ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Research Article

The Effect of Silver Diamine Fluoride in Preventing Secondary Caries in Primary Teeth: *In-vitro* Study

Osama M Felemban[1]*, Weaam A Dabroom[2], Mona T Alsharif[2], Bashaer Alghamdi[2], Faris S Bantan[3], Ghada Farie[2], Luluah K Alhagas[2] and Sumaya M Nouri[4]

[1]*Assistant Professor of Pediatric Dentistry, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia*

[2]*General Dentist, Jeddah, Saudi Arabia*

[3]*General Dentist, King Abdulaziz Hospital, Ministry of Health, Makkah, Saudi Arabia*

[4]*PhD Candidate in Pediatric Dentistry, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia*

***Corresponding Author**: Osama M Felemban, Assistant Professor of Pediatric Dentistry, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia.

Received: July 31, 2018; **Published:** August 27, 2018

Abstract

Aim: The aim of our study is to evaluate the effect of silver diamine fluoride (SDF) in preventing secondary caries around composite restorations in primary teeth in comparison to fluoride varnish or no treatment.

Methods: A total of thirty cavities were prepared on primary human teeth on a carious free smooth tooth surface and randomly divided into three groups. The cavities in each group were pretreated with either: 1) 38% SDF solution, 2) 5% Fluoride varnish, or 3) water. In all groups teeth were filled with composite, immersed in an acidic medium for five days to mimic the caries process, and sectioned into 1 mm thick slices. Then, the samples were examined under a polarized microscope and analyzed using image analysis software (ImageJ) to measure outer lesion depth, inner lesion width, and inner lesion length.

Results: The SDF group showed consistently smaller measurements of secondary caries depth, width, and length, followed by fluoride varnish. Secondary caries formed in the control group was the largest in all dimensions.

Conclusions: Pretreatment of cavities in primary molars with SDF can prevent the formation of secondary caries.

Keywords: *Silver Diamine Fluoride (SDF); Secondary Caries; Primary Teeth*

Introduction

Silver Diamine Fluoride (SDF) is an alkaline material composed of silver and fluoride ions, with a pH of 8 - 9 [1]. It is manufactured in different concentrations such as 38%, 30% and 12%. Although it has been used for many years outside of the United States of America, the FDA approved it as a desensitizing agent on root caries in 2014. Nevertheless, SDF is used off-label to arrest caries [2]. The mechanism of action of SDF in caries arrestment is still not fully understood. However, it is hypothesized that the fluoride ions act directly on the tooth surface while the silver particles act as antimicrobials [3]. SDF is used in pediatric dentistry as a caries control agent due to its ease of application, especially with young and uncooperative patients. However, the major drawback of this material is that it causes a dark discoloration of carious tooth structure [1].

Previous clinical research showed that SDF is effective in arresting caries and in preventing the formation of future carious lesions in primary and permanent dentitions. In a sample of 452 schoolchildren with mixed dentition of both sexes, a controlled clinical trial was conducted to evaluate the efficacy of biannual applications of 38% SDF solution for preventing and arresting caries. The results after 36 months follow-up showed that SDF prevented caries by 79.7% in deciduous teeth and by 65% in first permanent molars [4]. Liu., *et al.* in 2012 showed that annual application of silver diamine fluoride on sound occlusal surfaces of permanent first molars was effective in preventing pit and fissure caries after 24 months [5]. Llodra., *et al*. in 2007 showed that biannual application of 38% SDF on first permanent molars decreased the development of new carious lesion in the SDF group (mean = 0.37) compared to the no treatment group (mean = 1.06). A systematic literature review of 7 studies indicated that the use of SDF in concentrations of 30% and 38%, is more effective than other preventive management strategies in preventing and arresting dentinal caries in the primary and permanent dentition [6].

Secondary caries, or recurrent caries, is defined as a primary carious lesion detected at the margins of existing restorations [7]. It is believed that the etiological factors of secondary caries are the same causative factors for primary caries such as acidic environment, cariogenic bacteria, and quality and quantity of saliva [7]. Secondary caries is the main reasons to replace restorations [8,9]. In the year 2000, Mjor., *et al.* reported that 50 - 60% of all restorations were being replaced due to secondary caries [10]. The detection of secondary caries could be difficult since the diagnostic accuracies of the available techniques are relatively low [11]. The clinical management of restorations affected by secondary caries is either by replacement or repair of the restoration. Mjor., *et al*. recommended replacing composite restorations with secondary caries [12]. However, others suggest that repair is indicated rather than replacement as repair is more conservative and can be performed without using local anesthesia [12-16]. Repair may be preferred over replacement because repeated replacement of restorations may reduce tooth strength [13,16,17]. Whether the decision was to replace or repair the restoration, the management of secondary caries will be a financial burden to the patient and time consuming to the dentist [18].

According to previous research, it has been confirmed that SDF is effective in preventing primary caries. It has also been proven that the process of secondary caries is very similar to that of primary caries. Therefore, the aim of our study is to evaluate the effect of SDF application on cavity surfaces as a conditioning material prior to restoring the cavity with composite to prevent the formation of secondary caries in primary teeth in comparison to fluoride varnish or no treatment.

Materials and Methods

This *in-vitro* study received approval form the Research Ethics Committee of the Faculty of Dentistry, King Abdulaziz University (REC-FD No. 049-03-18). Thirty extracted human primary teeth with at least one intact surface were collected. The teeth were cleaned thoroughly with an ultrasonic scaler and pumice to remove calculus and any remaining tissue tags. Teeth were stored in separate ampules containing normal saline water. A box-shaped cavity (2 x 2 x 1.5 mm) was prepared on a carious free smooth tooth surface, using a high-speed handpiece, and a 330-carbide bur under copious water-cooling. Once the preparations in each group were completed, a new bur was used. All the prepared cavities were rinsed with water and dried with air before the restoration of the cavities. All teeth were randomly divided into three groups; each group was composed of 12 teeth. Group 1: The cavities were treated with a layer of 38% SDF solution (Advantage Arrest™, elevate ORAL CARE), topically applied using a micro-brush, and left to set for 3 minutes. Afterward, the cavities were rinsed with water and air dried. Group 2: The cavities were treated with a layer of 5% Fluoride varnish (Clinpro™ White varnish, 3M) using a micro-brush and left to set for 5 minutes. Then, the cavities were rinsed with water and air dried. Group 3: The cavities were rinsed with non-fluoridated tap water and air-dried to be the control group. In all groups teeth were etched using 37% phosphoric acid (N-Etch, IVOCLAR-VIVADENT) for 30 seconds, washed vigorously with water spray for 5 seconds then excess moisture was air dried. A Nano-filled single-component adhesive (Tetric® N-Bond, IVOCLAR-VIVADENT) was applied and gently spread with air to ensure complete coverage of the cavity and light cured for 20 seconds. Cavities were filled with composite (Filtek™ Z350 XT, 3M ESPE) and light cured for 30 seconds. All restored surfaces were polished using polishing discs (Sof-Lex™, 3M) to ensure there was no excess material around the margins. The roots were sectioned off the teeth to ease the handling. The teeth in each group were then coated with a layer of different colored acid-resistant nail varnish leaving approximately a 1 mm unvarnished margin all around the restoration. To mimic the caries process, the teeth were put in glass bottles containing an acidic medium composed of Calcium Chloride, Sodium Monophosphate, Acetic Acid, and Sodium Bicarbonate at a pH of 4.5 for five days. The teeth were retrieved from the acidic solution and washed with deionized water. The teeth were firmly attached to acrylic blocks using heated wax. One mm thick longitudinal serial sections of the crowns through the restorations were made using an automated low speed saw under water cooling (TechCut 4™, ALLIED HIGH TECH PRODUCTS. INC). The sections were polished using a polishing machine (MetaServ™ 250, BUEHLER). Then, the sections were placed on a glass slab for examination under a polarized microscope (ECLIPSE Ni, Nikon) set at a magnification of 40x. Images of the sections were captured via a camera mounted on the microscope (Nikon DS-Fi2). The images were imported to ImageJ software. Three linear measurements of the carious lesions were taken from each image: 1- The outer lesion depth. 2- The inner lesion width. 3- The inner lesion length (Figure 1). Each measurement was repeated ten times, and the mean was recorded. One-way ANOVA test was used to compare the measurements between the three groups using SPSS version 20.0 software.

Results

Table 1 shows the mean and standard of deviation of the outer lesion depth, inner lesion width, and inner lesion length of the three groups. The SDF group showed consistently smaller measurements of secondary caries length, width, and depth followed by the fluoride varnish group. Secondary caries formed in the control group was the largest in all dimensions. The differences between the groups were not statistically significant.

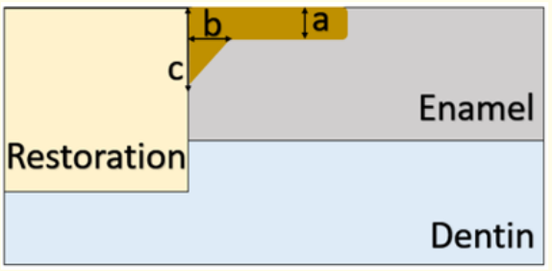

Figure 1: An illustrarti0on of the measurements of the carious lesions taken from the images of sections under the polarized microscope. a: Outer lesion depth. b: Inner lesion width. c: Inner lesion length.

Mean ± SD	Silver Diamine Fluoride	Fluoride Varnish	Control	p-Value
Outer Lesion Depth	121.56 ± 96.965	163.88 ± 109.484	183.75 ± 104.329	0.199
Inner Lesion Width	87.13 ± 43.940	139.43 ± 40.352	144.46 ± 91.677	0.184
Inner Lesion Length	211.88 ± 76.643	267.71 ± 112.316	333.69 ± 177.349	0.133

Table 1: Comparison of the mean measurements of the carious lesions using One-Way ANOVA test.

Discussion

Several studies focused on preventing or halting the progression of secondary caries. Many materials and techniques have been used to prevent secondary caries, such as 5% NaF varnish, 10% NaF solution, 42% and 25% silver nitrate, carbon dioxide laser, and SDF with its different percentages 38%, 30%, and 12% [19-21]. Given that SDF has been proven to be effective in preventing primary caries, and that the formation process of secondary caries is like that of primary caries, SDF might be effective in preventing secondary caries. The results of our study showed that the application of SDF on caries-free cavity surfaces prior to restoring the cavity with composite decreased the formation of secondary caries around composite restorations. Fluoride varnish was less effective in preventing secondary caries formation compared to SDF, but none of the differences in carious lesions measurements were statistically significant.

Few studies had previously attempted to use SDF and topical fluorides to prevent the formation of secondary caries in permanent teeth. In 2016, Mei., *et al.* found that SDF application on prepared cavities prior to restoration with composite or GIC slows down the formation of secondary caries on enamel surfaces adjacent to the restoration. Zhao., *et al*. in 2017 found that incorporating CPP-ACP into GIC along with SDF had a synergetic effect on preventing secondary dentin root caries [22]. Another study concluded that the use of SDF with KI on permanent teeth inhibits the development of secondary caries under GIC restoration [21]. As noticed, most of the previous studies tested the effects of SDF application in preventing secondary caries under GIC restorations in permanent teeth. Glass ionomer cements have several disadvantages such as, insufficient strength, toughness, and poor wear resistance which makes them undesirable for restorations in occlusal contact [23]. Some researchers found that fluoride released from GI was limited in preventing secondary caries development [24,25]. Others reported that if fluoride was released in high concentrations such as in GIC, it would effectively inhibit the development of secondary caries [26]. For that reason, resin composite restorations were used in this study instead of GIC, to avoid any misleading results which might occur from caries inhibition by fluoride released from GIC restorations. In our study, we used a polarized light microscope which is an optical instrument used to monitor the molecular order in living cells and tissues under a microscope, without using any exogenous dyes or fluorescence labels [27]. Many previous studies have used the polarized light microscope to evaluate the formation of artificial caries in *in-vitro* studies [28,29]. To the best of our knowledge, this is the first study to explore the effects of SDF in preventing secondary caries in primary teeth.

One of the main disadvantages of SDF is that it causes black stains on carious hard tissue, which might not be aesthetically acceptable to many patients [21]. In our study, it was found that the use of SDF did not just discolor carious hard tissue, but it also stained non-carious tooth structure after light curing the resin bonding agent. This finding was also reported in a study done by Uzel., *et al*. in 2013 [30]. The

oxidation of ionized silver into metallic silver causes SDF to stain tooth structure after light curing [30-32]. To overcome this, it has been suggested to use a combination of potassium iodide and SDF material which produces white products to counteract the dark stains [33]. Nano Silver Fluoride (NSF) was also found to be as effective as SDF but did not stain dental tissue. It also did not have any metallic taste [34].

Secondary caries is composed of two parts: An outer surface lesion, and an inner wall lesion between the restoration and the tooth structure [35]. It has been reported that microleakage into gaps around restorations causes secondary caries [36]. An increase in the gap between the restoration and tooth structure increases susceptibility to secondary caries [37]. Nevertheless, researchers reported that no secondary caries was diagnosed with gaps less than 50 μm [38]. To explore the effects of pretreating cavities with SDF on the bond strength of composite to the tooth structure, researchers showed that SDF does not affect the micro tensile bonding strength of composite resin to dentin in primary and permanent teeth [31,32]. Moreover, it was found that SDF pretreatment does not affect the microleakage around composite restorations [30].

Limitation of the Study

A limitation of this study was the subjectivity of the measurements of both outer and inner lesions. To overcome this limitation, ten measurements of each dimension were taken, and the mean was recorded. Some difficulties were also faced during this study; the most important one was the difficulty in distinguishing between the SDF discoloration which resulted after light curing and secondary caries under the polarized light microscope. This might be avoided in future studies by using self-cured composites instead of light-cured resin restorations.

Conclusion

Pretreatment of caries-free cavities in primary molars with SDF can prevent the formation of secondary caries.

Bibliography

1. Chu C and Lo E. "Promoting caries arrest in children with silver diamine fluoride: a review". *Oral Health and Preventive Dentistry* 6.4 (2008): 315-321.

2. Burgess JO and Vaghela PM. "Silver Diamine Fluoride: A Successful Anticarious Solution with Limits". *Advances in Dental Research* 29.1 (2018): 131-134.

3. Rosenblatt A., *et al*. "Silver diamine fluoride: a caries "silver-fluoride bullet"". *Journal of Dental Research* 88.2 (2009): 116-125.

4. Llodra JC., *et al*. "Efficacy of silver diamine fluoride for caries reduction in primary teeth and first permanent molars of schoolchildren: 36-month clinical trial". *Journal of Dental Research* 84.8 (2005): 721-724.

5. Liu B., *et al*. "Randomized trial on fluorides and sealants for fissure caries prevention". *Journal of Dental Research* 91.8 (2012): 753-758.

6. Contreras V., *et al*. "Effectiveness of silver diamine fluoride in caries prevention and arrest: a systematic literature review". *General Dentistry* 65.3 (2017): 22-29.

7. Kidd EA. "Diagnosis of secondary caries". *Journal of Dental Education* 65.10 (2001): 997-1000.

8. Burke F., *et al*. "Reasons for the placement and replacement of restorations in vocational training practices". *Primary Dental Care: Journal of the Faculty of General Dental Practitioners (UK)* 6.1 (1999): 17-20.

9. Mjor IA. "The reasons for replacement and the age of failed restorations in general dental practice". *Acta Odontologica Scandinavica* 55.1 (1997): 58-63.

10. Mjor IA and Toffenetti F. "Secondary caries: a literature review with case reports". *Quintessence International* 31.3 (2000): 165-179.

11. Brouwer F., *et al*. "Detecting Secondary Caries Lesions: A Systematic Review and Meta-analysis". *Journal of Dental Research* 95.2 (2016): 143-151.

12. Mjor IA. "Repair versus replacement of failed restorations". *International Dental Journal* 43.5 (1993): 466-472.

13. Gordan VV. "Clinical evaluation of replacement of class V resin based composite restorations". *Journal of Dentistry* 29.7 (2001): 485-488.

14. Gordan VV., *et al*. "A long-term evaluation of alternative treatments to replacement of resin-based composite restorations: results of a seven-year study". *Journal of the American Dental Association* 140.12 (2009): 1476-1484.

15. Gordan VV., *et al*. "Teaching students the repair of resin-based composite restorations: a survey of North American dental schools". *Journal of the American Dental Association* 134.3 (2003): 317-323.

16. Gordan VV., *et al*. "Replacement of resin-based composite: evaluation of cavity design, cavity depth, and shade matching". *Quintessence International* 33.4 (2002): 273-278.

17. Gordan VV. "In vitro evaluation of margins of replaced resin-based composite restorations". *Journal of Esthetic Dentistry* 12.4 (2000): 209-215.

18. Moncada G., *et al*. "Increasing the longevity of restorations by minimal intervention: a two-year clinical trial". *Operative Dentistry* 33.3 (2008): 258-264.

19. Klein AL., *et al*. "Caries inhibition around composite restorations by pulsed carbon dioxide laser application". *European Journal of Oral Sciences* 113.3 (2005): 239-244.

20. Mei ML., *et al*. "Inhibitory effect of silver diamine fluoride on dentine demineralisation and collagen degradation". *Journal of Dentistry* 41.9 (2013): 809-817.

21. Zhao IS., *et al*. "Effect of Silver Diamine Fluoride and Potassium Iodide Treatment on Secondary Caries Prevention and Tooth Discolouration in Cervical Glass Ionomer Cement Restoration". *International Journal of Molecular Sciences* 18.2 (2017): E340.

22. Zhao IS., *et al*. "Prevention of secondary caries using silver diamine fluoride treatment and casein phosphopeptide-amorphous calcium phosphate modified glass-ionomer cement". *Journal of Dentistry* 57 (2017): 38-44.

23. Khoroushi M and Keshani F. "A review of glass-ionomers: From conventional glass-ionomer to bioactive glass-ionomer". *Dental Research Journal* 10.4 (2013): 411-420.

24. Mei ML., *et al*. "Prevention of secondary caries by silver diamine fluoride". *International Dental Journal* 66.2 (2016): 71-77.

25. Wilson NH., *et al*. "Reasons for placement and replacement of restorations of direct restorative materials by a selected group of practitioners in the United Kingdom". *Quintessence International* 28.4 (1997): 245-248.

26. Dionysopoulos D. "The effect of fluoride-releasing restorative materials on inhibition of secondary caries formation". *Fluoride* 47.3 (2014): 258-265.

27. Oldenbourg R. "Polarized light microscopy: principles and practice". *Cold Spring Harbor Protocols* 2013.11 (2013).

28. Pereira P., *et al*. "In vitro secondary caries inhibition around fluoride releasing materials". *Journal of Dentistry* 26.5-6 (1998): 505-510.

29. Souto M and Donly K. "Caries inhibition of glass ionomers". *American Journal of Dentistry* 7.2 (1994): 122-124.

30. Uzel I., *et al*. "The Effect of Silver Diamine Fluoride on Microleakage of Resin Composite". *Journal of International Dental and Medical Research* 6.3 (2013): 105-108.

31. Quock RL., *et al*. "Effect of silver diamine fluoride on microtensile bond strength to dentin". *Operative Dentistry* 37.6 (2012): 610-616.

32. Wu DI., *et al*. "Effect of Silver Diamine Fluoride (SDF) Application on Microtensile Bonding Strength of Dentin in Primary Teeth". *Pediatric Dentistry* 38.2 (2016): 148-153.

33. Knight GM., *et al*. "An in vitro model to measure the effect of a silver fluoride and potassium iodide treatment on the permeability of demineralized dentine to Streptococcus mutans". *Australian Dental Journal* 50.4 (2005): 242-245.

34. Burns J and Hollands K. "Nano Silver Fluoride for preventing caries". *Evidence-Based Dentistry* 16.1 (2015): 8-9.

35. Hals E., *et al*. "Histopathology of natural caries around silver amalgam fillings". *Caries Research* 8.4 (1974): 343-358.

36. Jokstad A. "Secondary caries and microleakage". *Dental Materials* 32.1 (2016): 11-25.

37. Kuper NK., *et al*. "Gap size and wall lesion development next to composite". *Journal of Dental Research* 93.7 (2014): 108S-113S.

38. Jorgensen KD and Wakumoto S. "Occlusal amalgam fillings: marginal defects and secondary caries". *Odontologisk Tidskrift* 76.1 (1968): 43-54.

Volume 17 Issue 9 September 2018