

Comparison of Marginal Circumference of Two Different Pre-crimped Stainless Steel Crowns for Primary Molars After Re-crimping

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Abstract

Objectives: It is not clear what type of pre-crimped crown is more successful in achieving greater marginal adaptation following re-crimping. This study aimed to assess the changes in the circumference of 3M ESPE and MIB pre-crimped stainless steel crowns (SSCs) for the primary maxillary and mandibular first and second molars following re-crimping.

Materials and Methods: This was an in-vitro, experimental study. Initial photographs were obtained from the margins of 3M and MIB SSCs for the upper and lower primary molars using a digital camera. Crown margins were crimped by applying 0.2N force using 114 and 137 pliers. Post-crimping photographs were also obtained and the changes in crown circumference after crimping were calculated using AutoCad software. The percentage of reduction in the circumference of crowns for each tooth was statistically analyzed based on the type of crown using student t-test. The effect of crown design and the associated teeth on the decreased circumference percentage was statistically analyzed by two-sided ANOVA.

Results: The percentage of reduction in lower E SSC circumference was $3.71 \pm 0.39\%$ in MIB and $6.29 \pm 0.62\%$ in 3M crowns. These values were $3.55 \pm 0.55\%$ and $7.15 \pm 1.13\%$ for the lower Ds, and 3.95 ± 0.43 and $6.24 \pm 0.85\%$ for the upper Ds, respectively. For the upper Es, these values were found to be $3.12 \pm 0.65\%$ and $5.14 \pm 0.94\%$, respectively. For each tooth, a significant difference was found between MIB and 3M SSCs in terms of the percentage of reduction in crown circumference following crimping. The magnitude of this reduction was smaller in MIB compared to 3M SSCs ($P < 0.001$).

Conclusion: Considering the significant reduction in the marginal circumference of pre-crimped SSCs following re-crimping, it appears that this manipulation must be necessarily performed for MIB and 3M pre-crimped SSCs. By using 3M SSCs, higher marginal adaptation can be achieved following crimping.

Keywords: Stainless Steel; Crowns; Dental Marginal Adaptation; Molar

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INTRODUCTION

Stainless steel crowns have long been used as durable restorations for the reconstruction of

primary teeth that have undergone pulpotomy or pulpectomy and those with developmental defects or extensive, multi-surface carious

lesions [1]. These crowns can maintain the health of the surrounding tissues and prevent development of caries by full coverage of dental surfaces. Due to optimal durability and stability, these crowns are highly popular in pediatric dentistry. Application of SSCs is often preferred over extensive, multi-surface amalgam restorations. Also, the SSCs have longer clinical survival than two- or three-surface amalgam restorations [2]. The advantages of SSCs include their relatively easy application in a relatively short time, preserving the remaining tooth structure, resuming the function of the damaged tooth, restoring the lost contour of the tooth and subsequently, maintaining the length of the dental arch [3-5]. However, the principles of tooth preparation must be thoroughly followed before the placement of SSCs. Moreover, there are some limitations against their use due to inadequate marginal adaptation and insufficient retention in severely damaged teeth at the proximal walls or buccal and lingual surfaces. It has been reported that in case of achieving a favorable marginal adaptation, the longevity of SSCs can be five to 15 years [6]. Marginal adaptation of SSCs depends on several factors including the proper size of the crown, trimming of the crown to achieve adequate length, crimping of the crown margins for approximation to the prepared tooth surfaces and proper polishing of the crown [7].

Of different SSCs available in the Iranian dental market, 3M ESPE and MIB SSCs are the most commonly used types. These crowns are festooned, pre trimmed and pre-crimped. Considering the fact that these crowns already have a suitable contour, it appears that they barely need crimping. However, most dentists still crimp the crown margins to obtain a better fit with the tooth structure. But, no accurate information is available on the efficacy of re-crimping or to what extent, re-crimping can help to achieve better marginal fit. Moreover, it has been demonstrated that the mean marginal circumference of pre-crimped SSCs is

decreased by 7.3% following crimping and the marginal thickness of SSCs is increased by averagely 18 μ after crimping [8]. Thus, crimping seems necessary even for pre-crimped crowns. This study aimed to assess the circumference of 3M ESPE and MIB pre-crimped SSCs following re-crimping.

MATERIALS AND METHODS

This in-vitro experimental study was conducted to compare specifications of two widely used crowns namely 3M (3M ESPE, St. Paul, MN, USA) and MIB (Shinhung Co., Seoul, Korea). From each manufacturer 30 samples were selected, which are more commonly used (Table 1).

Table 1. Types and number of crowns in the study

Type of Crown	Upper D	Upper E	Lower D	Lower E
Size	4	3	4	3
Number of samples	7	8	8	7

Initial photographs were obtained from the margins of each of the selected 60 SSCs using a digital camera (Canon EOS 6000D, Tokyo, Japan); which was adjusted and fixed at 30cm distance using a tripod. The crown margins were then crimped using 114 and 137 pliers (Schweickhardt GmbH & Co., Seitingen-Oberflacht, Germany). For crimping, hammering forces were applied to the gingival one-third of the crowns using 114 (Johnson) and then 137 (Gordon) pliers. Crimping was done by one operator with 0.2N force (equal to 20g load); the operator's hand force was calibrated by a force meter. Controlled load was applied to the crown margins by using pliers with a walking motion to achieve a uniform contour. The secondary photographs were then obtained under similar conditions to the primary ones.

Sixty initial pre-crimping and 60 post-crimping photographs were saved in a computer.

The marginal circumference of SSCs before and after crimping was measured and compared using AutoCad 2013 software. The circumference of SSCs was determined blindly by an operator who was not aware of the study phases. Considering the reduction in the marginal circumference of SSCs in the two groups of 3M and MIB for upper and lower Ds and Es, the percentage of reduction in circumference was calculated as below:

$$\frac{\text{Pre-crimping circumference} - \text{post-crimping circumference}}{\text{Pre-crimping circumference}} \times 100 = \text{Percentage of reduction}$$

The data were statistically analyzed using SPSS version 18.0. Considering the pre-crimping and post-crimping circumference values, the magnitude of reduction in circumference was calculated in different groups and expressed as percentage. The mean and standard deviation (SD) of the crown circumference before and after crimping, changes in the circumference and their percentage based on the type of crown (3M or MIB) and type of tooth (upper and lower Ds and Es) were all calculated. Two-way ANOVA was used to assess the effect of type of crown and tooth on the percentage of reduction in crown circumference and changes in this value in millimeters. Student's t-test was applied to analyze the percentage of reduction in 3M and MIB crown circumference for each tooth. One-way ANOVA was also used to assess the difference in circumference reduction values for 3M and MIB crowns for each tooth. Pairwise comparison of teeth was done using Tukey's test.

Type one error was considered as 0.05 ($\alpha=0.05$) and P values ≤ 0.05 were considered statistically significant.

RESULTS

The mean reduction in the circumference of MIB and 3M SSCs for lower Es was 1.11 and 1.91mm, respectively. These values were 0.89 and 1.74mm for the lower Ds, 0.99 and 1.53mm for the upper Ds and 0.99 and 1.59mm for the upper Es, respectively (Table 2). The mean \pm standard deviation percentage of circumference reduction in MIB and 3M SSCs of lower Es was $3.71 \pm 0.39\%$ and $6.29 \pm 0.62\%$, respectively. These values were $3.55 \pm 0.55\%$ and $7.15 \pm 1.13\%$ for the lower Ds, $3.95 \pm 0.43\%$ and $6.24 \pm 0.85\%$ for the upper Ds and $3.12 \pm 0.65\%$ and $5.14 \pm 0.94\%$ for the upper Es, respectively. The results of two-way ANOVA revealed that type of crown ($P < 0.001$), type of primary tooth ($P < 0.001$) and the interaction of the two factors ($P = 0.023$) had significant effects on the absolute values of percentage of reduction in the circumference. In other words, the percentage of change in the crown circumference before and after crimping was significantly different based on the type of crown (3M or MIB) and type of tooth (upper or lower E or D). Student's t-test demonstrated that for each tooth, significant difference existed between 3M and MIB crowns in terms of the percentage of reduction in the circumference. Also, the magnitude of reduction in circumference was smaller in MIB compared to 3M SSCs following crimping ($P < 0.001$) (Table 3).

Table 2. The mean and standard deviation values of the marginal circumference of 3M and MIB SSCs before and after crimping and the magnitude and percentage of reduction in the circumference of SSCs for upper and lower Ds and Es

Tooth type	SSC type	Pre-crimping	Post-crimping	Reduction	Reduction percentage
Lower E	3M	30.350 \pm 0.319	28.440 \pm 0.271	1.91 \pm 0.20	6.29 \pm 0.62
	MIB	29.822 \pm 0.162	28.716 \pm 0.208	1.11 \pm 0.12	3.71 \pm 0.40
Lower D	3M	24.325 \pm 0.167	22.585 \pm 0.231	1.74 \pm 0.28	7.15 \pm 1.13
	MIB	25.144 \pm 0.192	24.252 \pm 0.092	0.89 \pm 0.14	3.55 \pm 0.55
Upper D	3M	24.519 \pm 0.211	22.990 \pm 0.285	1.53 \pm 0.21	6.24 \pm 0.85
	MIB	24.981 \pm 0.064	23.994 \pm 0.117	0.99 \pm 0.11	3.95 \pm 0.43
Upper E	3M	30.921 \pm 0.424	29.328 \pm 0.267	1.59 \pm 0.31	5.14 \pm 0.94
	MIB	31.824 \pm 0.192	30.831 \pm 0.152	0.99 \pm 0.21	3.12 \pm 0.65

Table 3. The absolute values of percentage of reduction in the circumference of 3M and MIB SSCs of upper and lower Ds and Es after crimping (t-test)

Tooth	Type of SSC	Mean	Standard deviation	Standard error	T-test
Lower E	MIB	3.71	0.39	0.15	0.0001
	3M	6.29	0.62	0.23	
Lower D	MIB	3.55	0.55	0.19	0.0001
	3M	7.15	1.13	0.39	
Upper D	MIB	3.95	0.43	0.16	0.0001
	3M	6.24	0.85	0.32	
Upper E	MIB	3.12	0.65	0.23	0.0001
	3M	5.14	0.94	0.33	

One-way ANOVA demonstrated that the percentage of reduction in the circumference of MIB ($P=0.03$) and 3M ($P=0.002$) SSCs was different among the understudy teeth and this difference was statistically significant. In other words, both types of crowns showed variable changes in circumference for upper and lower Ds and Es. The results of multiple comparisons by Tukey's HSD test demonstrated that in MIB SSCs, only the difference between upper D (3.95) and E SSCs (3.12) in terms of the percentage of reduction in circumference was statistically significant ($P=0.02$) and other pairwise comparisons revealed no significant difference among the teeth. Moreover, in 3M SSCs, the difference between lower D and upper E SSCs in terms of changes in the circumference was statistically significant ($P<0.001$) and no other significant difference was found in this regard. The results of two-way ANOVA by taking into account the changes in circumference in millimeters revealed that type of SSC ($P<0.001$) and type of tooth ($P<0.01$) both had significant effects on changes in crown circumference. However, the interaction effect of these two variables on changes in crown circumference was not significant ($P=0.14$). Pairwise comparison of teeth in this respect (using Tukey's HSD test) revealed that the differences between upper D and lower E ($P=0.02$) and also lower E and upper E ($P=0.04$) SSCs in terms of changes in crown circumference were statistically significant. No other significant difference was found in pairwise comparisons.

DISCUSSION

A suitable marginal adaptation between SSCs and the respective teeth can be achieved by some manipulations like crimping. The process of crimping includes inward bending of the gingival one-third of the crown aiming to achieve better adaptation between the crown and the tooth surface. The necessity of crimping for pre-crimped crowns has yet to be clearly stated and this issue is still a matter of debate. On the other hand, the fit of 3M SSCs has reported to be excellent and the need for crimping of these crowns seems to be minimal [9]. However, evidence shows that although pre-crimped SSCs require less manipulation to achieve accurate fit, final adaptation may need some case-specific modifications by the clinician. Afshar and Mozaffari Kojidi in their study in 2006 evaluated the changes in circumference of 3M SSCs after crimping and reported that the mean marginal circumference of pre-crimped SSCs significantly decreased by 7.3% after crimping. This finding confirms the need for re-crimping of pre-crimped crowns [8]. The MIB SSCs were recently introduced to the Iranian dental market. Thus, we evaluated the changes in the circumference of 3M and MIB crowns for upper and lower Ds and Es after crimping.

The percentage of reduction in the circumference of MIB and 3M SSCs for lower Es was found to be 3.71% and 6.29%, respectively. These values were 3.55% and 7.15% for the lower D, 3.95% and 6.24% for the upper D and 3.12% and 5.14% for the upper

E SSCs, respectively. Based on these results, in all cases, the circumference reduction in 3M crowns was significantly greater than in MIB crowns. Our results regarding the 3M SSCs were almost similar to those of Afshar and Mozaffari Kojidi reporting a 7.3% decrease in the circumference of crowns after crimping [8]. The percentage of reduction in the circumference of 3M crowns in our study was significantly greater than that in MIB crowns; indicating the greater efficacy of 3M crowns in achieving better marginal adaptation following crimping compared to MIB crowns (almost twice). Such a difference is probably due to the different alloy composition. The 3M SSCs are made of nickel-chromium alloy containing 77% nickel, 15% chromium and 7% iron [10]. The alloy composition of MIB crowns has not been revealed by the manufacturing company [11]; but, they seem to have a higher nickel content compared to 3M SSCs, which increases the hardness of crown alloy and thus, the resiliency of the MIB crown alloy is lower than that of 3M crowns. Due to the flexibility of SSC alloy, they can expand as they pass the height of contour and then return to their previous state. Therefore, the MIB crowns probably have lower potential for expansion than 3M crowns; thus, to solve this problem, the teeth must be further prepared at the cervical area of the buccal and lingual surfaces. However, 3M crowns do not need this extra preparation or need it to a lower extent. If this assumption regarding the higher nickel content of the alloy in MIB crowns is correct, this hypothesis can be suggested that due to increased hardness of alloy in these crowns, they are more resistant against occlusal loads and wear compared to 3M crowns and consequently, perforation may occur much later in these crowns compared to 3M crowns. However, this issue needs to be further investigated in a separate study. The reduction in the circumference of crowns for different tooth types manufactured by different companies was the same (no significant

difference) except for upper D and E MIB and lower D and upper E 3M crowns. This difference in MIB crowns may be due to the completely different morphology of D crowns, its similarity to premolar teeth and also the possibility of less crimping by the manufacturer because of the presence of a prominent cervical ridge in this tooth. Such differences also existed in 3M lower D and upper E crowns and were significant. However, this issue is in need of further investigation in a separate study.

CONCLUSION

Considering the significant reduction in the circumference of pre-crimped SSCs following re-crimping, it appears that this manipulation must be necessarily performed for 3M and MIB SSCs. Greater marginal adaptation can be achieved by crimping of 3M SSCs.

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