Original Article

An evaluation of microleakage of metallic copings cemented with three luting agents: A stereomicroscopic *in vitro* study

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AIM: The aim of the study was to assess, compare and evaluate the microleakage at the margins of cast metal copings cemented with three luting agents. **MATERIALS:** (A) Intact human molars, normal saline solution, (B) Medium inlay casting wax, die spacer—Durolon®, (C) Phosphate-bonded investment material—Ceramvest®, nickel-chromium base metal alloy, (D) Glass ionomer cement—Ketac™ Cem, resin-modified glass ionomer cement—RelyX™ Luting 2, resin cement—RelyX ARC, (E) 50% silver nitrate stain, developer—D-76 Eastman Kodak, 150 watt flood lamp and (F) Epoxy resin, carborundom disc. **METHODS:** A comparative study was done to evaluate the ability of three contemporary luting agents to resist microleakage in cemented nickel-chromium complete metal copings cast on prepared molars. The copings were placed back on the respective prepared teeth to check the fit and marginal adaptation was observed under an optical microscope. Copings with marginal discrepancies of more than 39 µm were rejected and castings were repeated for accurate marginal fit. The castings were cemented with the three luting agents under study, namely, glass ionomer cement, resin-modified glass ionomer cement and resin cement under ideal conditions. The cemented specimens were thermocycled after 24 hours between 5°C and 50°C. After thermocycling, the teeth were treated with 50% silver nitrate solution for 60 minutes, placed under a 150 watt flood lamp for five minutes to allow complete fixation of any unfixed stain, embedded in clear epoxy resin and sectioned twice longitudinally. **RESULTS:** It was concluded from the study that the glass ionomer cement, Ketac Cem showed less microleakage than the resin-modified glass ionomer cement, RelyX Luting 2 and the resin cement, RelyX ARC. The resin cement was associated with a higher degree of microleakage than the glass ionomer cement and the resin-modified glass ionomer cement.

Key words: Luting agents, microleakage

Dental luting cements form the link between a fixed restoration and the supporting tooth structure. Luting cements play a pivotal role in sealing the margins and prevent marginal leakage. Unfortunately, most of the dental cements available cannot guarantee continual impermeability because of their relatively high solubility in oral fluids. A gap thus created at the restoration margin may become a repository for microorganisms that release toxic products. These toxins may eventually cause gingival and pulpal inflammation, leading to secondary caries.[1]

Microleakage is defined as the seepage of oral fluids containing bacteria and debris between a tooth and its restoration or cement layer. Microleakage is of concern because of the effect bacteria may have on the remaining tooth structures and the pulpal tissues. The process of microleakage can affect the tooth-cement interface associated with a crown restoration as well as the tooth foundation. Marginal openings and microleakage are important causes of the failure of dental restorations. Marginal openings between cemented crowns and their tooth margins may be related to cement dissolution. Different luting agents vary considerably in solubility, strength and ability to adhere to tooth structures, therefore marginal gaps alone may not be the most important cause of microleakage.

Over the last two decades, a lot of interest has been focused on the selection of good adhesive luting agents for the cementation of fixed restorations. Investigators and researchers have advocated different materials and methods to improve the retention of the fixed prosthesis in the oral cavity. Considerable evolution has taken place from ionomer-based luting agents to resin-based adhesive luting agents. With wide acceptance of base metal alloys, numerous luting agents have been used

for the cementation of fixed restorations.

Therefore, it is important to assess and evaluate microleakage at the margins of cast metal copings so that it may be prevented.

MATERIALS AND METHODS

A comparative study was done to evaluate the ability of three contemporary luting agents to compare and evaluate the marginal leakage under cemented nickel-chromium complete metal copings cast on prepared molars. Tooth preparation was carried out on the mounted molars by following standardized tooth preparation procedures with the help of an airotor. An assembly with the airotor mounted on the dental model surveyor was used to achieve a uniform taper of six degrees. The prepared teeth were cleaned with pumice and water. Wax patterns were to be prepared for each prepared tooth. Three coats of the die spacer were applied on the tooth to provide space of 24-25 µm for the cement layer. Care was taken to keep it short of the margins by 1 mm. The wax patterns for the copings were fabricated using the dip wax technique to get a close adaptation of the wax to the tooth surface. The casting was carried out in the induction casting machine with nickel-chromium base metal alloy. The copings were placed back on the respective prepared teeth to check the fit and the marginal adaptation was observed under an optical microscope. Copings with marginal discrepancies of more than 39 µm were rejected and castings were repeated for accurate marginal fit.[2] The castings were cemented with three luting agents, namely, a glass ionomer cement—Ketac Cem, a resin-modified glass ionomer cement—RelyX Luting 2 and a resin cement—RelyX ARC under ideal conditions [Figure 1]. The cemented specimens were thermocycled after 24 hours between 5°C and 50°C. After thermocycling, the teeth were treated with 50% silver nitrate solution [Figure 2] for 60 minutes and placed under a 150 watt flood lamp for five minutes to allow proper fixation of any unfixed stain. The samples were embedded in clear epoxy resin [Figure 3] and allowed to set for 24 hours.

Microleakage was categorized as follows:

0: No evidence of stain penetration at the interface of the crown and tooth surface.

1: Evidence of slight stain penetration-less than half the height of the axial wall of the preparation.

2: Evidence of stain penetration equal to half the height of the axial wall of the preparation.

3: Evidence of stain penetration in excess of half the height of the axial wall and extending to the occlusal aspect of the preparation.

The sections were observed under the stereomicroscope [Figure 4] and stain penetration was recorded at the tooth-cement interfaces. The readings were tabulated in Tables 1-3 and analyzed statistically. Marginal microleakage is the linear penetration of silver nitrate stain from the external margin of the luting cement where the cement interfaces with the tooth.[3]

Eight interfaces of each sample were evaluated for microleakage under a stereomicroscope at X300 magnification and the extent of penetration was recorded.

RESULTS

It was concluded from the study that the glass ionomer cement—Ketac Cem showed less microleakage than the

Table 1: Microleakage values in the glass ionomer cement (A: Ketac™ Cem)

No. of samples	Sections							
	1	2	3	4	5	6	7	8
A1	1	0	0	0	1	2	0	2
A2	1	1	0	1	1	1	0	1
A3	1	1	0	1	1	0	0	0
A4	1	2	1	2	1	2	1	2
A5	2	0	0	0	0	0	1	2
A6	0	1	0	1	3	3	1	2
A7	1	1	3	0	2	1	1	3
A8	2	0	1	1	0	0	2	0
A9	2	1	0	0	2	1	0	0
A10	1	0	2	2	0	2	1	2

Table 2: Microleakage values in the resin-modified glass ionomer cement (B: RelyX™ Luting 2)

No. of samples	Sections							
	1	2	3	4	5	6	7	8
B1	3	3	0	1	0	1	3	1
B2	1	0	0	3	0	0	3	3
B3	0	0	1	0	0	0	1	1
B4	0	0	1	0	1	1	0	3
B5	2	0	0	0	0	3	3	2
B6	3	3	1	1	1	1	1	2
B7	0	0	0	2	1	2	0	1
B8	2	1	1	2	2	2	2	1
B9	1	1	2	2	0	1	0	0
B10	2	0	2	2	2	0	2	1

Table 3: Microleakage values in the resin cement (C; RelyX ARC)

No. of samples	Sections							
	1	2	3	4	5	6	7	8
C1	2	1	0	2	1	2	0	2
C2	3	2	1	1	2	3	2	2
C3	2	1	1	2	1	0	2	2
C4	1	0	3	1	3	3	0	2
C5	0	3	3	0	1	1	0	3
C6	1	3	3	0	1	1	0	1
C7	1	1	2	2	3	2	1	3
C8	2	1	2	2	1	2	2	0
C9	1	2	1	1	3	3	2	0
C10	1	0	2	1	3	3	3	1

Figure 1: Luting agents used in the study

Figure 2: Samples after stain fixation

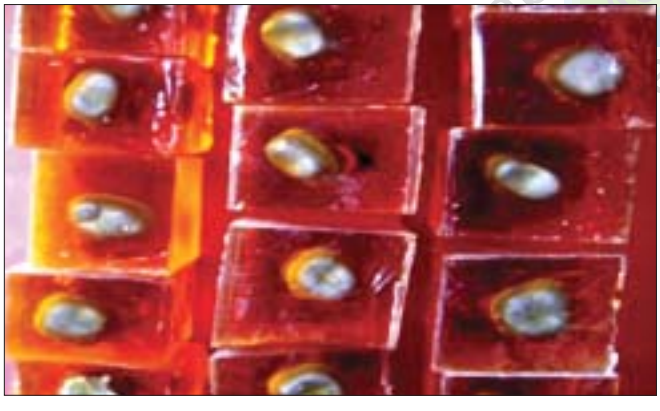


Figure 3: Samples mounted in clear epoxy resin

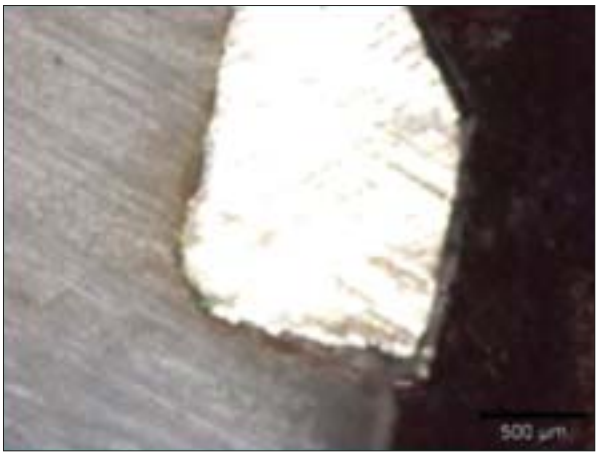
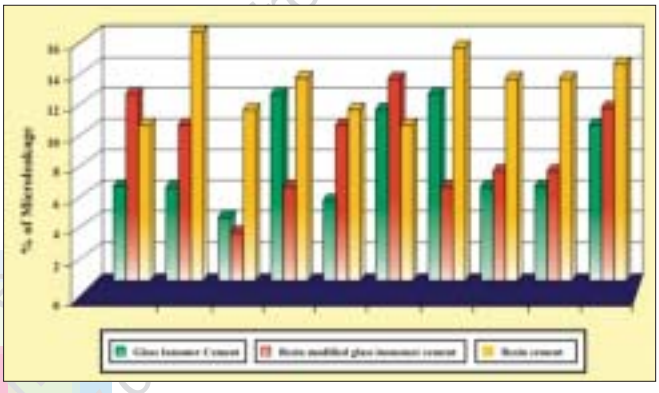


Figure 4: Evaluation of microleakage under a stereomicroscope



Graph 1: Comparative values of microleakage due to stain penetration between groups A (glass ionomer cement), B (resin-modified glass ionomer cement) and C (resin cement)

resin-modified glass ionomer cement—RelyX Luting 2 and the resin cement—RelyX ARC. The resin cement was associated with a higher degree of microleakage than the glass ionomer cement and the resin-modified glass ionomer cement [Graph 1]. The readings were tabulated in Tables 1-3 and analyzed statistically.

DISCUSSION

In the search for a material that bonds chemically to the tooth structure, it is essential to investigate its leakage-inhibiting potential. In most of the studies evaluating microleakage beneath full-cast crowns, investigators have used organic dyes, chemical tracers or radioactive isotopes.

The use of organic dyes as tracers has been one of the oldest and perhaps the most commonly used method in microleakage detection. However, it is highly technique-sensitive and the assessment of results requires careful standardization. The choice of whether to use a stain, dye or isotope should be based on the preference of the investigator.[4] All methods require meticulous technique and standardized criteria for evaluating and scoring the degree of marginal leakage. Radioactive isotopes require special handling and authorization for use. The use of a stain or a dye as a tracer may be more convenient for the researcher because no authorization is required for their possession and use. Therefore, silver nitrate stain was used in this study.

The greater leakage of the dual-cure resin cement (RelyX ARC) compared to the glass ionomer cement (Ketac Cem) and the resin-modified glass ionomer

cement (RelyX Luting 2) might be thus attributed to the polymerization shrinkage of the resin cement combined with the coefficients of thermal expansion of the material involved (*i.e.*, tooth substance, cement, metal crown). In contrast to resin cements, glass ionomer cements (*e.g.*, Ketac Cem) are considered to be dimensionally stable during setting. Furthermore, the hydrophilic formulation of the resin-modified glass ionomer cement can compensate for the initial setting contraction by subsequent expansion due to water uptake. This difference in chemical behavior might explain the different microleakage results found for the resin cement, the glass ionomer cement and the resin-modified glass ionomer cement.[5]

One possible reason for the reduced microleakage with the glass ionomer cement can be its low solubility and disintegration in oral fluids.

To better correlate thermocycle testing in *in vivo* conditions, the system used in this study used a short exposure time to the extremes of temperature with an adequate intervening period for the specimens to return to body temperature. Previous studies have generally used immersion times, which allow both the tooth and the restoration to stabilize at the extreme temperatures, which does not occur *in vivo*. The rationale for the cycling sequence used in this study is that the maximum *in vivo* exposure time of a tooth to an extremely hot or cold material is considered to be two to five seconds after which the tooth returns to the oral temperature.

There is, as yet, no ideal dental cement. Each material is to be used depending upon its merits, demerits and limitations. It has long been recognised that in general, dental materials do not bind or adapt to tooth structure well enough to provide a perfect seal and there is always a pathway for penetration of various solutes and solvents.

Hence, a clinical study would be required and the final evaluation of the material should be done only after long-term study.

CONCLUSION

Marginal microleakage is only one among the various factors, which influence the success of cemented restoration. Since none of the dental cements fulfil all the ideal qualities, the choice for a particular cement depends entirely on the judgment of the clinician based on the pertinent oral environment, biological and mechanical factors, which the clinical situation demands.

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