RESEARCH ARTICLE

Comparative Microleakage Evaluation through the Interfaces between the Tooth and Cement after Stainless Steel Crown Cementation in Primary Molars: An *In Vitro* Study

Manjari S Gundewar[1], Sonali Saha[2], Deval Arora[3], Kavita Dhinsa[4], Sakshi Tiwari[5], Abhay M Tripathi[6]

Abstract

Introduction: The longevity of stainless steel crowns is related to perfect adaptation and long-term union between restoration and teeth. In this respect, evaluation of marginal leakage of luting cement is essential.

Aim and objective: To compare and evaluate the ability of new adhesive cement to prevent microleakage under stainless steel crowns on primary teeth.

Materials and methods: Forty-five specimens were embedded, standardized preparations were made onto selected extracted primary molars, and stainless steel crowns were adapted. Samples were assigned randomly to cement groups: Glass ionomer (GI), resin-modified glass-ionomer (RMGI), and Adhesive resin (AR) cement, followed by storage in water, artificially aging, staining, sectioning, and the linear dye penetration and proportion of microleakage evaluation.

Results: AR showed the lowest microleakage, followed in increasing order by RMGIC and GIC showed the greatest microleakage (*p-value* < 0.0001).

Clinical significance: There are many kinds of luting agents that vary considerably from the viewpoint of solubility, strength, and ability to adhere to the tooth structure. Lack of adhesion of the luting cement to the tooth structure is one of the reasons for microleakage related to different types of crowns. Cement breakdown may result in the entrance of fluids and microorganisms along with the tooth restoration interface. In this study, attempts were made to simulate standard clinical procedures, although this is not a substitute for the complex oral environment, the results provide useful information to choosing the best cement materials.

Conclusion: Adhesive resin cement can be recommended for cementation of Stainless Steel Crowns because of added advantages over others.

Keywords: Luting cement, Microleakage, Stainless steel crown.

International Journal of Clinical Pediatric Dentistry (2022): 10.5005/jp-journals-10005-2359

Introduction

Caries is one of the leading oral issues affecting children. The consequences of untreated lesions cause pain and infection.[1]

Full coronal restorations may be indicated where multiple surfaces are affected and when pulpal therapy is indicated.[2]

Stainless Steel Crowns (SSC) are fitted onto respective teeth and affixed with a biologically adaptable cementing agent,[3]primarily filling voids at restoration-tooth interface. Recently, newer agents have been introduced claiming superior performance than predecessors.[4]

Since scanty literature exists regarding microleakage relating to newer luting agents, the current research was attempted to compare and assessability of new adhesive luting agents to halt microleakage under SSCs on primary teeth.

Materials and Methods

The present study was performed in the Department of Pedodontics and Preventive Dentistry. In the current study, the ability of new adhesive cement, that is, Conventional Glass Ionomer Cement, Resin Modified Glass Ionomer luting agents, as well as Resin-based luting agents, were compared and evaluated to avert microleakage beneath stainless steel crowns on primary teeth.

Sample size evaluation was done using G Power software (version 3.0). The sample size was assessed for the F test and "ANOVA: fixed effects, one way" was chosen. The lowest aggregate sample size of 45 (15 per cement group) was established to be plentiful for an alpha of 0.05, power of 80%, 0.5 as effect size (estimated from an analogous study).

Forty five extracted deciduous molars were selected with root resorption less than two-thirds according to the inclusion criteria. The extracted teeth were immersed in 10% formalin solution for 2 weeks for sterilization. Then the teeth were preserved in distilled water at 37°C. Firstly, a columnar acrylic block was formulated of height 1.5 cm and 1.5 cm width. Following which a rubber

[1,2,4,6]Department of Pedodontics and Preventive Dentistry, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India

[3]Department of Dentistry, Autonomous State Medical College, Shahjahanpur, Uttar Pradesh, India

[5]Private Dental Clinic, Karaikal, Puducherry, India

Corresponding Author: Kavita Dhinsa, Department of Pedodontics and Preventive Dentistry, Sardar Patel Post Graduate Institute of Dental and Medical Sciences, Lucknow, Uttar Pradesh, India, Phone: +91 9721222260, e-mail: manjari.gundewar@gmail.com

How to cite this article: Gundewar MS, Saha S, Arora D, *et al.* Comparative Microleakage Evaluation through the Interfaces between the Tooth and Cement after Stainless Steel Crown Cementation in Primary Molars: An *In Vitro* Study. Int J Clin Pediatr Dent 2022;15(2):159–163.

Source of support: Nil

Conflict of interest: None

base impression mould of the prepped acrylic block was made employing a rubber base impression material and positive copies were obtained by pouring the cold-cure acrylic resin into the rubber base impression mould and at the same time inlaying the roots of the teeth (from 2-mm beneath the cementoenamel junction) into it to form the test samples. This practice was redone until all 45 test samples were collected.

Standardized tooth preparation for stainless steel crowns was performed. Occlusal surfaces and an occlusal third of buccal and lingual surfaces were reduced to 1.0–1.5 mm with a 169L bur. All mesial and distal undercuts were reduced employing a diamond feather edge bur. Every line angle was rounded under a water spray. For each processed tooth, a prefabricated stainless steel crown was fitted, contoured, and crimped using pliers.

After adjusting the crowns, the teeth were segregated into three groups at random containing 15 teeth each, according to the luting cement used:

- Group I: Glass ionomer cement (Ketaccem, 3M ESPE)
- Group II: Resin-modified glass ionomer cement (Rely X luting2, 3M ESPE)
- Group III: Resin cement (Rely X Ultimate, 3M ESPE).

In all groups, luting cement was crossed according to manufacturer's policy, after which inner two-thirds of stainless steel crown was filled with the same, and crown was placed on the preparation with digital pressure. For the group with resin cement, the first bonding agent was applied which was cured for 10 seconds and then luting cement was filled in the crown, after which the crown was seated with finger pressure and again light cured. Each stainless steel crown was weighted axially with 5 kg for 10 minutes with a premeasured weight to administer uniform pressure to every crown. Surplus cement was ejected and the tooth was relocated to distilled water for aging over 4 weeks at 37ºC.

After this cycle, all teeth were exposed to 500 thermal cycles in 5ºC and 55ºC water baths with a dwell time of 30 seconds and 20 seconds transit time amidst baths. The root surfaces, barring a 1 mm wide zone around the margins of each SSC, were sealed with two coats of nail polish and preserved in distilled water. Following which all teeth were submerged in 1% methylene blue dye solution for 24 hours.

Upon extraction from the dye, the teeth were washed and sectioned buccolingually across the middle of the restorations using a diamond disc with uninterrupted water irrigation.

The sectioned teeth were then inspected under a calibrated digital microscope at 40X magnification. Linear dye infiltration was scored in millimeters. The proportion of microleakage was calculated by dividing the total length of penetration of dye with a total width of luting cement from the edge of the stainless-steel crown amid interfaces among tooth and cement. The data gathered was classified and assigned to statistical analysis (SPSS version 21).

Result

Group-wise comparison of linear dye penetration was done among the various tested luting cement which ranged from 0.00–3.01 wherein group I showed the maximum linear dye penetration followed by group II and group III, respectively (Table 1).

Group-wise comparison of the proportion of microleakage was also done among the various tested luting cement which ranged from 0.00–6.02 wherein group I showed the maximum proportion of microleakage followed by group II and group III, respectively (Table 2).

Table 3 shows an intergroup comparison of Linear dye penetration using one-way Analysis of Variance test among the various tested luting cement. The mean square was found to be 17.349 between the groups and 0.187 within groups. A statistically significant difference was found in the mean linear dye penetration among three study groups (<0.0001).

Table 4 shows an intergroup comparison of the proportion of microleakage among the various tested luting cement using a one-way Analysis of Variance test. The mean square was 69.398 between the groups and 0.749 within groups. A statistically significant difference was found in the mean proportion of microleakage among the three study groups (<0.0001).

Table 1: Group wise comparison of linear dye penetration among the various tested luting cements

Group	*N*	*Mean*	*Std. deviation*	*Std. error*	*95% confidence interval for mean*		*Min*	*Max*
					Lower bound	*Upper bound*		
1.00	15	2.4000	0.47,378	0.12,233	2.1376	2.6624	1.48	3.01
2.00	15	1.3540	0.48,525	0.12,529	1.0853	1.6227	0.50	2.05
3.00	15	0.2493	0.31,930	0.08,244	0.0725	0.4262	0.00	1.00

Table 2: Group wise comparison of proportion of microleakage among the various tested luting cements

Groups	*N*	*Mean*	*Std. deviation*	*Minimum*	*Maximum*
Gr I	15	4.8000	0.94,757	2.96	6.02
Gr II	15	2.7080	0.97,050	1.00	4.10
Gr III	15	0.4987	0.63,859	0.00	2.00

Table 3: Intergroup comparison of linear dye penetration using one way analysis of variance test among the various tested luting cements

		Sum of squares	*df*	*Mean square*	*F*	*'p'*
Linear dye penetration	Between groups	34.699	2	17.349	92.631	<0.0001
	Within groups	7.866	42	0.187		
	Total	42.565	44			

Table 4: Intergroup comparison of proportion of microleakage among the various tested luting cements using one-way analysis of variance test

		Sum of squares	*df*	*Mean square*	*F*	*p-value*
Microleakage proportion	Between groups	138.795	2	69.398	92.63	<0.0001
	Within groups	31.466	42	0.749		
	Total	170.261	44			

Discussion

Marginal leakage is always associated with the presence of carious lesions around the dental restoration. Before and after cementation of the crown, the presence of empty spaces results in the occurrence of caries.[5] Method used to test microleakage in this study is consistent with that performed by Memarpour et al.[6] Considering this fault, a study was carried out using three types of an adhesive cement. The study used primary posterior teeth to closely model clinical practice. According to Trubman et al. and Allison et al. primary molars are preferred because the thickness of enamel and dentin in primary teeth is less compared to permanent teeth thereby making them more prone to caries.[7–10] In order to simulate creating the same situations as the oral cavity, the artificial aging process was done, where the study tooth samples were immersed in distilled water for 4 weeks [Tanumiharja et al.].[11] After 4 weeks of aging, study samples were introduced to the thermocycling procedure. Total 500 cycles at 55°C and 5°C with a dwell time of 30 seconds and 20 seconds transit time between baths. According to Mirkarimi et al., thermocycling was done to stimulate the thermal stresses of the cemented crowns.[12] According to Schmid-Schwap et al., there are two ways in which thermal stress can be pathogenic, either the mechanical stresses which are induced by changes in temperature which can directly cause propagation of crack through bonded interfaces, or due to change in size and shape of gaps that are related to pathogenic fluid flowing in and out of gaps.[13]

Observations of the present study revealed a marked and significant leakage under stainless steel crowns. Whenever there is less microleakage, there are chances of less failure which is vice versa in cases of increased microleakage as a sequela of any pathology of pulp, caries, or root canal therapy failure caused by leakage from the coronal portion. This may be an important clinical benefit as SSCs are placed on teeth after procedures like pulpotomy and pulpectomy. Decreased premature tooth loss and patient suffering may be reduced if reinfection of the teeth becomes less.[14]

On overall comparison of linear dye penetration and proportion of microleakage among different study groups, results stated that there was maximum dye penetration and proportion of microleakage in group I followed in descending order by group II and group III, respectively (Fig. 1). The results were in accordance with Castro et al. and Yilmaz et al.[15,16]

The reason for glass ionomer showing maximum linear dye penetration and proportion of microleakage may be attributed to the susceptibility of glass ionomer cement to break down easily in presence of water before it completely sets and also due to its weaker binding affinity with the metal surface of SSC and underlying dentin surface [Bhandari et al.].[17]

On the evaluation of linear dye penetration and proportion of microleakage, resin-modified glass ionomer cement showed more linear dye penetration and proportion of microleakage less than GIC rather more than resin cement (Fig. 2). Similar results were obtained by Memarpour et al. and Lindquist et al.[6,18]

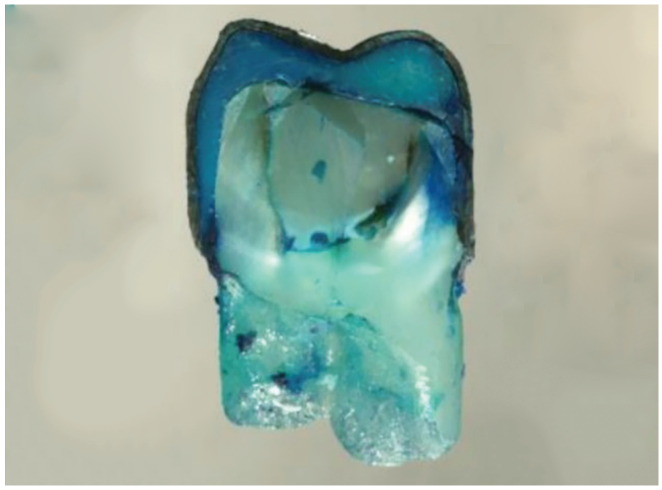

Fig. 1: Glass ionomer cement

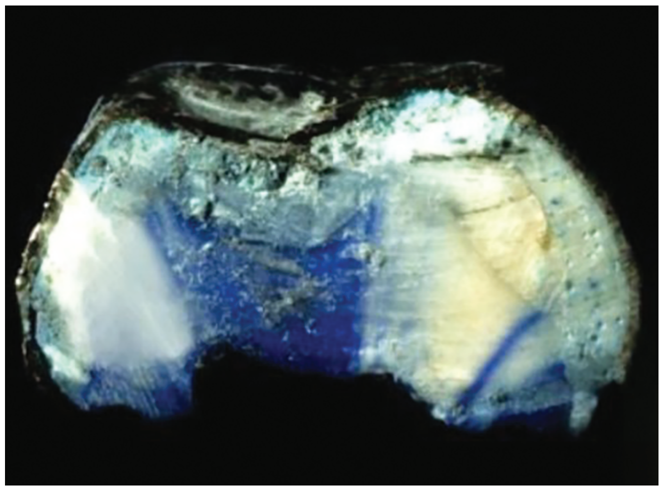

Fig. 2: Resin modified glass ionomer cement

As stated by Pegoraro et al. in resin-modified glass ionomer cement, the addition of resin monomer offers several advantages such as an increase in flexural strength, reduction of sensitivity to water, high bond strength. In the case of RMGIC, the polymer penetrates into demineralized dentin surface leading to a strong mechanical bond thereby, resulting in decreased microleakage.[19]

Results of the study also stated that mean microleakage in conventional GIC was much higher as compared to the other two groups due to its susceptibility to dehydration. As this is an *in vitro* study, avoiding dehydration becomes even more difficult. These findings were explained by Shah et al.[5]

On the evaluation of linear dye penetration and proportion of microleakage, resin cement showed the least amount of linear dye penetration and proportion of microleakage when compared with

RMGIC and conventional GIC (Fig. 3). The above findings were in support of Shah et al. and Reddy.[5,20]

The adhesive resin cement was found to be better because enamel bonding occurs by the micromechanical interlocking of resin to hydroxyapatite crystals and rods of etched enamel whereas, bonding to dentin is achieved by resin infiltrating into etched dentin, forming micro-mechanical interlock with semi demineralized dentin, underlying hybrid layer, or resin interdiffusion zone. On the contrary, filler particles boost marginal wear resistance. Luting agents containing resin also exhibit favorable bond strength to the sand-blasted base metal due to mechanical retention. This may also be because luting agents containing resins have increased modulus of elasticity that lowers microleakage [Attar et al.].[21]

In contrast to the results of the present study, Shiflett et al. compared the abilities of different luting cement, where SSCs were used on primary anterior teeth to prevent microleakage and inferred that the resin cement has high microleakage than RMGIC and low when compared to GIC which could be due to change in sample size in the GIC group and RMGIC group.[14]

The proportion of microleakage was found to be highest in conventional GIC followed by RMGIC and the least was seen in adhesive resin cement.

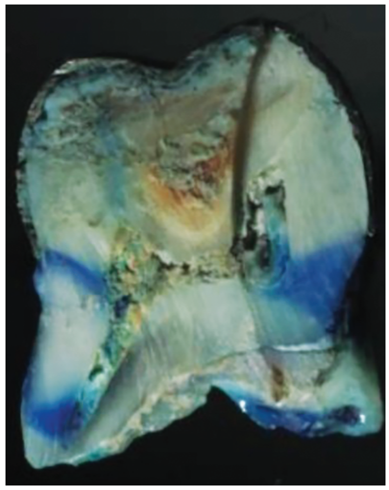

Fig. 3: Adhesive resin cement

Limitations

- The *in vitro* trial utilized in the current study doesn't by and large recreate the *in vivo* situation clinically.
- The results may be altered due to certain factors like the time between extraction of tooth and laboratory preparation, followed by thermal cycling, an occlusal load applied, and bonding agents that may be complicated to use in primary teeth clinically.
- In clinical terms, SSC is usually applied on teeth with extensive caries, thus the retentive property might be different.

Conclusion

On overall comparison of linear dye penetration and proportion of microleakage among different study groups, conventional glass ionomer cement revealed maximum value, then RMGIC and lastly, resin cement, respectively.

Clinical Significance

There are many kinds of luting agents that vary considerably from the viewpoint of their potential to stick to the tooth surface along with strength and solubility. The inability of the luting cement to adhere to the tooth structure is one of the reasons for microleakage related to different types of crowns. Cement breakdown may result in the entrance of fluids and microorganisms along with the tooth restoration interface. The oral environment is a complex biological ecosystem for which there is no substitute. But, to replicate the standard clinical procedures, certain efforts were made in this study which provides useful information to choosing the best cement materials.

Orcid

Sonali Saha https://orcid.org/0000-0001-5361-1698
Kavita Dhinsa https://orcid.org/0000-0002-3597-787X
Sakshi Tiwari https://orcid.org/0000-0002-4986-1093

References

1. Mulder R, Medhat R, Mohamed N. In vitro analysis of the marginal adaptation and discrepancy of stainless steel crowns. Acta Biomater Odontol Scand 2018;4(1):20–29. DOI: 10.1080/23337931.2018.1444995
2. Waggoner WF. Restoring primary anterior teeth. Pediatr Dent 2002;24(5):511–516. PMID: 12412967.
3. Garg V, Panda A, Shah J, et al. Crowns in pediatric dentistry: a review. J Adv Med Dent Scie Res 2016;4(2):41–46.
4. Lad PP, Kamath M, Tarale K, et al. Practical clinical considerations of luting cements: a review. J Int Oral Health 2014;6(1):116–120. PMID: 24653615.
5. Shah R, Shah D. An evaluation of microleakage under crowns cemented with different luting agents. J Adv Oral Res 2012:3(3):29–34. DOI: 10.1177/2229411220120305
6. Memarpour M, Mesbahi M, Rezvani G, et al. Microleakage of adhesive and nonadhesive luting cements for stainless steel crowns. Pediatr Dent 2011;33(7):501–504. PMID: 22353410.
7. Trubman A, Silberman SL, Meydrech EF. Dental caries assessment of Mississippi Head Start children. J Public Health Dent 1989;49(3): 167–169. DOI: 10.1111/j.1752-7325.1989.tb02055.x
8. Allison PJ, Schwartz S. Interproximal contact points and proximal caries in posterior primary teeth. Pediatr Dent 2003;25(4):334–340. PMID: 13678098.
9. Full CA, Walker JD, Pinkham JR. Stainless steel crowns for deciduous molars. JADA 1974;89(2):360–364. DOI: 10.14219/jada.archive.1974.0409
10. Randall RC. Preformed metal crowns for primary and permanent molar teeth: review of the literature. Pediatr Dent 2002;24(5):489–500. PMID: 12412964.
11. Tanumiharja M, Burrow MF, Tyas MJ. Microtensile bond strengths of seven dentin adhesive systems. Dent Mater 2000;16(3):180–187. DOI: 10.1016/s0109-5641(00)00007-5
12. Mirkarimi M, Bargrizan M, Estiri M. The microleakage of polycarboxylate, glass ionomer and zinc phosphate cements for stainless steel crowns of pulpotomized primary molars. Zahedan J Res Med Sci 2013:15(1);6–9.
13. Schmid-Schwap M, Graf A, Preinerstorfer A, et al. Microleakage after thermocycling of cemented crowns- a meta-analysis. Dent Mater 2011;27(9):855–869. DOI: 10.1016/j.dental.2011.05.002
14. Shiflett K, White SN. Microleakage of cements for stainless steel crowns. Pediatr Dent 1997;19(4):262–266. PMID: 9200198.
15. Castro A, Feigal RF. Microleakage of a new improved glass ionomer restorative material in primary and permanent teeth. Pediatr Dent 2002;24(1):23–28. PMID: 1187054.
16. Yilmaz Y, Dalmis A, Gurbuz T, et al. Retentive force and microleakage of stainless steel crowns cemented with three different luting agents. Dent Mater 2004;23(4):577–584. DOI: 10.4012/dmj.23.577

17. 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(2):65–71. DOI: 10.1007/s13191-011-0109-2
18. Lindquist TJ, Connolly J. In vitro microleakage of luting cements and crown foundation material. J Prosthet Dent 2001;85(3):292-298. DOI: 10.1067/mpr.2001.113705
19. Pegoraro TA, da Silva NRFA, Carvalho RM. Cements for use in esthetic dentistry. Dent Clin North Am 2007;51(2):453–471. DOI: 10.1016/j.cden.2007.02.003
20. Reddy KC. In vitro comparison of microleakage and tensile bond strength of self adhesive cement and conventional adhesive luting cements for cementation of stainless steel crowns in the primary molars. Research & Reviews: J Dent Sci 2017:5(1);76–83.
21. Attar N, Tam LE, McComb D. Mechanical and physical properties of contemporary dental luting agents. J Prosthet Dent 2003;89(2):127–134. DOI: 10.1067/mpr.2003.20