

Effect of Tooth Preparation on Microleakage of Stainless Steel Crowns Placed on Primary Mandibular First Molars with Reduced Mesiodistal Dimension

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Abstract

Objectives: Incomplete adaptation of stainless steel crown margins leads to microleakage. The aim of this study was to evaluate the effect of tooth preparation on microleakage of stainless steel crowns (SSCs) placed on mesiodistally reduced primary mandibular first molars.

Materials and Methods: In this In vitro study, 60 primary mandibular first molars with reduced mesiodistal dimension were selected. Pulp cavities were filled with amalgam and occlusal surfaces were reduced. The samples were randomly divided into two groups (groups P and BLP). Standard preparation was done in group P with only proximal reduction. In group BLP, after reducing the proximal undercuts, buccal and lingual surfaces were slightly reduced. Occlusal one-third of the buccal surfaces was beveled in both groups. Then, the SSCs of the primary maxillary and mandibular first molars were fitted and cemented in P and BLP groups, respectively. After immersing the samples into deionized water, thermo-cycling, and immersion in 2% basic fuchsin, the samples were sectioned buccolingually. The mesial halves were evaluated microscopically for microleakage in both buccal and lingual margins. Data were analyzed using Mann-Whitney U test in SPSS 19 at the significant level of 0.05.

Results: There was a significant difference in microleakage of the buccal margin ($P=0.003$); whereas, the difference observed in the lingual margin was not significant ($P=0.54$).

Conclusion: We suggest reduction of buccal and lingual surfaces of mesiodistally reduced primary mandibular first molars and placing lower (mandibular) crowns.

Keywords: Primary teeth; Leakage; Stainless steel; Crown

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INTRODUCTION

Prefabricated SSCs were introduced by Humphrey in 1950 as the definitive restoration of primary molars [1-4] and are now commonly used [5]. The design of these crowns has

changed over time; the changes have led to better adaptation, improved morphological properties and greater similarity to tooth anatomy [6]. These crowns are superior to amalgam restorations in multi-surface caries [7-9]

and their failure rate is much lower than that of other restorations [9,10]. These crowns are efficient and easy to use for restoring primary and permanent teeth with extensive caries and congenital or hypoplastic defects and pulp treated teeth [2,3,7,10-13].

Restorative materials show different degrees of microleakage [14]. Despite the superiority of SSCs to the multi-surface restorations, lack of adequate marginal adaptation is considered to be the main cause of microleakage around these crowns [1]. Microleakage is defined as the passage of oral fluids containing bacteria and debris through the gap between the tooth and restoration [14]. Due to the adverse effect of microleakage on achieving a successful and durable restoration; some studies have investigated the effect of the remaining tooth structure and cement type on the marginal microleakage of SSCs [1,3]. Other important factors affecting microleakage are the tooth preparation design and selecting the suitable crown [9]. The results of a research by Veerabadhran et al. showed that creating a retentive groove had no effect on the retentive strength of second primary molar SSCs [15]. Evaluating the effect of remaining tooth structure on the microleakage of primary maxillary and mandibular first molar SSCs, Seraj et al. reported no significant difference in microleakage of SSCs placed on intact and severely carious teeth [1]. Study results of Memarpour et al. also indicated that adhesive cements were more effective for reducing microleakage in SSCs than non-adhesive cements and use of bonding agent with resin-modified glass ionomer cement had better results than the use of adhesive cement alone [3].

In the primary dentition system, carious lesions often develop early in the primary first molars [1] and SSCs are considered a suitable restoration for these teeth [4]. In addition, relatively early eruption of the primary first molars and not restoring them in time can cause a possible reduction in mesiodistal dimensions and consequently, loss of space.

When the space loss occurs distal to the mandibular primary first molar in an amount of a few millimeters, it is not possible to select an appropriate size crown due to the loss of mesiodistal dimension.

In this case, selection of primary maxillary first molar crown of the opposite side is recommended [4,9]. Despite the importance of tooth preparation and selection of a suitable crown, there is no study on the effect of tooth preparation and crown selection (seating a smaller size lower crown or the opposite side upper one) on the microleakage of SSCs on primary mandibular first molars, with reduced mesiodistal dimensions. Therefore, the present study aimed to evaluate the effect of crown selection on the microleakage of SSCs placed on primary mandibular first molars with reduced mesiodistal dimension.

MATERIALS AND METHODS

In this *in vitro* study, 60 extracted primary mandibular first molars with reduced mesiodistal dimensions were evaluated. The inclusion criteria included: 1) Loss of mesiodistal dimension at the distal surface. 2) Mesial, buccal and lingual surfaces were intact or had tiny carious lesions. 3) The teeth had adequate root length to be mounted in acrylic resin.

The extracted teeth were immersed in 0.1% chloramine T solution for four weeks, until all the samples were collected. The studied samples were cleaned with rubber cup and pumice paste and washed with deionized water. Then, the teeth were mounted in cold-cured acrylic resin blocks in such a way that the crown was fully exposed.

Before tooth preparation for crown placement, the pulp tissue was removed from the pulp chamber and the pulp cavity was filled with amalgam. Occlusal surface was reduced by 1-1.5 mm with a diamond wheel bur (TeezKavan Ltd, Tehran, Iran). Then, samples were randomly divided into two groups of P and BLP. In group P, crown preparation was done according to a standard method.

That is, the proximal undercuts were reduced almost vertically using featheredge bur (TeezKavan Ltd, Tehran, Iran).

The occlusal third of the buccal surface was beveled using a wheel bur. In group BLP, reducing the proximal undercuts was followed by slight preparation of the buccal and lingual surfaces. Occlusal one-third of the buccal surface was beveled as well. In both groups, all linear angles were rounded. A hole (reference mark) was prepared in the middle of the lingual surface of the teeth mounted in the acrylic block for appropriate buccolingual sectioning and also to differentiate buccal and lingual surfaces under microscopic evaluation. Proper-size SSCs of the primary upper and lower first molars (3M ESPE, St. Paul, MA), were chosen for P and BLP groups, respectively. The crowns were fitted, contoured, crimped (no. 114, 3M ESPE, and no. 800-417, Denovo, Baldwin Park, CA) and controlled by the tip of an explorer in order to achieve the best marginal adaptation. The crowns were then filled with glass ionomer cement (GC America, Inc., Alsip, IL, USA) in such a way that two-thirds of the internal surface of the crown and all margins were covered with the cement. The crown containing cement was seated on the tooth and held with finger pressure. Finally, 5 kg of axial pressure was applied for 10 minutes until completion of the setting of the cement. Subsequently, samples were kept in 100% humidity at 37°C for 50 minutes and then stored in deionized water in an incubator at 37°C for four weeks. All procedures, including tooth preparation, selection, adjustment and cementation of crowns, were performed by a single operator (pedodontist). In addition, the mixing of cement was performed according to the manufacturer's instructions.

Then, samples were subjected to a thermocycling procedure of 2000 cycles at 5-50°C in a water bath with 30 seconds of dwell time and 20 seconds of transfer time. Then, the samples were immersed in 2% basic fuchsin solution for 24 hours. Subsequently, the samples were washed, dried, and embedded in a slow-setting clear epoxy resin. A buccolingual section was made through the reference hole on the lingual surface using a diamond disc (Dorsa, HLF86, Tehran, Iran) with plenty of water. Resultantly, the crown was divided into two mesial and distal halves.

For each sample, two separate scores were recorded (buccal and lingual marginal microleakage).

Finally, under blind conditions, the mesial halves were examined in terms of microleakage under a stereomicroscope (Nikon SMZ800, Japan) at 100X magnification. In this study, the following criteria were used to grade microleakage: Grade 0= No dye penetration at the enamel-crown interface, Grade I= dye penetration \leq 20% of the enamel-crown interface, Grade II= dye penetration $>$ 20% and \leq 50% of the enamel-crown interface and Grade III= dye penetration $>$ 50% of the enamel-crown interface. Finally, the data were analyzed in SPSS version 19 using Mann-Whitney U test at a significance level of 0.05.

RESULTS

All samples showed some degrees of microleakage.

In both P and BLP groups, microleakage of Grade I has the highest frequency. Comparison of microleakage based on the tooth preparation design is presented in Table 1.

There was no significant difference in the microleakage based on the tooth preparation design ($P=0.17$).

Table 1. Comparison of microleakage based on tooth preparation design

Tooth preparation design	Mean rank	Sum of ranks	P value
Group P	64.66	3879.50	0.17
Group BLP	56.34	3380.50	

Data regarding the frequency of microleakage at the buccal and lingual margins in each group and the respective statistical tests are shown in Tables 2 and 3. Lower mean rank of the microleakage at the buccal margin in BLP group indicates less microleakage in this group. According to the Mann-Whitney U test, this difference was statistically significant ($P=0.003$).

According to this table, the difference observed in the microleakage of lingual margin was not significant ($P=0.54$).

DISCUSSION

One of the reasons for the clinical failure of SSCs is the microleakage between the tooth and crown [3]. In addition, microleakage leads to the bacterial infection of the pulp cavity and subsequent treatment failure.

Minimizing microleakage with effective clinical measures can reduce the failure rate [1]. This study aimed to investigate the effect of tooth preparation design on microleakage of SSCs placed on primary mandibular first molars with reduced mesiodistal dimension.

The results showed that the difference in microleakage between the two groups of tooth preparation designs was not significant. Also, microleakage of buccal margin in the group BLP was significantly lower than that of the group P. In the lingual margin, the difference observed in the microleakage between the two groups of preparation designs was not significant. In this study, the microleakage was observed in all understudy samples. Considering the prefabricated form and incomplete adaptation of these crowns, despite contouring and crimping, this finding is somehow expected.

Table 2. The frequency of microleakage at the buccal and lingual margins based on the tooth preparation design

Margins	Tooth preparation design	Microleakage N (%)				
		Grade 0	Grade I	Grade II	Grade III	Total
Buccal	Group P	0 (0)	12 (40.0)	10 (33.3)	8 (26.7)	30 (100.0)
	Group BLP	0 (0)	23 (76.7)	5 (16.7)	2 (6.6)	30 (100.0)
Lingual	Group P	0 (0)	17 (56.7)	4 (13.3)	9 (30.0)	30 (100.0)
	Group BLP	0 (0)	14 (46.7)	6 (20.0)	10 (33.3)	30 (100.0)

Table 3. Comparison of microleakage at the buccal and lingual margins based on the tooth preparation design

Margins	Tooth preparation design	Mean rank	Sum of ranks	P value
Buccal	Group P	36.33	1090.00	0.003
	Group BLP	24.67	740.00	
Lingual	Group P	29.23	877.00	0.54
	Group BLP	31.7	953.00	

While Grade I microleakage was the most frequent type, Grade III was observed in one-fourth of samples.

Yet, considering the bigger size of oral bacteria and their products compared to dye molecules penetrating through the gap between the crown and the tooth as well as the accumulation of proteins and debris at the crown margins, intraoral microleakage is expected to be less than what was observed in the current in-vitro study [1,14-16].

In this study, although there was no significant difference in microleakage in terms of tooth preparation design, the findings showed less microleakage in the BLP group. Our findings also indicated significantly greater microleakage in the buccal margin of group P compared to group BLP. No significant difference was observed in the lingual margin. Although the considerably lower buccal marginal microleakage in group BLP contributes to lower microleakage in this group, the reversed but insignificant condition in the lingual margin led to no significant difference in microleakage of studied groups. Although it is not exactly clear why the microleakage difference in the two groups was significant in the buccal margin and insignificant in the lingual margin, the specific anatomy of the primary mandibular first molars as well as the form of the crown used might have played a role in achieving these results. Cervical ridge in the buccal surface of the primary lower first molar is slightly reduced in our proposed method (reduction of buccal, lingual and proximal surfaces) during the preparation; while such reduction is not performed during standard preparation (reduction of only proximal surfaces). In our opinion, the anatomy of the teeth prepared in group BLP is more similar to that of the mandibular SSCs compared to the similarity between the anatomy of the teeth prepared by the standard method (group P) and that of the upper SSCs.

Thus, the gap between the SSCs and the teeth is minimized in group BLP causing a signifi-

cant difference in the microleakage at the buccal surface. Due to the unique methodology used in this study, it is not possible to directly compare our findings with those of other studies. On the other hand, cement type is among the other factors affecting the success of crowns [2,3,13]. Subramaniam et al. [13], Memarpour et al. [3] and Veerabadhran et al. [15] have previously addressed this topic. In our study, all samples were cemented with GI cement. Due to the adhesive bonding to enamel and dentin and fluoride release, this cement is superior to others and is commonly used [1,2,13]. Also, to eliminate the confounding effect of cement manipulation, powder to liquid ratio was adjusted according to the manufacturer's instructions and mixing was performed by a single operator.

Although there are several methods to evaluate microleakage, dye penetration technique has been used in many studies to evaluate the marginal seal [15,16]. In our study, we evaluated microleakage using dye penetration model with 2% basic fuchsin solution. The advantages of dye penetration method are its accuracy for evaluation of marginal seal, the possibility of direct observation of markers under the microscope and its simple application. The disadvantage of this method is the substantially smaller diameter of marker particles compared to bacteria and their toxic products [16]. Since the crown retention is mainly due to proper contouring and crimping [9], in our study we used specific pliers to achieve optimal marginal adaptation, if necessary. Moreover, to increase the accuracy of this study, tooth preparation and crown selection were performed in accord with the clinical standard guidelines. Considering the fact that in the preset study, all factors except for tooth preparation and subsequent crown selection were matched, it can be concluded that these two factors play critical roles in development of microleakage at the buccal margin.

Our findings revealed improvement of microleakage at the buccal margin as a consequence

of buccolingual reduction of primary mandibular first molar with reduced mesiodistal dimension. Besides, due to the lack of significant differences in microleakage of groups, irrespective of the studied margin, buccolingual reduction may be recommended. In addition to the effect on microleakage, the tooth preparation method is also effective on crown retention [17]. Hence, the preparation method should be done carefully and cautiously, because retention of stainless steel crowns largely relies on natural undercuts of primary molar teeth [2,13]. Also, under in-vivo conditions, exposure to mechanical loads may lead to different results due to the impact of occlusal loading. Loading stress may increase microleakage of crowns by causing marginal distortion [16]. However, a study with a larger sample size is recommended. Also, considering the impact of buccal and lingual reduction on retention of crowns placed on mesiodistally reduced primary mandibular first molars, it is recommended that a similar study be conducted to investigate the effect of reduction on crown retention. Despite the fact that this research was a laboratory study under carefully controlled conditions, it cannot fully simulate the clinical setting and thus the results cannot be completely generalized to the oral environment. Clinical studies are required to better elucidate the effect of tooth preparation design on retention of crowns.

CONCLUSION

Due to the significantly lower microleakage in the buccal margin of BLP group, buccal and lingual reduction is recommended for primary mandibular first molars with reduced mesiodistal dimensions.

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