasim NH, Aziz RD. Microleakage testing. Ann Dent Univ Malaya 1997;4:317.
22. Wenner KK, Fairhurst CW, Morris CF, Hawkins IK, Ringle RD. Microleakage of root resorations. J Am Dent Assoc 1988;117:82528.
23. Arora SJ, Arora A, Upadhyaya V, Jain S. Comparative evaluation of marginal leakage of provisional crowns cemented with different temporary luting cements: *In vitro* study. J Indian Prosthodont Soc 2016;16:428.
24. Tjan AH, Dunn JR, Grant BE. Marginal leakage of cast gold crowns luted with an adhesive resin cement. J Prosthet Dent 1992;67:115.
25. Mash LK, Beninger CK, Bullard JT, Staffanou RS. Leakage of various types of luting agents. J Prosthet Dent 1991;66:7636.
26. Anusavice K. Philips Science of Dental Materials. 11th ed. Philadelphia, PA: Elsevier; 2003.
27. Hajmiragha H, Nokar S, Alikhasi M, Nikzad S, Dorriz H. Solubility of three luting cements in dynamic artificial saliva. J Dent 2008;5:958.
28. Rosenstiel SF, Bruce MF, Crispin J. Dental luting agents: A review of current literature. J Prosthet Dent 1998;80:2801.
29. Jacobs MS, Windeler AS. An investigation of dental luting cement solubility as a function of the marginal gap. J Prosthet Dent 1991;65:43642.
30. Li ZC, White SN. Mechanical properties of dental luting cements. J Prosthet Dent 1999;81:597609.
31. Bandgar S, Nagra SJ. Evaluation of marginal microleakage of three zinc oxide based non eugenol temporary luting agents: An *in vitro* study. J Indian Prosthodont Soc 2007;7:13236.