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ORIGINAL RESEARCH

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Clinical effectiveness and parental acceptance of silver diamine fluoride in preschool children: a non-randomized trial

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Abstract

Silver diamine fluoride (SDF) presents a promising approach in pediatric dentistry, simplifying procedures by eliminating the need for sharp instruments or anesthesia. This study aimed to evaluate the effectiveness of 38% SDF application in arresting active caries lesions in preschool children and to assess parental acceptance of the treatment. This non-randomized, prospective, single-arm clinical study included 48 children, presenting with a total of 158 active caries lesions. The lesions were treated with 38% SDF, and their characteristics, including changes in dentin color and lesion texture, were evaluated at baseline and at a 6-month follow-up visit. The rate of lesion non-progression post-SDF application was calculated. Additionally, parents completed an oral health behavior form and the Parental Perceptions of Silver Diamine Fluoride Dental Color Changes Questionnaire to assess acceptance. The study observed a high rate of caries arrest in multi-surface teeth following SDF application. There was a statistically significant improvement in parental acceptance of SDF treatment. However, no significant interaction was observed between the treatment and either child- or parent-related variables regarding parental acceptability. The application of 38% SDF effectively arrested caries lesions in preschool children, with an observed increase in parental acceptance pre- and post-treatment.

Keywords

Acceptance; Children; Dental caries; Silver diamine fluoride

1. Introduction

Dental caries in primary teeth profoundly affect children's health and their families' quality of life [1]. Challenges are particularly pronounced in treating preschool-aged children, where severe early childhood caries necessitating specialized care often lead to hospitalization and reliance on pharmacological behavior management techniques, imposing financial burdens [2]. These treatments are not universally accessible and carry associated health risks [3].

Accordingly, caries management strategies have evolved towards a medical model utilizing antimicrobial agents such as fluoridated and silver compounds [4]. Silver diamine fluoride (SDF) stands out within this spectrum, garnering widespread endorsement from dentists and researchers for its effectiveness and user-friendliness [5–7]. This shift towards preventive and minimally invasive approaches aims to alleviate the health and economic impacts of dental caries [8, 9].

SDF, an odorless, colorless alkaline solution, effectively arrests carious lesions across diverse demographic groups, including children, the elderly, and those reluctant to undergo invasive procedures [5, 10]. Its substantial fluoride concentration promotes remineralization, caries arrest and prevention [11]. The application of SDF is straightforward, non-invasive, economical and does not discolor intact enamel, rendering it ideal for managing dentin hypersensitivity [12]. This simplicity is particularly advantageous for children, individuals with special needs and the elderly [13]. SDF is especially valuable for patients at high risk due to salivary dysfunction or those with multiple carious lesions, offering a streamlined approach in pediatric dentistry and community oral health by enabling quick application without the need for sharp instruments or anesthesia [14–16].

Despite its numerous benefits, the primary limitation of SDF lies in its propensity to induce dark staining on treated teeth, which raises aesthetic concerns among children and their parents [17], potentially affecting the acceptance of this treatment [18]. The willingness of parents to opt for SDF treatment is influenced by factors such as the visibility of the treated tooth and the child's level of cooperation [19]. However, there is a scarcity of research evaluating the acceptability of the dental discoloration associated with SDF use in pediatric patients. This gap highlights the need for further studies to understand better the impact of aesthetic considerations on the acceptance of SDF as a treatment option.

This study aimed to evaluate the effectiveness and parental

acceptance of 38% SDF application in arresting active caries lesions in pediatric patients. The null hypotheses were as follow: (a) SDF application does not arrest active dental caries lesions, and (b) SDF application does not affect parental acceptance of SDF color change.

2. Materials and methods

2.1 Research design

This non-randomized, prospective, single-arm clinical study was conducted with pediatric patients and their parents who were recruited from the Department of Pediatric Dentistry, Faculty of Dentistry, Sivas Cumhuriyet University, Turkey. Participants were selected using a convenience sampling method. The sample size was determined based on a 5% alpha error, 80% power and an arrest rate of 35.7% derived from a previous study [20], indicating that a minimum of 40 participants was required. To account for potential loss to follow-up, the sample size was increased by 20%, leading to the inclusion of 48 children and their parents in the study. The study's research design and protocol are illustrated in the CONSORT (Consolidated Standards of Reporting Trials) flow diagram presented in Fig. 1.

2.2 Inclusion and exclusion criteria

The study included children aged 3–5 years who were mentally and physically healthy and willing to participate voluntarily, alongside their mentally and physically healthy parents possessing native literacy levels. Eligible children were required to have at least one carious lesion, as identified by the International Caries Detection and Assessment System (ICDAS) criteria [21]. The ICDAS classifications for inclusion were: active (soft) cavitated carious lesions extending into dentine (ICDAS 5 or 6), non-cavitated lesions (ICDAS 3 or 4), and initial carious lesions (ICDAS 1 or 2). Specifically, lesions with ICDAS scores of 3, 4, 5 and 6 were selected for inclusion in the study.

Children were excluded from the study if they presented with small interproximal caries not observable clinically, exhibited signs of spontaneous pain, tooth mobility, or pulp infection attributable to caries, had medical conditions that precluded treatment in a clinical setting, possessed congenital developmental defects, had allergies or sensitivities to SDF, or demonstrated non-cooperation or failure to attend follow-up visits.

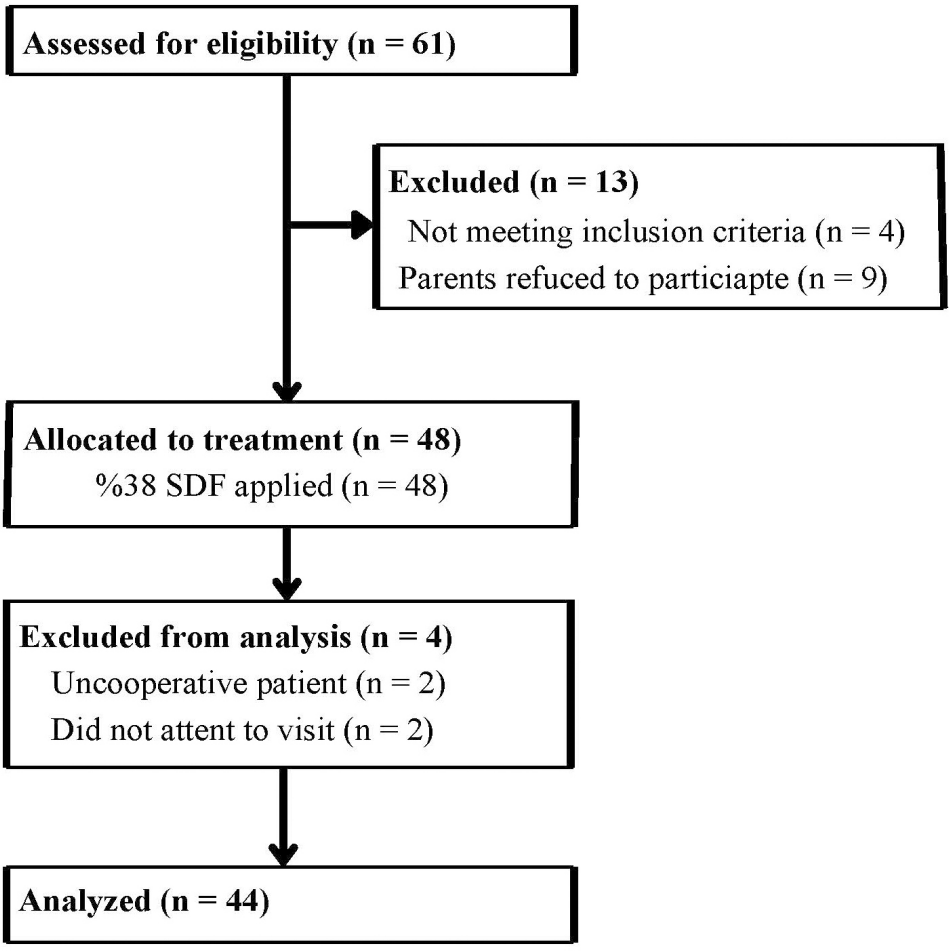

FIGURE 1. CONSORT flow diagram. SDF: Silver diamine fluoride.

2.3 SDF application

Informed consent was duly obtained from the parents or legal guardians of all participating children prior to their involvement in the study. Furthermore, parents received comprehensive information regarding SDF treatment protocols, follow-up care, oral hygiene practices and dietary recommendations.

A standard dental examination, including intraoral radiographs when deemed necessary, preceded the application of 38% SDF (22039255, Riva Star, SDI, Melbourne, VIC, Australia) to the identified carious lesions in primary teeth. The SDF application adhered strictly to the protocol outlined in relevant literature [21, 22] and followed the manufacturer's guidelines. A single, experienced researcher performed the SDF application on each patient to ensure consistency.

The procedure began with the isolation and drying of the affected teeth using gauze and cotton rolls. The SDF solution was then meticulously applied directly to the carious lesions using a microbrush, allowing for an absorption duration that varied between 30 to 120 seconds [22], tailored to the child's cooperativeness and behavior. Following the application, any residual solution was gently removed with gauze. Post-treatment, parents were advised to prevent their child from consuming food or beverages for at least one hour to maximize the efficacy of the SDF treatment. Consequently, participants were scheduled for follow-up appointments at intervals of 3 weeks, 3 months and 6 months to monitor the lesion's status. In cases where carious lesions did not become black and hard by the recall visits, suggesting lack of progression arrest, a second SDF application was performed.

Comprehensive records of the SDF treatments administered at each session were meticulously kept. The study's endpoint was reached either upon clinical completion of the treatment or when the active carious lesions were successfully arrested, coupled with observed improvements in the child's cooperation and behavior during follow-up.

Upon verification of carious lesion arrestation at the final treatment phase, subsequent restorative procedures were considered and planned for both anterior and posterior teeth as required.

For patients exhibiting difficulties in cooperation, arrangements were made for routine follow-up visits or referral for treatment under sedation or general anesthesia, tailored to the severity of the case and individual patient needs.

2.4 Data collection

2.4.1 Primary outcome

The primary objective was to evaluate the efficacy of SDF treatment in arresting active carious lesions, assessed through detailed clinical examinations. For the clinical evaluation, a standardized control form was employed. All treatment and follow-up procedures were executed by a single, experienced, and specifically trained pediatric dentist (identified here as BB for confidentiality). The assessment criteria [22] included the color of the dentin (yellow, black, brown) and the texture of the lesions (soft, hard, chalky, shiny), which were meticulously evaluated using a dental probe with gentle pressure at the initial visit and during each follow-up. Additionally, the presence or absence of pain and infection was systematically recorded at baseline and each subsequent follow-up, utilizing both clinical examination findings and parental interviews.

The success of the SDF treatment was determined based on clinical observations, where lesions that became dark, hard and black without associated pain or signs of infection were deemed positively arrested [22]. Conversely, indicators of treatment failure were identified as lesion progression, the persistence of a yellow, soft lesion texture or the emergence of pain and infection.

Documentation included the total application time for the SDF treatment, measured in seconds, with durations ranging from a minimum of 30 seconds to a maximum of 120 seconds per tooth.

2.4.2 Secondary outcome

The secondary outcome focused on evaluating parental acceptance of SDF treatment. This assessment was facilitated through the administration of a previously validated questionnaire. Parental acceptance of SDF treatment was evaluated using the "parental perceptions of silver diamine fluoride dental color changes questionnaire" [19]. This instrument was administered to parents both prior to the commencement of treatment and during the 6-month follow-up appointments. Developed by Crystal *et al.* [19], the questionnaire is available in its original English version and has been specifically designed to assess parental perceptions of dental color changes following SDF application. It employs a closed-ended Likert scale format, incorporating a series of full-color photographs that depict both anterior and posterior primary teeth before and after the application of SDF, thereby facilitating the collection of parental feedback through visual comparison. Cross-cultural adaptation, reliability and validity into Turkish have been established previously [23].

The survey is organized into three subscales that encompass a total of 14 items. The first subscale assesses overall acceptability based on the staining effects of SDF on posterior (item 1) and anterior (item 2) teeth. The second subscale measures acceptability in positive child cooperation scenarios, including when the child is cooperative (items 3–4) and when the child is upset but still cooperative (items 5–6). The third subscale evaluates acceptability in negative child cooperation scenarios that present increased barriers to traditional restorations. This includes scenarios when the child is crying (items 7–8), screaming or kicking (items 9–10) and the need for oral sedation (items 11–12) or general anesthesia (items 13–14).

Parents are requested to provide separate responses for anterior and posterior teeth across each of these scenarios. For items 1 and 2, the response options and their corresponding scores are as follows: "unacceptable" is scored as 1 point, "somewhat unacceptable" as 2 points, "somewhat acceptable" as 3 points and "acceptable" as 4 points. For items 3 through 14, the response options and scoring are: "extremely unlikely" is scored as 1 point, "somewhat unlikely" as 2 points, "somewhat likely" as 3 points and "very likely" as 4 points.

To determine specific scores for each domain, the scores from the items within that domain are averaged for both anterior and posterior teeth. Higher average scores suggest a greater level of parental acceptability of SDF staining. The

acceptability of SDF treatment among parents was assessed through a face-to-face completion of the relevant survey both before the treatment started and again at the 6-month follow-up appointment.

2.4.3 Socio-demographic and oral health behaviors form

Parents were given a socio-demographic and oral health behaviors survey form designed to assess socioeconomic status and oral health practices. This validated form [1] contained inquiries about the parents' education level, income status, health insurance coverage, tooth brushing frequency, dental visit frequency, the timing of their last dental visit and any negative dental experiences. Additionally, the survey solicited information regarding their children's gender, age, the timing and frequency of cariogenic food consumption, tooth brushing habits, dental visit frequency, the date of the last dental appointment and any negative dental experiences encountered.

2.5 Statistical analysis

The data were analyzed using SPSS software (Version 24, IBM Corp., Armonk, NY, USA). Descriptive statistics, including frequency and percentage or mean and standard deviation, were employed to outline the demographic characteristics and socioeconomic status of both the children and their parents.

The chi-square test was applied to investigate the association between the duration of SDF applications and the arrest of lesion progression. To ascertain the effectiveness of SDF in arresting lesion progression, the proportion of lesions that remained unchanged before and after the application of SDF was computed. For categorical variables, Fisher's exact chi-square test was utilized.

The Shapiro-Wilk test was conducted to check continuous variables for a normal distribution. The effects of treatment and various factors related to the sociodemographic characteristics and oral health behaviors of children and their parents were explored through repeated measures analysis of variance (ANOVA). The paired samples *t*-test was used to compare pre-test and post-test values within groups. A *p*-value of less than 0.05 was deemed to indicate statistical significance.

3. Results

The initial demographic characteristics of the subjects and caries lesions are detailed in Table 1. Initially, 48 patients were enrolled in the study. However, at the conclusion of the study, data from only 44 patients were analyzed. The reduction in participant numbers was due to four participants discontinuing the study; two of these participants were unable to establish cooperation for treatment and the remaining two did not attend the follow-up sessions. Analysis of the remaining participants revealed that 60.4%, equivalent to 29 participants, were girls, while 39.6% or 19 participants, were boys. The mean age of the participants was determined to be 3.9 years, with a standard deviation of 0.6 years.

At the outset, the study included 158 caries lesions from 48 patients. During the first follow-up session in the third week after the initial application of SDF, 2 patients with 5 caries lesions, were excluded from the study due to non-cooperation for a second application. Additionally, 2 patients with 9 caries lesions were excluded for failing to attend the follow-up sessions. At this initial follow-up, out of the 144 caries lesions examined, 140 were clinically deemed arrested due to their black and hard appearance. The remaining 4 caries lesions received a second application of SDF.

Patients with these 4 caries lesions were subsequently summoned for a second follow-up session, during which the lesions were evaluated and confirmed as arrested clinically, again noted for being black and hard. Thus, the study continued with a cohort of 44 patients, encompassing a total of 144 caries lesions, who were then scheduled for further follow-up appointments at 3 and 6 months to verify the sustained arrest of the caries lesions. At the 6-month follow-up, parents were once again asked to complete the parental acceptability survey forms for SDF treatment.

Table 2 presents the duration of SDF application and the rate of caries lesion arrest observed during the clinical phase of the study. The analysis of SDF application duration revealed an expected minimum cell count of 0.69, with a chi-square (χ^2) value of 1.593 and a *p*-value of 0.74. Despite the lack of a statistically significant difference between the groups, the highest rate of caries lesion arrest was noted in the group where SDF was applied for a duration of 91–120 seconds. The average duration for the application of SDF across all cases was calculated to be 61.9 $\pm$ 24.9 seconds, with the shortest application time being 30 seconds and the longest being 120 seconds.

Table 3 illustrates the rate of caries lesion arrest post-treatment, taking into account the lesion location and the number of surfaces affected. Initially, the highest rates of caries lesion arrest were recorded in anterior teeth involving two surfaces, achieving a 100% success rate. In contrast, the lowest rate of caries lesion arrest was noted in posterior teeth affecting three surfaces, where the arrest rate was 84.6%.

Table 4 presents the comparison of pre- and post-treatment scores regarding the parental acceptability of Silver Diamine Fluoride (SDF), focusing on child-related variables, as well as the main effects of treatment and the interaction between treatment and child-related variables. A repeated measures ANOVA was conducted to assess the impact of SDF treatment and child-related variables on parental acceptability scores. There was a significant main effect of SDF treatment on pre- and post-treatment acceptability scores for each investigated variable, indicating an increase in parental acceptability of SDF following treatment. However, there was no significant effect of the interaction between SDF treatment and any child-related variable on pre- and post-treatment acceptability scores for any of the investigated variables. This suggests that the increase in parental acceptability was influenced by the treatment itself, but not by the specific child-related variables investigated.

Table 5 presents the comparison of pre- and post-treatment scores regarding the parental acceptability of SDF, focusing on parent-related variables, as well as the main effects of treatment and the interaction between treatment and parent-related variables. A repeated measures ANOVA was conducted to assess the impact of SDF treatment and child-related variables

TABLE 1. Characteristics of subjects and caries lesions.

Variables	Enrolled (n = 48)		Lost to follow-up (n = 4)	Analyzed (n = 44)	
Subjects	n	%	n	n	%
Sex					
Girl	29	60.4	2	27	61.4
Boy	19	39.6	2	17	38.6
Age (yr)					
3	12	25.0	2	10	22.7
4	29	60.4	1	28	63.6
5	7	14.6	1	6	13.6
Caries lesion Location					
Anterior	37	23.4	3	34	23.6
Posterior	121	76.6	11	110	76.4
Surface number					
1	73	46.2	4	69	47.9
2	54	34.2	8	46	31.9
3	21	13.3	1	20	13.9
4	10	6.3	1	9	6.3

TABLE 2. Application time of silver diamine fluoride administered to subjects and the rate of caries lesion arrest.

Application time (s)	Lesions treated (n)	Lesions arrested (n)	Arrest rate (%)
30	35	32	91.4
31–60	51	46	90.2
61–90	48	46	95.8
91–120	10	10	100.0

TABLE 3. Post-treatment rate of caries lesion arrest according to lesion location and surface number characteristics.

Lesion location	Lesion surface number	Caries Arrest rate		
		Yes	No	Arrest rate
Anterior				
	1	17	1	94.4
	2	9	0	100.0
	3	6	1	85.7
Posterior				
	1	48	3	94.1
	2	34	3	91.9
	3	11	2	84.6
	4	9	0	100.0

TABLE 4. Comparison of pre- and post-treatment scores for the acceptability of silver diamine fluoride treatment by parents in terms of child-related variables.

Variables	N (%)	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	Treatment effect			Treatment*Variable effect		
				F	*p*	μ^2	*F*	*p*	μ^2
Sex									
Girl†	27 (61.4)	32.0 ± 11.1	42.4 ± 8.9	13.194	***0.001***	0.239	1.415	0.241	0.033
Boy	17 (38.6)	38.0 ± 9.3	43.3 ± 6.0						
Frequency of consumption of cariogenic food									
Always	12 (27.3)	36.16 ± 11.3	40.91 ± 6.0						
Occasionally†	28 (63.6)	34.3 ± 10.4	43.5 ± 8.6	10.571	***0.002***	0.205	0.740	0.484	0.035
Never	4 (9.1)	29.0 ± 12.3	42.8 ± 7.7						
Time of consumption of cariogenic food									
Any time†	22 (50.0)	32.4 ± 11.2	41.0 ± 7.3						
Snack	20 (45.5)	35.3 ± 10.1	44.2 ± 8.3	2.991	***0.009***	0.068	0.249	0.781	0.012
Main meal	2 (4.5)	45.5 ± 6.4	47.0 ± 7.1						
Frequency of toothbrushing									
Never†	10 (22.7)	34.1 ± 12.1	44.6 ± 9.0						
Rarely†	11 (25.0)	29.9 ± 12.2	43.9 ± 5.9	12.310	***0.001***	0.235	1.287	0.292	0.088
Occasionally	18 (40.9)	36.1 ± 7.2	41.4 ± 8.8						
Daily	5 (11.4)	38.4 ± 15.1	40.8 ± 5.5						
Frequency of dental visits									
When toothache†	29 (65.9)	33.8 ± 11.3	42.6 ± 8.0						
Occasionally	6 (13.6)	37.2 ± 10.5	39.5 ± 7.8	7.073	***0.011***	0.151	0.594	0.623	0.032
Once in a year†	6 (13.6)	33.5 ± 10.6	46.5 ± 7.7						
Once in 6 months	3 (6.8)	35.3 ± 10.3	42.7 ± 5.9						
The last dental visit									
Never†	18 (40.9)	29.8 ± 9.7	43.9 ± 8.0						
In last 1 year	12 (27.3)	36.0 ± 13.3	41.7 ± 8.6	14.249	***0.001***	0.258	2.938	0.064	0.125
In last 6 months	14 (31.8)	38.8 ± 7.5	42.1 ± 7.3						
Negative dental experience									
Yes†	15 (34.1)	35.8 ± 9.4	44.5 ± 6.9	14.269	***0.001***	0.254	1.016	0.901	0.001
No	29 (65.9)	33.6 ± 11.4	41.8 ± 8.2						

*Treatment: Silver diamine fluoride application; pre-treatment vs. 6-month post-treatment follow-up; Bold and italicized numbers indicate statistical significance ($p < 0.05$). †indicates statistical significance in within-group comparisons ($p < 0.05$); SD: Standard deviation. *indicates the combined effect of both the treatment and the variable on the outcome.*

TABLE 5. Comparison of pre- and post-treatment scores for the acceptability of silver diamine fluoride treatment by parents in terms of parent-related variables.

Variables	N (%)	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	Treatment effect			Treatment*Variable effect		
				F	*p*	μ^2	*F*	*p*	μ^2
Education level									
Elementary	10 (22.7)	35.4 ± 9.2	44.1 ± 8.6						
Secondary	8 (18.2)	33.2 ± 7.9	40.8 ± 8.9	13.481	***0.008***	0.252	0.509	0.679	0.037
High School	11 (25.0)	37.5 ± 11.7	42.1 ± 6.4						
University†	15 (34.1)	43.8 ± 10.7	43.3 ± 8.2						
Monthly income (TL)									
0–15,000	5 (11.4)	37.0 ± 9.7	36.6 ± 3.6						
15,001–30,000†	6 (13.6)	31.4 ± 8.7	43.3 ± 9.7	8.782	***0.005***	0.180	1.064	0.375	0.074
30,001–50,000	12 (27.3)	37.1 ± 14.2	44.0 ± 6.7						
>50,000†	11 (25.0)	34.5 ± 9.8	43.2 ± 6.6						
Health insurance									
None	5 (11.4)	35.4 ± 8.0	39.6 ± 7.2						
Green Card	3 (6.8)	30.6 ± 15.2	39.3 ± 6.7	5.802	***0.021***	0.127	0.245	0.861	0.018
Social security†	34 (77.3)	35.0 ± 10.6	43.6 ± 8.0						
Private	2 (4.5)	26.0 ± 17.0	40.0 ± 8.5						
Frequency of toothbrushing									
None	2 (4.5)	37.0 ± 5.7	44.5 ± 10.6						
Rarely†	14 (31.8)	30.1 ± 12.4	41.1 ± 8.1	8.127	***0.007***	0.169	0.682	0.568	0.049
Occasionally †	11 (25.0)	31.2 ± 10.3	42.1 ± 7.8						
Daily	17 (38.6)	39.5 ± 10.7	44.2 ± 7.7						
Frequency of dental visits									
When toothache	26 (59.1)	35.5 ± 11.7	40.4 ± 6.7						
Occasionally†	11 (25.0)	30.2 ± 9.4	44.0 ± 8.5	10.213	***0.003***	0.203	1.615	0.201	0.108
Once in a year†	5 (11.4)	34.0 ± 8.7	50.2 ± 8.8						
Once in 6 months	2 (4.5)	41.0 ± 4.2	46.5 ± 4.7						
The last time dental visit									
Never†	3 (6.8)	26.0 ± 6.9	47.0 ± 7.5						
In last 5 years	12 (27.3)	37.5 ± 6.8	41.4 ± 8.3	16.529	***0.001***	0.292	1.273	0.297	0.087
In last 1 year†	20 (45.5)	34.7 ± 13.4	43.7 ± 8.0						
In last 6 months	9 (20.5)	32.1 ± 8.0	40.8 ± 7.1						
Negative dental experience									
Yes†	6 (13.6)	36.3 ± 8.8	48.7 ± 11.1	10.677	***0.002***	0.205	0.560	0.458	0.013
No	38 (86.4)	34.0 ± 11.1	41.8 ± 7.4						

*Treatment: Silver diamine fluoride application; pre-treatment vs. 6-month post-treatment follow-up; Bold and italicized numbers indicate statistical significance ($p < 0.05$). †indicates statistical significance in within-group comparisons ($p < 0.05$); SD: Standard deviation. *indicates the combined effect of both the treatment and the variable on the outcome.*

on parental acceptability scores. There was a significant main effect of SDF treatment on pre- and post-treatment acceptability scores for each investigated variable, indicating an increase in parental acceptability of SDF following treatment. However, there was no significant effect of the interaction between SDF treatment and any parent-related variable on pre- and post-treatment acceptability scores for any of the investigated variables. This suggests that the increase in parental acceptability was influenced by the treatment itself, but not by the specific parent-related variables investigated.

Table 6 also presents the mean scores and distribution of scoring for each item in the parental perceptions of silver diamine fluoride dental color changes questionnaire. Parental acceptability was observed to be significantly higher for posterior teeth than for anterior teeth across all examined scenarios.

4. Discussion

The first null hypothesis was rejected, indicating that the application of SDF treatment is effective in arresting caries lesions in primary teeth. Similarly, the second null hypothesis was also rejected, demonstrating a significant impact of SDF treatment on the pre- and post-intervention parental perception of SDF-induced color changes. This study reveals the potential efficacy of SDF in arresting carious lesions among pediatric patients, especially those in younger age cohorts with elevated susceptibility to dental caries. This includes individuals with behavioral cooperation challenges and special needs. Additionally, the study elucidated shifts in parental attitudes and acceptance before and after the administration of SDF treatment.

To our knowledge, research focusing on evaluating the effect of SDF treatment on carious lesions and changes in parental acceptability has been limited. This study design enabled the assessment of differences in study outcomes between clinical efficacy and parental acceptability, utilizing both objective and subjective measurement tools. The most significant disadvantage of SDF is its propensity to cause black discoloration of decayed enamel and dentin [24]. This discoloration, affecting the aesthetic appearance of a child's teeth, may lead many parents to refuse SDF treatment, consequently causing most dentists to hesitate in offering SDF as a treatment option [25].

The primary limitation of implementing SDF treatment in young pediatric patients lies in its acceptability to parents [26], who play a crucial role in the decision-making process regarding their children's dental care. Despite the identification of discoloration caused by SDF as a primary reason for parental reluctance, the etiology, content and consequences of this concern have not been extensively explored in the literature.

SDF represents a minimally invasive, cost-effective and simple method that could reduce fear and anxiety in young children, offering a potential treatment for untreated early childhood caries, especially in populations where restorative and surgical treatment options are not applicable, such as in young children. Therefore, this study included preschool-aged children and their parents.

The evaluation of the efficacy of SDF in arresting carious lesions typically relies on the characteristics of the lesions, such as color and consistency (hardness/softness) [27]. Active caries lesions usually appear yellowish or brownish and exhibit a rough texture that feels soft upon gentle probing with an explorer [28]. In contrast, arrested caries are characterized by a black appearance, a smooth surface, and hardness under light exploration with an explorer. It has also been indicated that gentle probing does not compromise the structural integrity of non-cavitated lesions [22]. Thus, it is recommended to apply gentle pressure to assess the hardness of the lesion, avoiding any attempts to penetrate the lesion with the dental instrument.

In this study, patients were followed at control appointments before and after the completion of SDF application, with a short-term follow-up period. Consistent with previous studies [29, 30], short-term follow-ups were deemed sufficient for monitoring arrested lesions. However, evaluating the long-term prognosis of SDF treatment and determining the necessary recall and maintenance periods would benefit from longer-term patient follow-up. The high rate of caries lesion arrest observed in this study aligns with previous studies [27–30], which may partly result from the exclusion criteria that omitted primary teeth with clinical symptoms such as pain or infection. On the other hand, in the study by Mabangkhru *et al.* [20], the arrest rate was found to be 35.7%, which is significantly lower than that of the current study. This discrepancy may be due to the fact that the study group in their research consisted of children aged 1–3, who are younger than the population in the current study. It is more challenging to achieve an appropriate diet and oral health behavior control at younger ages, which may have affected the effectiveness of SDF. Additionally, the relatively small sample size might have influenced the significance of observed differences. Despite this, appropriate sample size determination and power analysis were conducted to address this limitation.

Teeth treated with SDF typically exhibit a charcoal black color and a smooth, hardened surface, consistent with characteristics documented in prior studies. The efficacy of SDF in arresting the progression of clinically detectable carious lesions was confirmed.

The duration for which decayed teeth can be isolated for SDF application without contamination depends on patient cooperation [29]. The level of cooperation among patients aged 3–5 years in this study varied significantly. Following the literature [7, 10, 22], the SDF application time ranged from a minimum of 30 seconds to a maximum of 120 seconds, with actual exposure time varying due to the limited cooperation levels of the children. Nonetheless, lesion arrest was achieved across all exposure times, suggesting that low patient cooperation should not preclude the use of SDF, especially when isolation of the tooth for more than 30 seconds is unfeasible.

Inconsistent with existing literature [18, 19, 22, 26, 31], the findings revealed that parental acceptability was significantly higher for posterior teeth compared to anterior teeth across all examined scenarios. This discrepancy may be attributed to parents' heightened aesthetic concerns regarding discoloration of anterior teeth. Similarly, similar concerns have been reported among both dentists [31] and dental students [32] regarding the acceptability of SDF. This aesthetic consideration may represent a primary disadvantage of SDF and could explain why some dentists may be reluctant to utilize it in such cases

TABLE 6. Mean scores and distribution of scoring for each item in the parental perceptions of silver diamine fluoride dental color changes questionnaire.

Item Number	Mean	SD	Min	Max
General acceptability				
Item 1: If your child had cavities on the back teeth. Would the discoloration with the new treatment be acceptable to you?	2.22	1.19	1	4
Item 2: If your child had cavities in the front teeth. Would the discoloration with the new treatment be acceptable to you?	1.63	0.99	1	4
Positive scenario				
Item 3 (anterior): If your child was fine (cooperative) to do fillings. Would you choose the new treatment instead of doing fillings?	1.97	0.87	1	4
Item 3 (posterior): If your child was fine (cooperative) to do fillings. Would you choose the new treatment instead of doing fillings?	2.34	0.96	1	4
Item 4 (anterior): If your child was upset but could cooperate enough to get fillings. Would you choose the new treatment instead of doing fillings?	1.98	0.92	1	4
Item 4 (posterior): If your child was upset but could cooperate enough to get fillings. Would you choose the new treatment instead of doing fillings?	2.25	0.99	1	4
Negative scenario				
Item 5 (anterior): If your child cried but could cooperate enough to have fillings. Would you choose the new treatment instead of doing fillings?	2.02	0.95	1	4
Item 5 (posterior): If your child cried but could cooperate enough to have fillings. Would you choose the new treatment instead of doing fillings?	2.34	1.07	1	4
Item 6 (anterior): If your child kicked/screamed and could not have fillings done. Would you choose the new treatment instead of trying to do fillings? The new treatment instead of doing fillings?	2.56	1.04	1	4
Item 6 (posterior): If your child kicked/screamed and could not have fillings done. Would you choose the new treatment instead of trying to do fillings?	2.95	1.03	1	4
Item 7 (anterior): If your child required sedation (medicine to make him/her tired) to do fillings. Would you choose the new treatment instead of doing fillings? Of doing fillings?	2.72	1.04	1	4
Item 7 (posterior): If your child required sedation (medicine to make him/her tired) to do fillings. Would you choose the new treatment instead of doing fillings? Of doing fillings?	2.95	1.07	1	4
Item 8 (anterior): If your child required general anesthesia to do fillings. Would you choose the new treatment instead of doing fillings?	3.09	1.00	1	4
Item 8 (posterior): If your child required general anesthesia to do fillings. Would you choose the new treatment instead of doing fillings?	3.27	0.99	1	4

SD: Standard deviation.

[31].

This study presents several limitations. Carious lesions with ICDAS scores of 1 and 2 were excluded due to their limited visibility on radiographs and the difficulty of clinical assessment, indicating a need for further research on the effectiveness of SDF on incipient lesions. Moreover, the challenge of clinically assessing arrest underscores the benefit of longitudinal radiographic monitoring of treated lesions to evaluate progression or stabilization.

The findings from this study could significantly contribute to the literature by assessing the use of SDF in preschool children, a demographic previously given limited attention. This study uniquely examined parental acceptability of SDF application, both before and after treatment, which could significantly enhance understanding and implementation of SDF. Additionally, postponing dental interventions and arresting caries can reduce discomfort, infections, emergency visits, the need for general anesthesia and traumatic dental experiences in uncooperative children. Future research could focus on conducting long-term randomized clinical trials to determine the optimal frequency of SDF application necessary to maintain decay arrest, offering valuable insights for clinical practice.

SDF represents a convenient, effective and well-received non-surgical alternative for managing active caries lesions in

young children, compared to conventional restorative dental procedures. While not the focus of the present study, it is noteworthy that SDF incurs lower costs than other interventions for early childhood caries, adding to its benefits.

5. Conclusions

In conclusion, this study demonstrated the high efficacy of SDF in arresting dental caries progression in preschool children, coupled with increased parental acceptance post-application. Thus, SDF treatment is recommended as a promising therapeutic intervention for public health dentistry in preventing dental caries among preschool children. Future research should aim to explore SDF as a non-surgical alternative through long-term, randomized, controlled trials to validate its ease of application, efficiency and acceptance compared to traditional restorative procedures for early childhood caries.

AVAILABILITY OF DATA AND MATERIALS

The data used to support the findings of this study can be made available upon request to the corresponding author.

AUTHOR CONTRIBUTIONS

BB and BT—conceived the idea, collected the data; BB—analysed the data. Both authors wrote and reviewed the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study's clinical examinations and data collection were carried out at the Department of Pediatric Dentistry, Faculty of Dentistry, Sivas Cumhuriyet University, Turkey. Ethical approval was granted by the Local Clinical Research Ethics Committee on 14 June 2022 (Approval No: 2022-06/04). Prior to any procedures, all parents or legal guardians of the participating children were informed about the study's nature, objectives and potential risks. Informed consent forms, duly signed by them, were obtained, ensuring compliance with ethical standards and respect for participant autonomy. The study has been registered in ClinicalTrials.org (ID: NCT06293547).

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Burak Buldur is serving as one of the Editorial Board members of this journal. We declare that Burak Buldur had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to GS.

REFERENCES

[1] Buldur B, Güvendi ON. Conceptual modelling of the factors affecting oral health-related quality of life in children: a path analysis. International Journal of Paediatric Dentistry. 2020; 30: 181–192.

[2] Rashewsky S, Parameswaran A, Sloane C, Ferguson F, Epstein R. Time and cost analysis: pediatric dental rehabilitation with general anesthesia in the office and the hospital settings. Anesthesia Progress. 2012; 59: 147–153.

[3] Kries T, Rupf S, Hannig M, Naim J, Gund MP. The impact of general medical health status, demographical, and patient-specific variables on need for dental treatment of children and adolescents under general anesthesia. Clinical Oral Investigations. 2023; 27: 4245–4257.

[4] Crystal YO, Chaffee BW. Silver diamine fluoride is effective in arresting caries lesions in primary teeth. Journal of Evidence-Based Dental Practice. 2018; 18: 178–180.

[5] Rosenblatt A, Stamford T, Niederman R. Silver diamine fluoride: a caries "silver-fluoride bullet". Journal of Dental Research. 2009; 88: 116–125.

[6] Soni A, Paul S, Sachdeva P. Silver diamine fluoride as a minimally invasive and aerosol free approach in pediatric dentistry: an extensive case series. Contemporary Pediatric Dentistry. 2021; 2: 113–125.

[7] Crystal YO, Niederman R. Evidence-based dentistry update on silver diamine fluoride. Dental clinics of North America. 2019; 63: 45–68.

[8] Seifo N, Robertson M, MacLean J, Blain K, Grosse S, Milne R, *et al.* The use of silver diamine fluoride (SDF) in dental practice. British Dental Journal. 2020; 228: 75–81.

[9] Crystal YO, Marghalani AA, Ureles SD, Wright JT, Sulyanto R, Divaris K, *et al.* Use of silver diamine fluoride for dental caries management in children and adolescents, including those with special health care needs. Pediatric Dentistry. 2017; 39: 135–145.

[10] Crystal YO, Rabieh S, Janal MN, Rasamimari S, Bromage TG. Silver and fluoride content and short-term stability of 38% silver diamine fluoride. The Journal of the American Dental Association. 2019; 150: 140–146.

[11] Crystal YO, Niederman R. Silver diamine fluoride treatment considerations in children's caries management. Pediatric Dentistry. 2016; 38: 466–471.

[12] Greenwall-Cohen J, Greenwall L, Barry S. Silver diamine fluoride-an overview of the literature and current clinical techniques. British Dental Journal. 2020; 228: 831–838.

[13] Hendre AD, Taylor GW, Chávez EM, Hyde S. A systematic review of silver diamine fluoride: effectiveness and application in older adults. Gerodontology. 2017; 34: 411–419.

[14] Chu C, Lo E. Promoting caries arrest in children with silver diamine fluoride: a review. Oral Health & Preventive Dentistry. 2008; 6: 315–321.

[15] Seifo N, Cassie H, Radford JR, Innes NP. Silver diamine fluoride for managing carious lesions: an umbrella review. BMC Oral Health. 2019; 19: 145.

[16] Oliveira BH, Rajendra A, Veitz-Keenan A, Niederman R. The effect of silver diamine fluoride in preventing caries in the primary dentition: a systematic review and meta-analysis. Caries research. 2019; 53: 24–32.

[17] Crystal YO, Kreider B, Raveis V. Parental expressed concerns about silver diamine fluoride (SDF) treatment. Journal of Clinical Pediatric Dentistry. 2019; 43: 155–160.

[18] Sabbagh H, Othman M, Khogeer L, Al-Harbi H, Al Harthi A, Abdulgader Yaseen Abdulgader A. Parental acceptance of silver Diamine fluoride application on primary dentition: a systematic review and meta-analysis. BMC Oral Health. 2020; 20: 227.

[19] Crystal YO, Janal MN, Hamilton DS, Niederman R. Parental perceptions

and acceptance of silver diamine fluoride staining. The Journal of the American Dental Association. 2017; 148: 510–518.e4.

[20] Mabangkhru S, Duangthip D, Chu CH, Phonghanyudh A, Jirarattanasopha V. A randomized clinical trial to arrest dentin caries in young children using silver diamine fluoride. Journal of Dentistry. 2020; 99: 103375.

[21] Pitts NB, Ekstrand KR, Foundation I. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS)—methods for staging of the caries process and enabling dentists to manage caries. Community Dentistry and Oral Epidemiology. 2013; 41: e41–e52.

[22] Clemens J, Gold J, Chaffin J. Effect and acceptance of silver diamine fluoride treatment on dental caries in primary teeth. Journal of Public Health Dentistry. 2018; 78: 63–68.

[23] Yildiz Y, Buldur B. Determination of parental perceptions towards silver diamine fluoride treatment in children. 2024. Available at: https://www.researchgate.net/publication/383219508_Determination_of_parental_perceptions_towards_silver_diamine_fluoride_treatment_in_children (Accessed: 01 April 2024).

[24] Sayed M, Matsui N, Hiraishi N, Inoue G, Nikaido T, Burrow MF, *et al.* Evaluation of discoloration of sound/demineralized root dentin with silver diamine fluoride: *in-vitro* study. Dental Materials Journal. 2019; 38: 143–149.

[25] Chhokar SK, Laughter L, Rowe DJ. Perceptions of registered dental hygienists in alternative practice regarding silver diamine fluoride. Journal of Dental Hygiene. 2017; 91: 53–60.

[26] Bagher SM, Sabbagh HJ, AlJohani SM, Alharbi G, Aldajani M, Elkhodary H. Parental acceptance of the utilization of silver diamine fluoride on their child's primary and permanent teeth. Patient Preference and Adherence. 2019; 13: 829–835.

[27] Gao SS, Zhao IS, Hiraishi N, Duangthip D, Mei M, Lo E, *et al.* Clinical trials of silver diamine fluoride in arresting caries among children: a systematic review. JDR Clinical & Translational Research. 2016; 1: 201–210.

[28] Zhi QH, Lo ECM, Lin HC. Randomized clinical trial on effectiveness of silver diamine fluoride and glass ionomer in arresting dentine caries in preschool children. Journal of Dentistry. 2012; 40: 962–967.

[29] Zheng FM, Yan IG, Duangthip D, Lo ECM, Gao SS, Chu CH. Caries prevention using silver diamine fluoride: a 12-month clinical trial. International Dental Journal. 2023; 73: 667–673.

[30] Abdellatif HM, Ali AM, Baghdady SI, ElKateb MA. Caries arrest effectiveness of silver diamine fluoride compared to alternative restorative technique: randomized clinical trial. European Archives of Paediatric Dentistry. 2021; 22: 575–585.

[31] Antonioni MB, Fontana M, Salzmann LB, Inglehart MR. Pediatric dentists' silver diamine fluoride education, knowledge, attitudes, and professional behavior: a national survey. Journal of Dental Education. 2019; 83: 173–182.

[32] Dang C, Comnick CL, Tabrizi M, Kaufman L, Soto A, Smith BM, *et al.* Assessment of knowledge and perception about silver diamine fluoride (SDF) for treating older adults among graduating dental students. Journal of Dental Education. 2020; 84: 1210–1218.

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