Scientific Article

Microleakage of Stainless Steel Crowns Placed on Intact and Extensively Destroyed Primary First Molars: An In Vitro Study

Bahman Seraj, DDS, MSc[1] • Mahdi Shahrabi, DDS, MSc[2] • Pouria Motahari, DDS, MSc[3] • Rahil Ahmadi, DDS, MSc[4] • Sara Ghadimi, DDS, MSc[5] • Shahram Mosharafian, DDS, MSc[6] • Kaveh Mohammadi, DDS[7] • Mohammad Javad Kharazifard, DDS[8]

Abstract: ***Purpose:*** *The purpose of this investigation was to evaluate the effect of residual tooth structure on the microleakage of stainless steel crowns cemented with glass ionomer on primary maxillary and mandibular first molars.* ***Methods:*** *Thirty extracted primary molars were divided into 2 groups: group 1 included intact teeth; and group 2 included extensively carious samples. Each tooth received standard preparation, and each crown was luted with G-CEM on its specific specimen. Teeth were loaded vertically and transferred to distilled water. After thermocycling and immersing in methylene blue solution, the teeth were sectioned and examined microscopically for microleakage. Data were analyzed using Mann-Whitney U and Wilcoxon signed-rank tests.* ***Results:*** *All specimens (intact and damaged teeth) had microleakage, although most of these presented only minimum microleakage. No statistically significant differences were found in the microleakage of sound and extensively carious teeth on either the buccal (P=.62) or lingual (P=.65) side. Buccal (P=.73) and lingual (P=.63) surfaces showed similar microleakage scores in primary maxillary and mandibular molars.* ***Conclusions:*** *There was no significant difference in the microleakage of sound or extensively carious teeth and primary maxillary or mandibular first molars (Pediatr Dent 2011; 33:525-8)* *Received April 7, 2010 / Last Revision November 8, 2010 / Accepted November 16, 2010*

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Dental caries is the most prevalent chronic childhood disease.[1] Rich carbohydrate diets, inadequate plaque control, low salivary flow, and the presence of enamel defects lead to the development and progress of dental caries.[2,3] Large carious lesions, early involvement of the pulp tissues, abscess formation, and pain are predictable in the absence of any preventive or treatment procedures. In this situation, particularly primary first molars are extracted to relieve pain and discomfort or prevent future treatment complications.[4,5]

Premature loss of primary molars causes supraeruption of opposing teeth, space loss, unattractive appearance, and disruption in jaw relationships.[6] Therefore, preserving the primary teeth is strongly recommended. It is advocated that, even in the condition of extensive destruction of the crown with pulp tissues involved, if there is a proper pulp treatment prognosis, the pulp therapy should be performed[3,4,7,8] Regardless of the pulp therapy employed, long term success of this procedure is significantly affected by the integrity of the coronal seal; lack or loss of a coronal seal causes failure[3,8]. Nevertheless, restoring multisurface carious posterior primary teeth, with or without pulpal involvement, is a challenging task in pediatric dentistry. The restoration should adequately protect the remaining tooth and prevent the seepage of oral fluids through its margins.[3,4,7,8]

In 1950, Humphrey described the use of a stainless steel crown (**SSC**) to serve as a definitive restoration in primary molars.[7,9,10] These prefabricated, preformed crowns are the ideal choice in managing extensive carious lesions, particularly multisurface decay of primary first and second molars, fractured teeth, restoring primary molars following pulp therapy, poor oral hygiene conditions, and the treatment of hereditary and developmental anomalies.[3,7,10,11]

Currently, SSCs are widely used in the restorative treatment of primary teeth.[3,7,9,11] Advantages which make these restorations inevitable in everyday practice include: low cost; less chair time; saving the tooth from future caries attacks; lack of mercury; and preserving normal vertical dimensions.[10,11] Retrospective studies have shown that SSCs are superior in durability and lifespan compared to multisurface amalgam and composite restorations.[9,12,13]

Despite all the benefits mentioned above, similar to any other restoration, microleakage through the SSC margin is the major deterrent to the development of a durable, successful restoration.[14,15] The clinically undetectable passage of bacterial toxins and oral fluids may lead to some complications and, consequently, failure within a few years.[16] Tooth hypersensitivity, pulpal irritation, periodontal disease, and deterioration of restorative or luting materials may be associated with this phenomenon.[14,16]

Because of the destructive complications associated with microleakage, it is essential to assess the influence of different clinical methods and factors in restoring teeth with SSCs in order to understand how these parameters might affect microleakage

Drs. [1]Seraj and [6]Mosharafian are assistant professors; [2]Dr. Shahrabi is associate professor, Department of Pediatric Dentistry; [5]Dr. Ghadimi is an assistant professor, Department of Pediatric Dentistry and Laser Research Center; [3]Dr. Motahari is assistant professor, Oral Pathology Department, [8]Dr. Kharazifard is a research adviser, Dental Research Center, [7]Dr. Mohammadi is a graduate student, Pediatric Dentistry Department, all at the Dental School, Tehran University of Medical Sciences, Teharn, Iran. [4]Dr. Ahmadi is an assistant professor, Department of Pediatric Dentistry, Dental School, Shahed University, Tehran, Iran.

Correspond with Dr. Rahil Ahmadi at rahilsh@yahoo.com

and, thus, the survival and success rate of the restoration. As stated by many investigators, the success rate and longevity of the crown restorations are related to numerous factors. These include quality of tooth preparation, crown size selection, and cementation.[9,11,14,17-21] There is some evidence that occluso-gingival length of the prepared tooth is an important factor regarding retention and, thus, microleakage of the crowns.[18,19,22] By contrast, Myers et al. and Full et al. described that retention of the crown is mainly attained when the tooth's cervical area is intact, and the remaining tooth structure has limited influence on the restoration's success.[20,23] Despite these controversial outcomes about the remaining tooth structure following tooth preparation, little has been done to evaluate the influence of the residual tooth structure, in grossly destroyed teeth, on the microleakage of the SSCs.[20]

Thus, the purpose of this study was to assess the effect of the remaining tooth structure on the microleakage of SSCs luted with glass ionomer cement (**GIC**) placed on extensively destroyed primary maxillary and mandibular first molars.

Methods

Thirty extracted primary maxillary and mandibular first molars (17 and 13 teeth, respectively) were selected and according to the tooth's destruction, divided into 2 groups (Table 1). Group 1 specimens had little or no decay, whereas Group 2 specimens demonstrated extensively carious lesions with only 1 mm of sound tooth structure on the lingual, mesial, and distal sides and little or no decay on the buccal surface (Figure 1a). Each of the 30 teeth was cleaned with a prophy cup and pumice to remove debris.

At the study time, teeth were mounted in a self-curing acrylic base, to allow for easy handling. All crown preparations were performed by a single operator so that the samples in both groups received standard crown preparations by a high-speed handpiece. In Group 2, at first all supragingival tooth structure 1 mm above the cementoenamel junction on the lingual, mesial, and distal sides was reduced. Afterward, standard tooth preparation was performed so that the occlusobuccal side was reduced by 1 mm, and near vertical reductions were made on the proximal surfaces with no ledge orshoulder present (Figure 1b). Two reference marks were made on the acrylic block, indicating mid-buccal and mid-lingual of each tooth.

Subsequently, primary first molar SSCs (3M ESPE, St. Paul, Minn) were fitted for proper size. Each crown was examined with an explorer for the best marginal adaptation. If there was any doubt about the proper marginal fit, uniform crimping and contouring was performed by a single operator (an expert pediatric dentist). To ensure a sealed margin, crowns were completely filled with G-CEM cement (GC America, Inc, Alsip, Ill) and placed on the prepared teeth using finger pressure; all the specimens exhibited excess cement expressed from all areas of the margins. Afterward, a mechanical load of 5 kg for 10 minutes was applied on each sample until the setting of the cement was accomplished. After the setting time had elapsed, excess cement was removed, the teeth were placed in 100% humidity at 37°C for 50 minutes, and samples were kept in an incubator at 37°C in distilled water for 14 days.

Prior to the evaluation of microleakage, the specimens were subjected to a thermocycling procedure of 2,000 cycles at 5°C±2 and 55°C±2 in a water bath with a dwell time of 30 seconds and a transfer time of 20 seconds. Then, the samples were immersed in a 2% methylene blue solution for 24 hours, rinsed under tap water, and subsequently dried. Teeth were embedded in a slow-setting clear epoxy resin. The samples were sectioned buccolingually through the reference marks using a diamond disk (Dorsa, HLF86, Tehran, Iran). Finally, the specimens were evaluated by a stereo microscope at a magnification of 100x for microleakage (Figure 2).

The following grading system was employed for microleakage assessment: grade 0=no dye penetration; grade 1=dye penetration ≤ 20% of the enamel-crown interface; grade 2=dye penetration >20% and ≤50% of the enamel-crown interface; and grade 3=dye penetration >50% of the enamel-crown interface. Both the buccal and the lingual surfaces were evaluated in each section.

Statistical analysis. Statistical analyses were performed using the Mann-Whitney U and Wilcoxon signed-rank tests. The level of statistical significance was set at 0.05.

Results

Thirty primary first molars consisting of 17 maxillary and 13 mandibular teeth were divided into 2 groups of the damaged and intact samples. Of the 15 intact specimens, approximately 53% (N=8) belonged to the maxilla and 47% (N=7) belonged to the mandible. Extensively destroyed teeth were 60% (N=9) and 40% (N=6) from the maxilla and mandible, respectively (Table 1).

Tables 2 and 3 show the microleakage scores in primary maxillary and mandibular first molars on the buccal and lingual sides, respectively. Statistical analysis showed no significant difference between microleakage of sound and extensively carious teeth on the buccal (P=.62) or lingual (P=.65) side. Similar microleakage scores were observed in primary maxillary and mandibular first molars on buccal (P=.73) and lingual (P=.63) surfaces, regardless of the degree of the destruction.

Tables 2 and 3 show dye penetration for all surfaces. More than half of the restorations exhibited minimum microleakage (Score 1) in both groups. On the whole, 9 damaged teeth

Table 1. NUMBER AND PERCENTAGE OF TEETH IN EACH GROUP

Groups	Maxilla N (%)	Mandible N (%)
Intact	8 (53)	7 (47)
Damaged	9 (60)	6 (40)

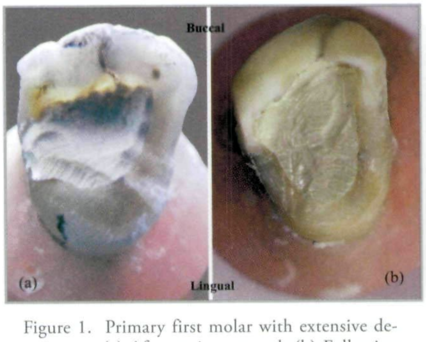

Figure 1. Primary first molar with extensive destruction. (a) After caries removal; (b) Following final tooth preparation.

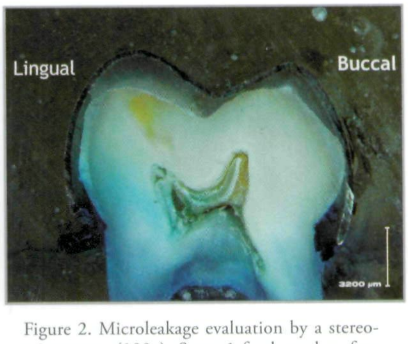

Figure 2. Microleakage evaluation by a stereomicroscope (100x). Score 1 for buccal surface and Score 2 for lingual surface.

Table 2. MICROLEAKAGE SCORES IN PRIMARY MAXILLARY AND MANDIBULAR MOLAR ON THE BUCCAL SURFACE

Jaw	Tooth type	Score 0	Score1	Score 2	Score 3	Total
		N (%)	N (%)	N (%)	N (%)	N (%)
Maxilla	Intact	0 (0)	4 (50)	4 (50)	0 (0)	**8 (100)**
	Damaged	0 (0)	5 (56)	2 (22)	2 (22)	**9 (100)**
Mandible	Intact	0 (0)	5 (71)	2 (29)	0 (0)	**7 (100)**
	Damaged	0 (0)	4 (67)	0 (0)	2 (33)	**6 (100)**

Table 3. MICROLEAKAGE SCORES IN PRIMARY MAXILLARY AND MANDIBULAR MOLAR ON THE LINGUAL SURFACE

Jaw	Tooth type	Score 0	Score 1	Score 2	Score 3	Total
		N (%)	N (%)	N (%)	N (%)	N (%)
Maxilla	Intact	0 (0)	4 (50)	2 (25)	2 (25)	**8 (100)**
	Damaged	0 (0)	5 (56)	0 (0)	4 (44)	**9 (100)**
Mandible	Intact	0 (0)	6 (86)	0 (0)	1 (14)	**7 (100)**
	Damaged	0 (0)	4 (67)	1 (17)	1 (17)	**6 (100)**

demonstrated a score of 1 on both surfaces, while the least microleakage was observed on 9 buccal and 10 lingual surfaces of the intact specimens.

The maximum microleakage (Score 3) was noticed on the lingual (N=5) and buccal (N=4) surfaces of damaged teeth followed by the lingual surface (N=3) of sound teeth. Score 3 of dye penetration was not present on the buccal surfaces of intact teeth in either the maxilla or the mandible (Tables 2 and 3).

Discussion

Stainless steel crowns are widely recognized as a durable alternative to extensive, multisurface fillings, which are known to have a poor prognosis and often need to be repaired or replaced.[9] Despite the superior longevity of the SSC, like any other restoration, one of the reasons for its clinical failure may be microleakage between the tooth wall and the crown.[3,14,16,19,24] Minimizing the seepage of oral fluids by identifying the affecting clinical factors may improve their success rate.[15,24] In this study, we assessed the influence of residual tooth structure on the microleakage of cemented preformed crowns.

Yilmaz et al., showed that the increased retention of the crown will reduce the possibility of microleakage development.[19] Retention of the crown avoids removal of the restoration along the tooth's long axis. Shillingburg et al., advocated leaving as much tooth structure as possible during the permanent tooth preparation procedure in order to interfere with any crown dislocation and improve the retention and resistance of the crown.

It is demonstrated that the occluso-gingival length serves as an important factor in retention. This may be true in view of the fact that occluso-gingivally longer buccal and lingual walls will resist pivoting and axial movements of the restoration.[22]

Our results showed that, although the maximum microleakage was mostly seen on the buccal and lingual sides of damaged samples compared to intact teeth, no significant difference in microleakage scores were found between the 2 groups in both jaws. According to our results, the height of the residual tooth structure (intact or destroyed) and tooth location (maxilla or mandible) were not major parameters contributing to the microleakage.

Similar results were reported on the impact of preparation and residual tooth structures on the retention of SSCs.[20,23] Myers et al., stated that the cervical portion of the primary tooth plays the most important role in crown retention. In other words, if the cervical part of the primary molar is intact, the remaining tooth structure will not affect the retention.[20] Savide and Rector et al., however, postulated that restorations on primary molars with ideal tooth preparation and minimal tooth structure removed are the most retentive.[18,25]

Possible reasons for results obtained in the present study include anatomy of primary molars in the cervical region and elastic deformation of SSCs. In fact, the presence of a prominent cervical ridge of enamel and the undercut area beneath this region, which serve as retentive areas, in addition to elastic deformation of the crown into the undercut portion, contribute to retention of the crown and, thus, reduces the microleakage.[3,11,19,23,26]

We observed microleakage in all of our samples in both groups. This finding is logical and practical, considering that no restoration precisely duplicates the tooth structure. McDonald et al., stated that, no matter how proficient the operator is and how perfectly the tooth preparation has been performed, all restorations permit the ingress of oral fluids between the tooth and restoration.[3] More than half of the evaluated surfaces in this study, however, showed minimum microleakage.

All of the present results should be evaluated in light of the fact that in vitro microleakage assessments are stricter than those carried out in the oral cavity. This is due to smaller dimensions of dye molecules compared to oral bacteria and their byproducts, which help them diffuse more easily. On the other hand, proteins and debris accumulation in the marginal area of the crowns may calcify, improving the restoration seal in the oral cavity. Thus, it is presumable that intraoral leakage will be less than that observed in laboratory conditions.[27-29]

To standardize the cervical adaptation of the crowns, we have selected 3M ESPE SSC with a tight snap fit for each tooth. According to Kindelan et al., SSCs from 3M ESPE need little or no manipulation, since they are cervically contoured and anatomically trimmed.[9] In the present study, none of the samples were trimmed. Those with questionable cervical adaptation were uniformly crimped and contoured by a single operator, so that an acceptable marginal fit on the basis of thorough examination with an explorer was achieved.[24]

Although there is no doubt that cement diminishes the microleakage and enhances the retention capacity of the crown, the specific choice of the cement is not as important as the crown selection, tooth preparation, and marginal adaptation.[9,19,26] Additionally, it was not our purpose to assess or compare the effect of different cement materials on the microleakage of SSCs, as this was examined by numerous previous studies.[14,19,20,21,24,30] Therefore, in the present investigation, all the subjects were luted with GIC as an acceptable and widely used luting agent for cementing SSCs.[19,31]

Our results showed that, similar to intact specimens, most of the damaged teeth revealed minimum microleakage, indicating that the amount of tooth destruction had no significant influence on the microleakage of SSCs. In other words, teeth with extensive destruction that would be otherwise not restorable and should be extracted may be successfully restored with SSCs. The testing methods and conditions used in this study, however, can not accurately reproduce the oral environment. Therefore, the results observed in this in vitro investigation cannot necessarily be extrapolated to the clinical circumstances. There is a need for further long-term clinical studies on this subject, specifically on the primary second molars, as they are essential in establishment of a functional, acceptable permanent dentition.[3]

Conclusions

Based on this study's results, the following conclusions can be made:

1. Every specimen exhibited microleake; however, it appeared to be minimal, and the amount of microleakage was not greater in grossly destroyed teeth compared to intact samples.
2. Restoring teeth with SSC, regardless of the tooth destruction results in minimal amount of microleakag.
3. Additional long-term in vivo studies are recommended.

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