A Retrospective Study on Outcomes of Silver Diamine Fluoride (SDF) Treated Primary Teeth

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1 Introduction

In 2014, the U.S. Food and Drug Administration (FDA) approved SDF for dentin desensitization, and in 2016, granted it breakthrough therapy status for caries arrest, prompting further clinical trials. In 2020, the American Dental Association (ADA) supported the use of SDF for caries management, and the introduction of national billing codes such as D1354 for SDF therapy in the United States further validated its growing role in clinical practice. Despite extensive studies, the long-term effects of multiple SDF applications on primary teeth remain underexplored. This study aims to assess these outcomes in children aged 1 to 5, focusing on whether additional interventions, such as restorations or extractions, were completed after SDF application. Current guidelines exist, but comprehensive evidence-based recommendations for optimal SDF use are still lacking, underscoring the need for further research.

2 Methods

- This retrospective cohort study analyzed de-identified dental claims data from patients treated at Nicklaus Children's Hospital Dental Department (NCHDD) aged 1 to 5, who received SDF treatment (CDT code D1354) between January 2016 and December 2020. The study was approved by the Institutional Review Board at Nicklaus Children's Hospital. Inclusion criteria were: 1) patients aged 1 to 5 whose primary teeth were treated with SDF between 2016 and 2020, and 2) patients monitored for 24 months. Exclusion criteria included patients who had a restoration placed on the same tooth prior to SDF application.
- Demographic and clinical data recorded included age at initial SDF application, gender, ASA classification, tooth type and letter, number of SDF applications, dates of applications and subsequent interventions, types of interventions (e.g., resin-composite restorations, SSCs, P/SSCs, strip crowns, extractions), sedation or anesthesia dates, Frankl score, and recall/follow-up visits. Data were retrieved from Dentrix Enterprise 8.0 electronic dental records.
- The primary outcome was whether any additional intervention (e.g., composites, SSCs, P/SSCs, strip crowns, extractions) occurred within 24 months after SDF application. Secondary outcomes included associations between patient age, ASA classification, and the number of SDF applications, as well as the relationship between the number of SDF applications and the likelihood of an additional intervention. Tooth type and ASA classification were also examined for their influence on the likelihood of receiving an intervention. Additionally, the time from first SDF application to first intervention, sedation, or general anesthesia was assessed as separate outcome measures.
- Descriptive statistics (frequencies for categorical variables; means ± SD for quantitative variables) summarized the data. Chi-square tests and odds ratios assessed differences in age and SDF applications. Bivariate analysis used Pearson's chi-square test and odds ratios with confidence intervals for secondary outcomes. Multivariable analysis included a Cochran–Mantel–Haenszel test to assess the association between the second SDF application and the first intervention, stratified by ASA. Logistic regression evaluated age and ASA as predictors of the second SDF application, and a second model assessed their association with the likelihood of receiving the additional intervention. A p-value <0.05 was considered significant. Analyses were conducted using IBM SPSS Statistics v29.0.2.0.

3. Results

- The analysis included 182 patients (46.7% female, 53.3% male) (Table 1), with 36% receiving one SDF application, 64% a second, 11% a third, and 2% a fourth. Posterior teeth were 3.59 times more likely to receive an additional intervention than anterior teeth (OR = 3.59, P < .001). Among patients requiring sedation, 12.1% received oral conscious sedation and 18.7% underwent general anesthesia, with an average intervention delay of 14 and 13 months, respectively.

Table 1. Sample Characteristics and Univariate Descriptive Statistics

Characteristic	No. (%)
Sex	
Female	85 (46.7)
Male	97 (53.3)
Age	
1	6 (3.3)
2	49 (26.9)
3	57 (31.3)
4	33 (18.1)
5	37 (20.3)
ASA	
I	123 (67.6)
II	47 (25.8)
III	12 (6.6)

Table 2. Pearson Chi-Square Analysis of ASA and Age in Relation to Second SDF Application

Index	Yes 2nd Application, no. (%)	No 2nd Application, no. (%)	p-Value
ASA			
I	72 (58.5)	51 (41.5)	.019
II	36 (76.6)	11 (23.4)	
III	7 (58.3)	5 (41.7)	
AGE			
1	6 (100)	0 (0)	0.009
2	36 (73.5)	13 (26.5)	
3	41 (71.9)	16 (28.1)	
4	18 (54.5)	15 (45.5)	
5	16 (43.2)	21 (56.8)	

Table 3. Logistic Regression Analysis of Age and ASA Classification in Relation to the Second SDF Application

	Adjusted Odds Ratio (aOR)	95% C.I. for aOR Lower	Upper	p-Value
AGE				.013
1-5	6.769	.697	65.713	.099
2-5	3.946	1.556	10.007	.004
3-5	3.385	1.390	8.242	.007
4-5	1.464	.555	3.861	.441
ASA				.038
II-I	2.677	1.203	5.955	.016
III-I	2.253	.556	9.134	.255

- Table 2 presents the Pearson chi-square analysis of ASA and age in relation to second SDF application; these variables are further analyzed in the logistic regression presented in Table 3. Age was significantly associated with second SDF application rates (P = 0.009), with younger children receiving it more often. ASA II patients were 2.30 times more likely to receive a second application (P = 0.019) and had a 63% lower likelihood of additional intervention than ASA I patients (P = 0.002). Patients receiving a second SDF application had 50% lower odds of first intervention (P = 0.026).

Table 4. Pearson Chi-Square Analysis of Age, ASA and Second SDF Application in Relation to First Intervention

Index	Yes 1st Intervention, no. (%)	No 1st Intervention, no. (%)	p-Value
2nd SDF application			
Yes	62 (53.4)	54 (46.6)	.026
No	24 (36.4)	42 (63.6)	
ASA			
I	75 (61.0)	48 (39.0)	.002
II	17 (36.2)	30 (63.8)	
AGE			
1	2 (33.3)	4 (66.7)	.174
2	29 (59.2)	20 (40.8)	
3	32 (56.1)	25 (43.9)	
4	18 (54.5)	15 (45.5)	
5	15 (40.5)	22 (59.5)	

Table 5. Logistic Regression Analysis of Age, ASA Classification, and Second SDF Application Associated with Likelihood of First Intervention

	Adjusted Odds Ratio (aOR)	95% C.I. for aOR Lower	Upper	p-Value
Age				.070
(1&2-3)	.820	.372	1.809	.623
(1&2-4)	.674	.263	1.725	.410
(1&2-5)	.291	.113	.748	.010
ASA	.394	.201	.771	.007
2nd SDF application	.391	.193	.793	.009

- Table 3 revealed that age adjusted for ASA was a statistically significant predictor of receiving a second SDF application (p = 0.013). Table 3 also showed that ASA status significantly predicted a second SDF application (p = 0.038); individuals with ASA II were 2.67 times more likely to receive it than those with ASA I (OR = 2.67, p = 0.016). Table 4 presents the Pearson chi-square analysis of age, ASA and second SDF application in relation to the additional intervention; these variables are further analyzed in the logistic regression presented in Table 5. Table 5 showed that specifically, children aged (1 and 2 vs. 5) years had significantly lower odds of receiving the additional intervention compared to other age groups, being 70.9% less likely to receive the additional intervention (aOR = 0.291, p = 0.010), higher ASA status reduced additional intervention likelihood by 60.6% (aOR = 0.394, p = 0.007), and a second SDF application decreased intervention odds by 60.9% (aOR = 0.391, p = 0.009).

4. Discussion

- SDF (38%) is known to be effective for caries arrest in primary teeth, but long-term outcomes, particularly with 1, 2, 3, or 4 applications over 24 months, remain underexplored. This study aimed to address this by analyzing how age, ASA classification, number of SDF applications, and tooth type influenced whether or not additional interventions (e.g., composites, crowns, extractions) were needed within 24 months. The findings offer valuable insights for clinicians and contribute to refining SDF guidelines with evidence-based recommendations.
- In this study, posterior primary teeth treated with SDF were 3.59 times more likely to require a first intervention compared to anterior teeth (OR = 3.59, P < .001), supporting previous research on SDF's lower effectiveness in posterior teeth. Clinicians should be mindful of this when applying SDF to posterior teeth and prioritize optimizing moisture control, especially in cases with limited patient cooperation. Age was also found to influence the rate of second SDF applications (P = .009), with younger children receiving more applications, suggesting that improved behavior with age may lead to alternative treatments. These findings emphasize that SDF use should not decline with age, and this option should always be presented to parents, if applicable, for consideration.
- Our study found that the average delay to the additional intervention was 14 months for patients who received sedation and 13 months for those who underwent general anesthesia, which is beneficial for minimizing risks and improving outcomes, especially in children under age 3. Additionally, as the first study to evaluate how ASA classification influences the application of SDF, we found that ASA II patients were 2.30 times more likely to receive a second SDF application (P = .019) and 63% less likely to undergo an additional intervention (P = .002). These findings emphasize the significance of SDF as an important minimally invasive treatment option, particularly for medically complex patients.
- Our study found that the likelihood of requiring an additional intervention was approximately 50% lower when a second SDF application was administered (P = .026), supporting previous research that shows two applications are more effective than one. These findings provide valuable evidence to inform clinical decision-making and guide discussions with parents, highlighting the importance of follow-up SDF applications for optimal caries management. However, the study's short follow-up and lack of data on the reasons for additional interventions are limitations. Future research with longer follow-ups and more detailed patient records could provide deeper insights into long-term effects and treatment decisions.

5. Conclusions

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Based on the study's results, the following conclusions can be drawn:

- Age significantly influenced the rate of the second SDF application, with younger children more likely to receive a second SDF application (P = 0.009).
- ASA II patients were 2.30 times more likely to receive a second SDF application (P = 0.019) and 63% less likely to require the additional intervention (P = 0.002).
- Receiving a second SDF application reduced the likelihood of needing an additional intervention by 50% (P = 0.026).

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