



Effectiveness of Silver Diamine Fluoride with Light Cure in Arresting Dentin Caries: Randomized Clinical Trial

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Abstract

Silver Diamine Fluoride (SDF) is an alternative treatment for arresting caries in uncooperative patients, but the AAPD's recommended treatment time of 1 to 3 minutes is too long. Light was chosen to enhance the efficiency of SDF. In this study, the light-emitting diode (LED) curing light is used to improve SDF's efficacy and reduce the treatment time. This study aims to compare the caries arrest rates in primary teeth between two treatments which applied 38% SDF for 10 seconds along with a light cure for 20 seconds (SDF10LC) and 38% SDF for 60 seconds (SDF60). Forty healthy children with 128 caries surface pairs between the ages of 2 and 5 participated in this study. The children had at least one pair of active cavitated enamel or dentin caries (Nyvad score 3). Two different treatments were administered to each child with a contralateral tooth in the same arch. The treatment was successful if active caries changed to arrested caries (Nyvad score 6). The study found that the caries arrest rate of SDF10LC was 85.6% (107/125) and the caries arrest rate of SDF60 was 89.6% (112/125) at 3-month follow-up. There was no statistically significant difference in the result between the two treatments ($p = 0.337$). In conclusion, using SDF alone provides the same results in arresting caries as when the light cure and SDF treatment were combined. In addition, using light curing together with SDF takes less time compared to using SDF alone. Hence, shorter treatment durations are possible with a light curing SDF in uncooperative children.

Keywords: *Silver Diamine Fluoride, Light Cure, Arrested Caries*

1. Introduction

One of the most prevalent chronic diseases in children is dental caries. According to the Department of Health's Bureau of Dental Health's 8th National Oral Health Survey statistics from 2017, 52.9% of 3-year-old children had decay, missing teeth, or fillings. 52% of teeth with decay had not received treatment. 75.6% of children aged 5 had teeth that were decayed, missing, or filled. For the teeth with decay, 73.8% had not had treatment (Department of Health's Bureau, 2018). It is seen as being high rate and poses a significant issue for the public health system. The causes of problems in treatment for children of those ages are lack of appropriate personnel, tools, and uncooperative children. In addition, the accessibility and the cost of treatment are factors that lead to many untreated dental caries. If the therapy is not done, the disease will worsen and progress more negatively. It will also result in pain that interferes the quality of life, children's growth, and the expense and complexity of therapy. Therefore, dental caries should be treated as soon as possible. The alternative conventional treatment ought to be considered for children in those ages. The right course of treatment should be brief, simple, and painless. That treatment is arresting dental caries by using Silver Diamine Fluoride (SDF) (AAPD, 2021a).

SDF is suggested by the American Academy of Pediatric Dentistry (AAPD) as an alternative treatment for arresting caries in uncooperative patients or who have a systemic disease that cannot have normal restoration and patients with restricted access to dental care. SDF's capacity includes reduction of the growth of bacteria, promotion of remineralization, inhibition of demineralization and protection of the

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collagen matrix in dentine degradation. SDF is also simple to use and acquire 1 to 3 minutes for application time (AAPD, 2021b). However, this application time may not be appropriate for a patient that does not cooperate in treatment. According to Crystal and Niederman's review of randomized control trials using SDF for consideration of treatment, anterior teeth have a higher arresting caries rate than posterior teeth due to their ease of cleaning and the possibility of more active silver precipitation from carious lesions exposed to natural light that enhances remineralization (Crystal & Niederman, 2016). By this, there are some studies that were conducted to shorten the treatment time by using light to increase the efficiency of SDF. According to the literature review in *in vitro* studies, light can improve the efficacy of SDF by enhancing the mineral density, the surface hardness, and the silver precipitation on carious lesions. Additionally, it lessens the depth of the carious lesion, indicating that it promotes remineralization. Moreover, in cases of deep dental caries, light might lessen the amount of SDF that reaches deeper layers, preventing SDF irritation of the pulp. Furthermore, caries might turn dark faster when exposed to light (Hassan, Bakhurji, & Sheihk, 2021; Karnowakul et al., 2023; McDonald, 2018; Phuensuriya, Techatharatip, Trairatvorakul, & Thanyasrisang, 2022; Toopchi, Bakhurji, Loo, & Hassan, 2021). The study has also presented results that is contrary to the studies mentioned above y. The depth of silver precipitation in the dentin of primary teeth was examined in a study conducted in 2021 by Lorraine et al. According to the results, there was no statistical difference in the depth of silver precipitation in the dentin of the groups that received and did not receive light after applying SDF (Lau et al., 2021). From the foregoing, previous studies were limited in number and had conflicting results. Moreover, no clinical studies were found. Therefore, this leads to the purpose of this clinical research study.

2. Objectives

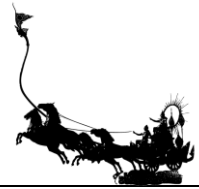
To compare the caries arrest rate between Silver Diamine Fluoride combined with the light cure and Silver Diamine Fluoride without light cure in primary teeth

3. Materials and Methods

This split-mouth, randomized-controlled clinical trial study was conducted in children aged 2 to 5 at five development centers and schools in Wapi Pathum, Mahasarakham, Thailand, from July 2023 until February 2024. The study was approved by the Human Research Ethics Committee, Faculty of Dentistry, Chulalongkorn University (HREC-DCU2023-033). The children were healthy and had at least one pair of active cavitated enamel and dentin caries (Nyvad score 3). The pair of dental caries were the same type, at the same position anterior/posterior) and on the same caries surface (buccal/palatal/occlusal/mesial/distal) at contralateral side. If the adjacent anterior teeth were treated with either treatment, the caries surfaces would not be adjacent. Due to SDF contamination on the other side, which had a therapeutic effect, we selected only one surface for the sample when the tooth had multiple caries surfaces. The children who participated in the study must have no history of allergies to silver, ammonia, or fluoride. The children also obtained caregiver's consent and can come for the follow-up after 3 weeks and 3 months of treatment. The children were dropped from this study when they were uncooperative in treatment, had symptoms of pulpitis or infection such as pain or gingival abscess, did not come for follow-up or their caregivers did not want to continue in the study.

Sample size was estimated by G*Power 3.1.9.7 based on a study conducted in 2020 by Mabangkhu et al. because the measurements were the same. The usefulness of light cure following the use of SDF in clinical practice has not yet been investigated in any research. They compared the effectiveness of a 38% SDF and a 5% Sodium Fluoride varnish by assessing the caries arrest rate in 302 1 to 3-year-old children. There were 2,249 surfaces with caries. As the result, the duration of 6 months after treatment revealed that

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the group receiving SDF application had arrested caries on 228 surfaces out of 1,111 surfaces (20.5%) which was higher percentage compared to the group receiving Sodium Fluoride varnish application, which arrested 140 surfaces out of 1,138 surfaces (12.3%) ($p = 0.001$) (Mabangkhu et al., 2020). The JavaStat website (<https://statpages.info/ctab2x2.html>) was used to determine the odds ratio which was 1.841. The sample size was generated at 106 pairs by fixing the power of the study at 80% ($\beta = 0.2$) and $\alpha = 0.05$ at the significance level. To compensate for participants drop out for 20%, the total number of samples was 128 pairs or 256 caries surfaces.

Participants who complied with the criteria and caregivers who accepted to take part in the study will receive toothpaste with 1,000 ppm fluoride, oral hygiene instruction (brushing and flossing technique and frequency) and behavior-related oral hygiene education (sweet drink and snack intake, weaning milk bottle).

All participants will receive two different types of treatment on the opposite tooth in the same arch. The first type of treatment is SDF10LC treatment which applied SDF for 10 seconds and light cured for 20 seconds. Another type of treatment is SDF60 treatment which applied SPF for 60 seconds. Afterwards, participants were randomly allocated the following order of treatment in either side.

We used 38% SDF (Saforide®), Tokyo Seiyaku Kasei Co. Ltd., Japan, and LED light cure (TPC advance LED 60N cordless curing light), wavelength 430 to 490 nm, light intensity 1,400 mW/cm². The treatment procedure involved dropping one drop of SDF on the plastic plate, and removing the gross food debris. The next step is applying petroleum gels to the lips, skin, and gingiva where SDF might contact them. Subsequently, gauze was used to isolate saliva from the cavity and wipe the cavity and dry with a cotton pallet. Then, the cavity was rubbed SDF on the cavity with a microbrush for 10 seconds, followed by light cure for 20 seconds and rubbed SDF on the cavity for 60 seconds on the other side. In the case of the light-cure method was the second method. We needed to use the foil cover samples that had already been treated with the first method.

The treatments were followed up at 3 weeks and 3 months. Nyvad criteria was used to identify changes in severity and activity of carious lesions. If active cavitated enamel and dentin caries (Nyvad score 3) were changed to arrested cavitated enamel and dentin caries (Nyvad score 6), the treatment was successful.

Nyvad score 3 indicates active cavitated enamel and dentin caries that are light or yellowish color in combination with a soft texture. Nyvad score 6 indicates inactive or arrested cavitated enamel and dentin caries that is glossy, smooth, hard on probing and whitish to brownish or black (Figure 1).



Figure 1 A. The carious lesions before applying SDF: light/yellowish color with soft texture (Nyvad score 3). B. The carious lesions after applying SDF: brownish/black color with glossy, smooth, and hard texture (Nyvad score 6).

The investigator received training and calibration from a pediatric dentistry specialist at the department of Pediatric Dentistry, faculty of Dentistry, Chulalongkorn University. The examination was calibrated on 10 children, and Kappa's values of inter-reliability and intra-reliability were equal at more than 0.8.

The Chi-Square test statistics were used to analyze the caries arrest rate at different times, at a significant level of 0.05 by using SPSS statistics 29.

4. Results and Discussion

4.1 Results

Forty healthy children of age 2 to 5 with 128 caries surface pairs were included in this study. The mean age was 4.31 (SD = 0.76) years. 28 of them were male (70.0%) and 12 were female (30.0%). One child did not go to school, so she lost the follow-up at 3 weeks after treatment, but she came to follow up at 3 months after treatment. In and 3-week follow-up, 39 children (127 caries surface pairs) remained. For the 3-month follow-up, 39 children (125 caries surface pairs) were examined because one child moved to another school as the following CONSORT diagram shown in Figure 2.

Thirty-nine children with 127 carious surfaces pairs came to follow up 3 weeks after treatment. The result of treatments shows that SDF10LC arrested caries on 116 surfaces (91.3%) and SDF60 arrested caries on 119 surfaces (93.7%). The results between the 2 treatments were not statistically significant ($p = 0.474$) at the 3-week follow-up. During the 3-month follow-up, 39 children with 125 carious surface pairs came to follow up. One child with 3 caries surfaces dropped out because he moved to another school. SDF10LC arrested caries on 107 surfaces (85.6%). SDF60 arrested caries on 112 surfaces (89.6%). The results between the 2 treatments were not statistically significant ($p = 0.337$) (see table 1).

The results of the inter-reliability analysis showed good results (Kappa = 0.87). The intra-reliability assessment performed good at baseline, the 3-week and 3-month follow-up (Kappa = 0.9, 1 and 0.99).

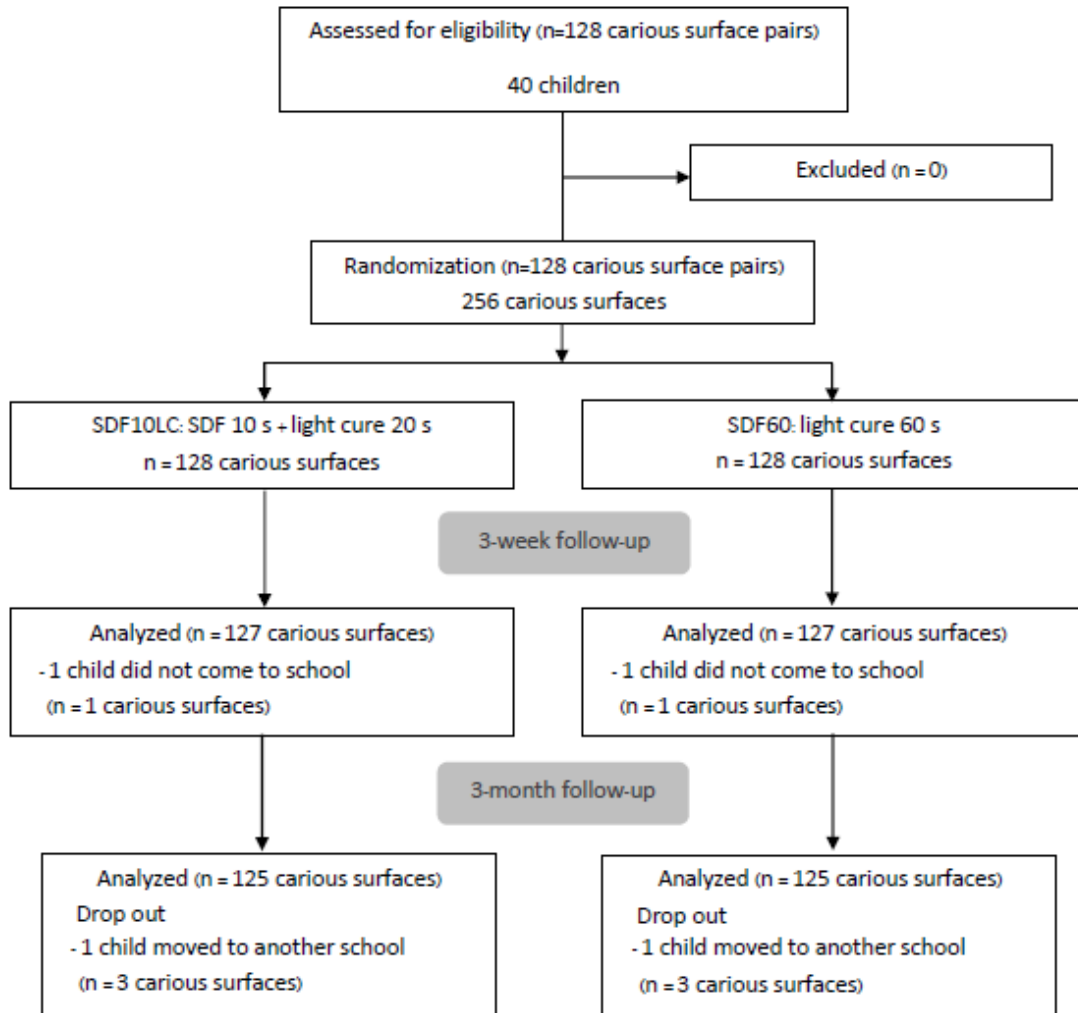


Figure 2 CONSORT diagram

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**Table 1** Caries arrest rate at 3-weeks and 3-months follow-up

Treatment	Caries arrest rate (%)					
	3 weeks			3 months		
	Anterior teeth	Posterior teeth	Total	Anterior teeth	Posterior teeth	Total
SDF10LC		90.3 (65/72)	91.3	90.7 (49/54)	81.7 (58/71)	85.6
	92.7 (51/55)		(116/127)			(107/125)
SDF60	94.5 (52/55)	93.1 (67/72)	93.7	92.9 (50/54)	87.3 (62/71)	89.6
			(119/127)			(112/125)
<i>p</i> -value			0.474			0.337

4.2 Discussion

Split mouth study design was chosen to reduce bias of sample, the samples have the same characteristic at contralateral side.

In the case of the light-cure method, which was the second method, foil was used to cover samples that had already been treated with the first method. It can protect the sample of SDF60 from light contamination.

Although we prepared carious surfaces which were the same type and at the same position, some pairs of comparable carious surfaces consisted of varying numbers of carious surfaces. Therefore, it might be a confounding factor in arresting caries.

The protocol of treatments in this study was set based on the AAPD's recommendation and the previous *in vitro* study. AAPD recommends rubbing SDF for 60 seconds. In *in vitro* studies compared the differences between lesion depth changes and mineral density changes among many treatments of SDF application. The two treatments are rubbing SDF for 60 seconds on carious lesions and rubbing SDF for 10 seconds followed by the LED light cure for 20 seconds on carious lesions. Results showed that there was no statistically significant difference between the two groups in decreasing lesion depth and increasing mineral density. Their outcomes concur with ours. Since the light cure can enhance the precipitation of silver ions after SDF application, it is indicated that light promotes the remineralization effectiveness of SDF. (Karnowakul et al., 2023; Phuensuriya et al., 2022).

Nevertheless, the duration of the follow up may be short; if the samples are followed up continuously. Behaviors related to oral health, including frequency of daily milk feeding, snack taking or the presence of plaque on the carious lesions may alter the arresting caries rate (Mabangkhru et al., 2020).

5. Conclusion

The results of the study showed that the light cure combined with SDF used a total treatment time of 30 seconds had the same result of arresting caries as applying only SDF for 60 seconds. Therefore, shorter treatment durations are possible with a light curing SDF in uncooperative children.

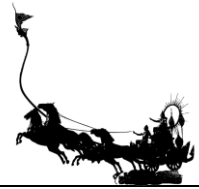
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7. References

- AAPD. (2021a). Policy on the use of silver diamine fluoride for pediatric dental patients. *The Reference Manual of Pediatric Dentistry*, 68-71.
- AAPD. (2021b). Chairside guide: silver diamine fluoride in the management of dental caries lesions*. *The Reference Manual of Pediatric Dentistry*, 638-639.
- Department of Health's Bureau. (2018). Dental Health's 8th National Oral Health Survey statistics from 2017.

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- Crystal, Y. O., & Niederman, R. (2016). Silver diamine fluoride treatment considerations in children's caries management brief communication and commentary. *Pediatric dentistry*, 38(7), 466-471.
- Hassan, M., Bakhurji, E., & Sheihk, R. (2021). Application of Er,Cr:YSGG laser versus photopolymerization after silver diamine fluoride in primary teeth. *Scientific Reports*, 11. <https://doi.org/10.1038/s41598-021-00204-x>
- Karnowakul, J., Punyanirun, K., Jirakran, K., Thanyasrisung, P., Techatharatip, O., Pornprasertsuk-Damrongsri, S., & Trairatvorakul, C. (2023). Enhanced effectiveness of silver diamine fluoride application with light curing on natural dentin carious lesions: an *in vitro* study. *Odontology*, 111(2), 439-450. <https://doi.org/10.1007/s10266-022-00755-z>
- Lau, L., Quock, R. L., Wu, D. I., Harrington, D. A., Patel, S. A., & Barros, J. A. (2021). Effect of surface preparation and light curing on penetration of silver particles from 38% silver diamine fluoride in dentin of primary teeth: An *in vitro* evaluation. *American Journal of Dentistry*, 34(1), 44-48.
- Mabangkhu, S., Duangthip, D., Chu, C. H., Phonghanyudh, A., & Jirattanasopha, V. (2020). A randomized clinical trial to arrest dentin caries in young children using silver diamine fluoride. *Journal of Dentistry*, 99, 103375. <https://doi.org/10.1016/j.jdent.2020.103375>
- McDonald, J. L. (2018). *Evaluating the Effectiveness of Light Cured SDF and Its Penetration: An In Vitro Study*. A thesis for the degree of Master of Science in Oral. University of Illinois at Chicago.
- Phuensuriya, J., Techatharatip, O., Trairatvorakul, C., & Thanyasrisang, P. (2022). Remineralization of upper and lower molar dentin carious lesion after using light curing method on silver diamine fluoride treatment: *In vitro*. Chulalongkorn University.
- Toopchi, S., Bakhurji, E., Loo, C. Y., & Hassan, M. (2021). Effect of light curing on silver diamine fluoride in primary incisors: A microscopic *ex vivo* study. *Pediatric Dentistry*, 43(1), 44-49.