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MICROLEAKAGE ASSESSMENT USING DIFFERENT COMPOSITE APPLICATION TECHNIQUES IN PRIMARY MOLARS. AN IN-VITRO COMPARATIVE STUDY

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ABSTRACT

INTRODUCTION: Resin-based materials are being used in restorative dentistry on a large scale. Since their introduction, they have replaced amalgam restorations due to their esthetics and ongoing improved physical properties. However, microleakage which results from polymerization shrinkage remains to be the main problem of resin restorations.
AIM: To assess the microleakage in primary molars after composite application with different layering techniques.
MATERIALS AND METHODS: Standardized class I cavities were done in 40 primary extracted molars, filled with composite, placed in 0.5% basic fuchsin solution, and assessed for microleakage using stereomicroscope.
RESULTS: Composite filling using the Hot-Dog technique showed the least microleakage when assessed under the stereomicroscope.
CONCLUSION: Restoring primary teeth with composite restoration using the Hot-Dog application technique exhibits less marginal leakage with statistically significant differences when compared with the horizontal placement technique, the split horizontal placement technique, and the succussive cusp build-up technique.
KEYWORDS: Composite, Pediatric dentistry, Primary teeth, Polymerization shrinkage, Microleakage, Hot-Dog technique.
RUNNING TITLE: Microleakage using different composite layering techniques.

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INTRODUCTION

Resin composites are being widely used by pediatric dentists due to the increased demand of parents to give their children the best treatment without compromising esthetics. In addition, their improved physical properties, minimal cavity preparation needed, and decreased cost than similar ceramic and esthetic restorations made them more popular among dentists and laypeople. (1,2) For decades, many attempts have been made to further improve the physical properties of composite materials. Nano-sized particles were used in composite manufacturing by the beginning of the second millennium, and these nano-filled composites proved better strengths, less discoloration, and fewer failures. (3)

However, polymerization shrinkage remains to act as an obstacle to the success of composite restorative materials resulting in a defective tooth-restoration interface which leads to marginal leakage, discoloration, recurrent caries, breakdown of tooth or restoration material, and even pulpal involvement. (4,5) Polymerization shrinkage and microleakage are affected by the bond strength of the material to the tooth structure, the coefficient of thermal expansion of the material relative to the enamel and dentine, cavity orientation, and the C-factor which is the ratio of the bonded area of the tooth surface to the unbonded area. (2,5) Consequently, the Incremental composite application technique has been suggested to decrease stress exerted on the tooth from polymerization shrinkage and also decrease microleakage. (6)

One of the techniques described by the literature is the horizontal layering technique which denotes the application of layers of the composite material to the cavity floor in a horizontal manner. This technique was reported to increase the C-factor increasing the stresses resulting from the polymerization shrinkage on the walls of the cavity. (2) Another technique is the split horizontal technique, signifying the splitting of each horizontal increment into 4 triangular-shaped segments. After light curing, each split cut is filled with another increment of composite which is light cured again separately. (2) This technique was suggested to decrease the stresses on the cavity walls since each increment is not connected by the 4 walls of the cavity as in the previously mentioned technique decreasing the C-factor as well. (2) The successive cusp build-up technique was proposed to be used also as building each cusp separately with a discrete sloped increment that would greatly decrease the polymerization stresses of the composite exerted on the cavity walls. (2)

Terry and Leinfelder (7) in 2006 explained the “Hot-Dog” technique. They claimed that this technique decreases the C-factor and polymerization shrinkage to very small values. They explained that “hotdog-shaped” increments are used, condensed, and light cured at the bucco-pulpal and linguo-pulpal line angles before adding another increment occlusal to the previous separately cured increments. This occlusal increment will be further condensed in a pulpal direction and cured.

In this context, Baig et al (5) in 2013 claimed that poor clinical evidence relates polymerization shrinkage to decreased clinical performance. Therefore, the present study was designed to evaluate and compare the occurrence of microleakage in primary teeth restored with composite resin using different application techniques. The null hypothesis was that there were no significant differences in microleakage scores in primary teeth restored with composite resin by different application techniques.

MATERIALS AND METHODS

The present study was designed to be an in-vitro experimental comparative study. It took place at the Faculty of Dentistry, Pharos University in Alexandria (PUA) and was approved by the Unit of Research Ethics Approval Committee (UREAC) with serial no. PUA02202401273174. It was performed and reported according to the CRIS guidelines. (8) The sample size was calculated using Power Analysis and Sample Size Software (PASS 2020) “NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/pass”. The minimal total hypothesized sample size of 40 eligible sampling units [10 Per Group] was needed to evaluate and compare microleakage occurrence in primary teeth restored with composite resin using different application techniques; taking into consideration an effect size of 20%, significance level of 5% and power of 80% using Chi square test. (9,10) Therefore, the estimated sample of 40 sound maxillary first primary molars was collected.

The molars collected for the study were sound maxillary primary first molars that were obtained from serial extraction procedures. They had at least one-third of their roots intact. Excluded were molars that were extracted due to periapical pathology or badly destructed molars. The teeth were cleaned from debris and blood, and stored in artificial saliva. All teeth were mounted in wax blocks and received standardized class I cavity preparations of (4mm mesio-distal*2mm bucco-lingual*1.5mm depth), using a 330 carbide bur with a rubber stopper mounted on it to control the depth of the cavity. A periodontal probe (15 UNC Perio Probe, Hu-Friedy Mfg. Co., Chicago, USA) was used to determine the width and the length of the cavity. (11,12)

After cavity preparation, the teeth were randomly divided into 4 groups according to the method of composite application. Group 1: Ten teeth received the composite restorations by the horizontal technique; Group 2: Ten teeth received the composite restorations by the Hot-Dog technique; Group 3: Ten teeth received the composite restorations by the split horizontal technique; and finally Group 4: Ten teeth received the composite restorations by the successive cusp building technique.

All teeth were etched for 20 seconds using 37% phosphoric acid gel (3M™ Scotchbond™ Universal Etchant, USA), rinsed for 5 seconds with a water-air flush, dried by a gentle air blow, bonded using a micro-brush (3M™ ESPE™ Adper™ Scotchbond™ Multi-Purpose Adhesive, USA) and light-cured (3M™ Paradigm™ DeepCure LED Curing Light, USA) for 20 seconds.

In Group 1: The first layer consisted of 0.5mm of flowable composite covering the whole cavity floor (3M™ Filtek™ Supreme Flowable Restorative, USA), light cured for 40 seconds, then 2 increments of packable composite (3M™ Filtek™ P60 Restorative Syringe, USA) were applied, each increment was properly condensed against the floor of the cavity and light-cured for 40 seconds separately.

In group 2: The first “hotdog” shaped increment (1mm thick) was packed against the buccal cavity wall including the bucco-lingual line angle, the second “hotdog” shaped increment (1mm thick) was packed against the lingual cavity wall including the linguo-pulpal line angle, and finally, flowable composite was applied to the cavity floor until the normal fossa depth. Each increment was light-cured for 40 seconds.

In Group 3: The first layer consisted of a 1mm increment of packable composite that was split into 4 segments leaving a cross-shaped groove and then light cured for 40 seconds. The central groove was filled with packable composite and light cured. Finally, the remaining 2 grooves were filled and cured separately.

In Group 4: Two increments (1mm thick each) were packed against each of the buccal and lingual cusps, and then the final increment was placed and packed against the floor of the cavity. Each increment was light-cured for 40 seconds.

Each group of teeth was subjected to thermocycling (1000 cycles) from 5°**C to 55**°C (3), then coated with 2 layers of nail varnish leaving the occlusal surface exposed, and then immersed in 0.5% basic Fuchsin solution for 24 hours. The samples were then sectioned longitudinally (buccolingually) into 2 halves using a circular disc mounted on a slow-speed handpiece, and each half was examined by the stereomicroscope (Olympus SZ1145, Optical Co., LTD. Tokyo, Japan) for evaluation of microleakage (Figure 1). Criteria for scoring microleakage were implemented according to Radhika et al in 2010 (13) (Table 1).

Statistical analysis of the data

Data were collected and fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). The Shapiro-Wilk test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance of the obtained results was judged at the 5% level.

For abnormally distributed quantitative variables, the Kruskal Wallis test was used to compare the abnormally distributed data between the studied groups, and Post Hoc (Dunn's multiple comparisons test) for pairwise comparisons

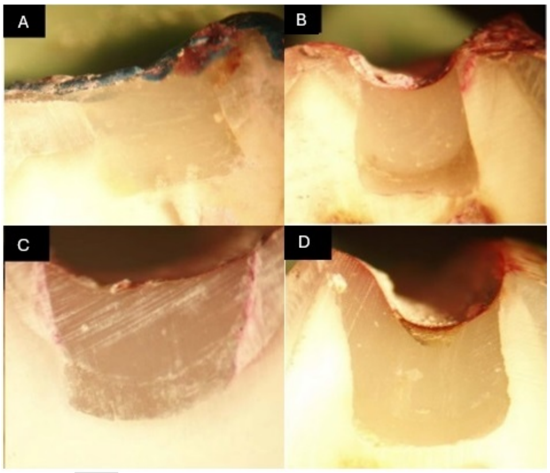

Figure 1: Stereomicroscopic pictures of specimens for evaluation

Horizontal technique, B. Hot-Dog technique, C. Split horizontal technique, D. Successive build-up technique.

Table 1: Criteria for scoring microleakage

Score	
0	No dye penetration
1	Dye penetration into enamel
2	Dye penetration beyond the dentinoenamel junction
3	Dye penetration into the pulpal wall

Table 2: Comparison between the different studied groups according to score

Score	Horizontal technique (n = 10)	Hot-Dog technique (n = 10)	Split-horizontal technique (n = 10)	Successive cusp building technique (n = 10)	H	p
Min. – Max.	0.0 – 2.0	0.0 – 1.0	0.0 – 2.0	0.0 – 1.0		
Mean ± SD.	0.38 ± 0.74	0.13 ± 0.35	1.25 ± 0.71	0.50 ± 0.53	11.097*	0.011*
Median (IQR)	0.0 (0 – 0.5)	0.0 (0.0 – 0.0)	1.0 (1.0 – 2.0)	0.5 (0.0 – 1.0)		
Sig.bet.groups	p_1=0.529, p_2=0.012*, p_3=0.529, p_4=0.002*, p_5=0.208, p_6=0.059					

H: H for Kruskal Wallis test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Dunn's for multiple comparisons test)

p: p value for comparing between the studied groups

p_1: p value for comparing between Horizontal and Hot-dog technique

p_2: p value for comparing between Horizontal and Split-horizontal technique

p_3: p value for comparing between Horizontal and Successive cusp building technique

p_4: p value for comparing between Hot-dog and Split-horizontal technique

p_5: p value for comparing between Hot-dog and Successive cusp building technique

p_6: p value for comparing between Split-horizontal and Successive cusp building technique

*: Statistically significant at $p \leq 0.05$

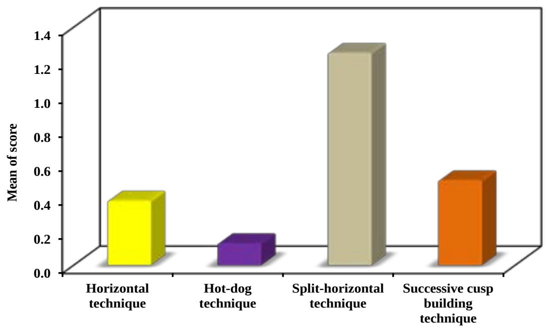

Figure 2: Comparison between the different studied groups according to score

RESULTS

In the present study, the teeth collected received composite restoration and were evaluated for microleakage. The sample of teeth receiving the composite using the horizontal application technique (n=10) showed microleakage scores from 0.0 to 2.0 with mean±SD of 0.38±0.74, while those receiving the composite using the Hot-Dog application technique (n=10) showed microleakage scores from 0.0 to 1.0 with a mean±SD of 0.13 ± 0.35. Nonetheless, teeth receiving the composite using the split-horizontal technique application technique (n=10) showed microleakage scores from 0.0 to 2.0 with a mean±SD of 1.25 ± 0.71. Finally, the sample of teeth receiving the composite using the successive cusp-building application technique (n=10) showed microleakage scores from 0.0 to 1.0 with a mean±SD of 0.50 ± 0.53. (Table 2)

Comparisons were made between each 2 groups of the 4 tested groups as well as between the 4 groups altogether. Results showed no statistically significant differences when comparing the occurrence of microleakage between; the horizontal placement technique (Gp1) and the Hot-Dog technique (Gp2) (P=0.529), the horizontal placement technique (Gp1) and the successive cusp building technique (Gp4) (P=0.529), the Hot-Dog technique (Gp2) and the successive cusp building technique (Gp4) (P=0.208), and finally between the split-horizontal technique (Gp3) and the successive cusp building technique (Gp4) (P=0.059). On the other hand, statistically significant differences were recorded when comparing the horizontal technique (Gp1) and the split-horizontal technique (Gp3) (P=0.012) as well as between the Hot-Dog technique (Gp2) and the split-horizontal technique (Gp3) (P=0.002), where both the Hot-Dog technique and the horizontal technique showed better results than the split-horizontal technique. (Figure 2)

In addition, the posthoc test showed a statistically significant difference when comparing the 4 groups with each other (P=0.011). These results showed that placement of composite by the Hot-Dog technique showed the lowest microleakage scores than other techniques. Also, the horizontal and successive cusp build-up technique showed lower microleakage scores than the split horizontal technique. (Figure 2)

Discussion

The present study was designed to evaluate the microleakage occurring after restoring a sample of primary molars using different composite application techniques and comparing them. Although it was thought that the application of composite in layers to the dental cavity decreases the C-factor and accordingly decreases polymerization shrinkage, many authors stated that there was no relation between the so-called layering techniques and microleakage. Yet, they also stated that some layering techniques give less microleakage scores than others. (5,14-17) In contrast, the null hypothesis was rejected in this study, as there were statistically significant differences between the horizontal layering technique and the split horizontal technique as well as between the Hot-Dog layering technique and the split horizontal layering technique.

Adhesives and cavity designs were also attributed to the microleakage and success of composite restorations. (18-23) Nonetheless, in this study, all teeth received class I cavity preparations with standardized dimensions. This supports the claims of many authors that standardized box-shaped cavities tend to decrease the volume of the light-cured resin and thus decrease the polymerization stresses. (24-26) In this context, the results of the present study proved that different composite layering techniques result in different marginal sealing abilities and consequently different microleakage scores.

Many layering techniques have been proposed in the literature in an attempt to decrease marginal leakage, (27,28) but as mentioned earlier, most studies claimed that there were no differences between the application techniques used in decreasing microleakage. (29-31) On the contrary, the results of the present study stated that there were statistically significant differences between the horizontal application technique and the split horizontal application technique. However, these results may be due to the modification done to the horizontal technique supported by Estafan and Estafan in 2000. (32) They claimed that using flowable composite as the first increment ensures the complete coverage of the cavity floor. They also stated that this increment acts as a cushion between the adhesive and composite material as well as decreasing the entrapment of voids between increments of composite.

Another statistically significant difference was recorded between the Hot-Dog technique and the split horizontal technique. No evidence is available on the use of the Hot-Dog technique which was explained in 2006 by Terry and Leinfelder. (7) However, they claimed that this technique helped in decreasing the operating carving time, increasing the carving efficiency as well as decreasing the polymerization shrinkage stresses. Another modification was made in this study based on the previously mentioned assumptions by Estafan and Estafan (32) in 2000 as well as the claims of Attar et al (33) in 2004, where flowable composite material was used as the final layer in the Hot-Dog Technique.

Despite the satisfying results, the small sample size may be recorded as a limitation of the study. Yet, further experimental and clinical trials are recommended to test the microleakage and the longevity of the composite restorations using the Hot-Dog technique.

Conclusion

Restoring primary teeth with composite restoration using the Hot-Dog application technique exhibits less marginal leakage with statistically significant differences when compared with the horizontal placement technique, the split horizontal placement technique, and the succussive cusp build-up technique.

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Conflict of interests

The authors declare that they have no conflict of interest.

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