Original Article

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Dissemination of the splatter generated during resin-based and glass ionomer sealant application procedures

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Objectives: The aim of this study was to compare the dissemination of the splatter generated during resin-based and glass ionomer sealant application procedures.
Materials and Methods: The experiment was conducted on a dental phantom head that was inserted into the head rest of a dental chair and set in a reclined position, mimicking the sealant application procedure routinely performed on a patient. To trace the dissemination of splatter droplets generated during the sealant application procedure, a 0.1% fluorescein dye solution was connected to the dental unit water supply and a 1 x 1 ft^2 cotton sheet, with a hole in the middle for the mouth, was placed on the phantom's head. Resin-based and glass ionomer sealant application procedures were performed on the right and left posterior teeth by four operators. After the sealant application procedure was completed and the fluorescent stain was completely dried, a transparent grid with 0.5x0.5 cm^2 squares was placed over the cotton sheet and the number of squares with splatter stain visible through the grid was counted under ultraviolet light by two examiners who were blinded to the treatments. The examiners performed intra- and inter-correlation tests for reliability.
Results: The splatter production varied among the operators. There was no significant difference between the number of contaminated squares generated from the glass ionomer sealant and resin-based sealant application procedures (p>0.05). Moreover, the number of contaminated squares was not significantly different between the two sealant materials' application on the same treatment side (p>0.05).
Conclusion: The application process of the resin-based and glass ionomer sealant generated the same level of splatter dissemination.

Keywords: dissemination, splatter, glass ionomer sealant, resin-based sealant, infection control

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Introduction

The coronavirus disease-2019 (COVID-19) pandemic, caused by SARS-CoV-2 [1], has raised concerns about the transmission of COVID-19 disease in the dental office [2, 3]. Routine dental treatments usually generate splatter and droplets that are contaminated with microorganisms, causing a potential risk of airborne respiratory disease transmission, such as pneumonia, measles, influenza, tuberculosis, SARS, and COVID-19 [3-7].

Dental sealant application is a dental procedure that generates aerosols and droplet splatter [3, 4]. A dental sealant is a thin coating that covers the occlusal pits and fissures of a posterior tooth. Sealants have been demonstrated to be effective in preventing caries and controlling dental caries progression [8-10]. There are two main materials that are used as a dental sealant;

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i.e., resin-based and glass ionomer sealants. The advantage of a resin-based sealant is the high retention of the material on the tooth surface. However, the application process of a resin-based sealant is technique-sensitive and requires good moisture control and dry field isolation [11]. In contrast, glass ionomer sealant is less moisture susceptible and easier to place, therefore, it requires a shorter time and the process of glass ionomer sealant application is simpler compared with resin-based sealant application. The disadvantage of a glass ionomer sealant is the lower retention compared with a resin-based sealant [11]. However, both materials have been demonstrated to be effective in preventing dental caries [10, 12, 13].

During the COVID-19 pandemic, sealant application has been considered a dental procedure that generates airborne particles and droplet splatter, increasing the risk of respiratory disease transmission [4, 14]. To reduce the spread of infectious microorganisms during sealant application, glass ionomer sealant was suggested as the material of choice, based on the fact that the application process of a glass ionomer sealant is shorter, simpler, and less susceptible to water compared with a resin-based sealant, which could lead to lower production of airborne droplets and splatter [15]. However there is no report comparing the production and distribution of splatter generated from these two sealant procedures. Therefore, the aim of this study was to compare the dissemination of splatter generated during resin-based and glass ionomer sealant application procedures.

Materials and Methods

The experiment was performed on a dental phantom head with an artificial dentition. The phantom head containing a typodont teeth model (KaVo Dental Technologies, Charlotte, North Carolina, USA) was inserted into the headrest of a dental chair. The dental chair was set in a reclined position, mimicking the sealant application procedure routinely performed on patients. To obtain a power of 0.8 and type I error of 0.05, a sample size of 5 trials for each sealant group was required.

Sealant application procedure

The sealant applications were performed on the right and left lower posterior teeth that consisted of the 1st premolars, 2nd premolars 1st molars, and 2nd molars. The experiment used two types of sealant materials; resin-based sealant (Concise™; 3M ESPE, MN, USA) and Fuji VII glass ionomer sealant (Fuji VII, GC Corporation, Tokyo, Japan). The application process for each sealant material was performed according to the manufacturer's instructions. Briefly, for the resin-based sealant, the teeth were cleaned using a rubber cup with pumice paste, rinsed for 15 sec, and dried with air from a three-way air-water syringe for 15 sec. A 37% phosphoric etchant (Scotchbond™, 3M ESPE) was applied for 30 sec followed by water rinsing for 30 sec. The teeth were air blown for 15 sec and the tooth surfaces were completely dried. The resin-based sealant was then applied on the surfaces and light-cured for 20 sec. For the glass ionomer sealant, the teeth were cleaned using a rubber cup with pumice paste, rinsed with water for 15 sec, gently air blown for 15 sec using a three-way air-water syringe. A 10% polyacrylic acid solution (Dentin conditioner, GC Corporation) was applied to the tooth surface for 20 sec, rinsed with water for 15 sec, and gently air blown for 10 sec. The glass ionomer sealant was applied on the surfaces and allowed to self-cure.

Two types of oral evacuation systems; a saliva ejector and high volume evacuation (HVE), were simultaneously used as for moisture control.

The sealant application procedures were performed by four pediatric dentists with >2 years of experience in the field of pediatric dentistry, with the help of a dental assistant and the same dental assistant helped every operator during the sealant application procedures throughout the entire experiment.

Each operator was required to apply the glass ionomer and resin-based sealants on the left and right posterior teeth as presented in Figure 1. Moreover, the dental unit used for the sealant application procedures was the same for each operator.

Detection of splatter contamination

A 0.1% fluorescein solution (Sigma-Aldrich, St. Louis, Missouri, USA) was used for the dental unit water supply. To detect the splatter dissemination of the fluorescein dye, a cotton sheet (1 x 1 ft^2 and 0.2 mm thick), with a hole in the middle for the mouth, was placed on the phantom's head (Figure 2 A and B). After the sealant application procedure was completed, the dye splattered on the cotton sheet was visualized under ultraviolet light and the fluorescent stain on the cotton sheet was counted using a transparent grid with 0.5x0.5 cm^2 squares. The grid was placed over the cotton sheet and the fluorescein stain detection was done under ultraviolet light in the dark, as illustrated in Figure 3. The spots seen through the grid were counted and if one or more spots of fluorescence were detected within the square, it was considered as a contaminated square. The contaminated squares were counted by two examiners who were blinded to the treatments. The reliability of the examiners was evaluated by selecting 25% (n=20) of the samples for intra- and inter-correlation tests for reliability.

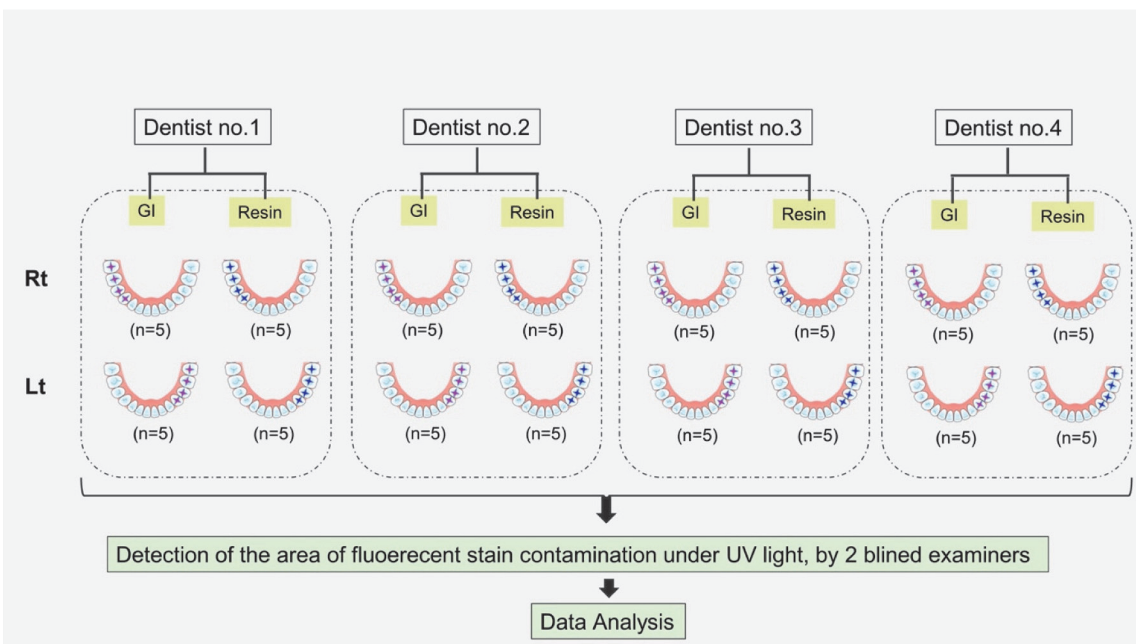

Figure 1 Experimental flow chart. The application of dental sealant on lower posterior teeth were performed by four dentists. Each dentist applied the resin-based (resin) and glass ionomer (GI) on the right (Rt) and left (Lt) side of the lower posterior teeth. The fluorescent stain of the splatter contamination was detected and counted under ultraviolet light (UV) by two blinded examiners.

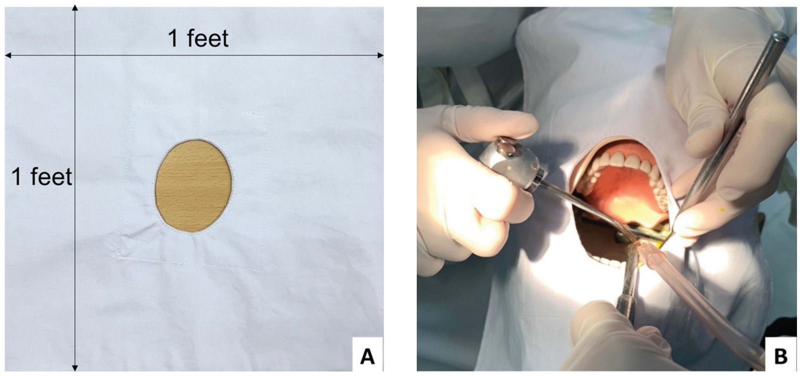

Figure 2 Cotton sheet for detection of splatter dissemination. A, The 1 x 1 ft^2 sheet had a hole in the middle for the mouth opening. B, Placement of the sheet on the phantom's head during the sealant application procedure.

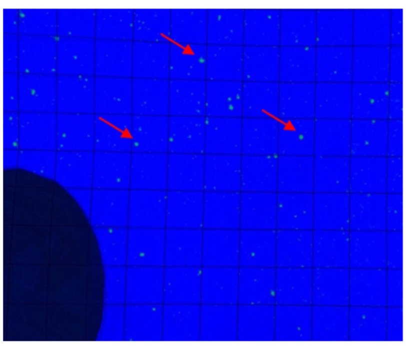

Figure 3 Fluorescent splatter detection. Fluorescein stains with overlay grid were identified and counted under ultraviolet light. Red arrows indicate fluorescent spots.

Statistical analysis

Statistical analysis was performed using SPSS 18 (IBM, Armonk, New York, USA). The splatter dissemination generated from both sealant procedures was compared within the same operator. The normality of the data was investigated. For non-parametric analysis, the difference between the two sealant groups was analyzed using the Mann-Whitney U test. A *p*-value < 0.05 was considered statistically significant. Moreover, the intraclass correlation coefficient was performed to measure the inter-rater and intra-rater reliability of the examiners.

Results

The fluorescent stains detected on the grid were counted and analyzed by two blinded examiners. The inter-rater and intra-rater reliability were 0.99 and 0.99, respectively, indicating excellent reliability of the examiners [16]. The dissemination of splatter patterns generated from resin-based and glass ionomer sealant application procedures is presented in Figure 4.

The number of contaminated squares was compared between the glass ionomer sealant and resin-based sealant applications by the same operator. There was no significant difference in the number of contaminated squares between the two sealant application procedures (Table 1).

When comparing the number of contaminated squares on the same treatment side, there were no significant differences between the two sealant application procedures that were performed by the operators, except for operator number 3, where on the lower right posterior teeth, the number of contaminated squares generated from the glass ionomer application procedure was significantly lower than that of the resin-based sealant ($p<0.001$) (Table 2).

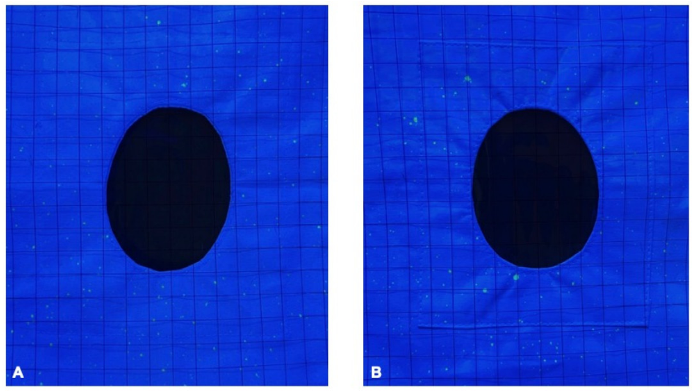

Figure 4 Dissemination of fluorescent splatter generated during the resin-based and glass ionomer sealant application procedures. A resin-based sealant, B glass ionomer sealant.

Table 1 Number of contaminated squares generated from the resin-based and glass ionomer sealant application procedures

Operators	Numbers of contaminated grid Median (min/max)		*P*-value
	Resin	Glass ionomer	
Number 1 (n=20)	31.50 (12.00/91.00)	19.00 (11.00/32.00)	0.172
Number 2 (n=20)	7.50 (2.00/29.00)	3.50 (0.00/21.00)	0.069
Number 3 (n=20)	11.00 (0.00/29.00)	3.5 (0.00/11.00)	0.288
Number 4 (n=20)	21.00 (12.00/40.00)	17.00 (7.00/34.00)	0.226

Table 2 Number of contaminated squares generated from the glass ionomer and resin-based sealant applications according to the treatment sides

Operators	Treatment sides	Numbers of contaminated grid mean (SD) / median (min/max)		*P*-value
		Resin	Glass ionomer	
Number 1	Lower right (n=10)	40.00 (12.00/91.00)	21.00 (17.00/32.00)	0.117
	Lower left (n=10)	17.00 (12.00/36.00)	17.00 (11.00/20.00)	0.399
Number 2	Lower right (n=10)	17.00 (2.00/29.00)	5.00 (3.00/21.00)	0.402
	Lower left (n=10)	7.00 (5.00/10.00)	1.00 (0.00/15.00)	0.112
Number 3	Lower right (n=10)	24.00 (17.00/29.00)	6.00 (2.00/11.00)	0.009*
	Lower left (n=10)	1.00 (0.00/5.00)	2.00 (0.00/7.00)	0.831
Number 4	Lower right (n=10)	29.00 (17.00/40.00)	21.00 (7.00/34.00)	0.249
	Lower left (n=10)	20.00 (12.00/27.00)	16.00 (12.00/19.00)	0.344

*Indicates a significant difference ($p < 0.05$).

Discussion

Dental sealants are an effective treatment for arresting and preventing dental caries [9]. Sealants are widely used in fieldwork, community settings, and in dental offices. Applying a sealant is recommended as the standard dental treatment for preventing occlusal caries in the primary and permanent molars of children and adolescents [9].

Two main dental sealant treatments, resin-based sealant application and glass ionomer sealant application, were used in this study. Resin-based sealant is superior to glass ionomer sealant in material retention on the tooth surface and acts as a barrier for food and plaque deposition [9, 11]. However, the technique of applying a resin-based sealant is more complicated compared with applying a glass ionomer. Because a resin-based sealant has high water sensitivity, good moisture control is needed [10, 11]. This sealant type also requires the teeth to be completely dry, which requires using a stronger force for air blowing and takes a longer time compared with the glass ionomer sealant application process. In contrast, the advantage of glass ionomer sealant is its fluoride-releasing behavior and that it arrests initial caries [9, 11]. Glass ionomer is less water susceptible and unlike a resin-based sealant, it doesn't require the tooth surface to be completely dry [10, 11], which requires less spraying of air and water compared with resin-based sealant application. However, both materials are considered effective for preventing caries [10, 12].

Sealant application is regarded as a procedure that generates airborne particles and droplets that could cause the transmission of contagious diseases [3, 4]. For preventing the spreading of airborne particles and droplet splatter during the process of sealant application, glass ionomer was suggested as the material of choice because it has low water susceptibility and requires short working time, resulting in using less time and amount of water rinsing and air blowing compared with resin-based sealant application [15]. However, the evidence supporting this assumption has never been reported. This study is the first to compare the dissemination of splatter generated from resin-based and glass ionomer sealant application procedures.

To detect the pattern of splatter dissemination, fluorescein dye solution was used as a fluorescent tracer in this study. Fluorescein is a well-recognized substance that is considered safe and has been widely used as a diagnostic tool in the field of Ophthalmology and Angiopathy [17].

The study selected lower posterior teeth as the sealant application model because dental procedures performed on lower posterior teeth generate a significant amount of splatter distribution [18] and also because lower posterior teeth are easier to perform dental treatment on compared with the upper posterior teeth.

For moisture control, a saliva ejector and HVE were simultaneously used in our study because HVE significantly reduces the dissemination of aerosols and airborne particles generated from dental procedures [19, 20]. Furthermore, using HVE was recommended as an effective method to reduce the distribution of splatter generated by sealant application procedures [21].

Four pediatric dentistry specialists performed the process of sealant application and the results demonstrated that the number of the contaminated squares varied among operators. In addition, no difference in the number of the contaminated squares was observed between materials according to the left and right sides performed by the same operator. However, the number of contaminated squares was significantly lower for the glass ionomer sealant compared with the resin-based sealant placed on the lower right posterior teeth that were performed by operator number 3. These results suggest that the personal skill and preference of the operator can affect the amount of splatter dissemination. Moreover, this may be because the right side of the mouth was more convenient and easier to perform the sealant application on compared with the left side, therefore a significant difference was observed on the lower right side for operator number 3.

Clinically, the time and magnitude of rinsing and air blowing are different based on the skill and preferences of operators. Therefore, our study set the time period of water rinsing and air blowing to control this factor. Although the time factor was controlled in the study, the magnitude of rinsing and air drying could not be controlled.

The results of this study revealed that there was no significant difference in the number of contaminated squares between glass ionomer and resin-based sealant application. Although the results of the two sides of the mouth were analyzed, there were no significant differences among most of the results. This may be due to the effectiveness of HVE in reducing the splatter distribution and also from the similarity between the two sealant application procedures.

In contrast to the previous investigation that found no spatter of water outside the oral cavity when HVE was used during the process of sealant application [21], the distribution of splatter outside the phantom's mouth was detectable in our study. This may be because the treated teeth in our study consisted of four lower posterior teeth, whereas the previous study used only one lower posterior tooth, therefore the magnitude of water spraying, and air blowing could be higher in our investigation leading to a detectable splatter distribution outside the oral cavity. The use of 4 posterior teeth in our study may also better reflect how a sealant would be applied on a patient's teeth and the overall amount of splatter dissemination that would occur clinically.

In this study, although the dental chair was set in a reclined position mimicking the dental sealant application procedure, the head rest position was not fixed to be in the same position for each operator. The head rest position was set according to the preference of the operators. This may be a reason why the number of contaminated squares varied among the operators. Another factor that could affect the variation of the number of contaminated squares among the operators was that each operator has his/her own preference on the magnitude of rinsing and air blowing during the sealant application procedure. However, this study only compared the number of contaminated squares between two sealant materials within the same operator.

The number of contaminated squares generated from the sealant application procedures was low compared with the number of contaminated squares generated during tooth preparation and scaling procedures [5, 6]. More importantly, the splatter generated from sealant application was low when considered on its own. Additional dry field isolation techniques, dental rubber dam or dental isolation, and suction systems, such as Isolite systems and Easyprep, may provide a further reduction in saliva contamination and splatter dissemination.

A limitation in our laboratory investigation was the absence of saliva that can also be disseminated when performing dental procedures. Although saliva is one of the main sources of SARS-CoV-2 transmission [1, 2], the transmission of the COVID19 disease via the direct spread of saliva splatter was not evaluated in the present study. However, Tianviwat and Thitasomakul reported that HVE was effective in eliminating the splatter of saliva outside the oral cavity when the salivary flow was simulated [21]. Another limitation is that the number of contaminated squares varied among the operators, which was likely due to differences in the operators' individual preferences. Therefore the splatter dissemination from resin-based and glass ionomer sealant applications could only be compared and analyzed within the same operator.

The level of splatter dissemination was not different between the two sealant application processes. Moreover, the splatter dissemination generated from the sealant application was considered low compared with other dental procedures [5, 6]. Therefore, the material properties and field of operation should be the main factors to consider when choosing materials rather than the level of splatter dissemination.

Conclusion

The results from our preliminary study indicate that the glass ionomer sealant application and resin-based sealant application procedures produced the same level of splatter dissemination.

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