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Introduction

- In 2014, the US Food and Drug Administration approved usage of silver diamine fluoride (SDF) as a desensitizing agent; it is used off-label as a caries prevention and arresting agent.¹
- 38% ,44,800 ppm fluoride SDF is most commonly used.² In this configuration at pH 10, it is composed of 25% silver, 8% ammonia, 5% fluoride, and 62% water. The silver component of SDF has antimicrobial properties.³ Silver directly kills the bacteria and also works synergistically with fluoride to prevent caries by inhibiting demineralization.¹
- SDF can have an unpleasant metallic taste and also leave a permanent black-brown stain on the carious tooth.² Dark staining is one of the clinical markers that indicate potential caries arrest.⁴
- SDF is an effective caries management tool in the proper context.⁴
- SDF is effective in preventing and arresting caries. Compared to no treatment, placebo, and fluoride varnish application, SDF was found to be significantly more effective in preventing dentinal caries.⁵ Over a 12 month follow-up, SDF had 66% higher rate of caries arrest compared to other active materials and 154% higher when compared to placebo.⁶ Annual application of SDF was found to be more effective than application of 5% sodium fluoride varnish four times per year.⁴ The highest dentinal caries arrest rate was found in semi-annual application of SDF.^{7,8}
- Depending on location and size of lesion, the effectiveness of one-time SDF application was between 47-90 percent; increased frequency of application resulted in increased caries arrest rate.⁴
- If possible, the recommendation is to re-evaluate caries arrest after 2-4 weeks since first SDF application and reapply as needed, and then based on patient's disease activity and caries risk level, establish a re-care regimen of every three, four, or six months.⁴
- Studies have predominantly focused on SDF's efficacy in arresting cavitations on non-interproximal surfaces. One retrospective chart analysis from 2020 found SDF to be effective in arresting 84% of interproximal lesions on primary molars and canines at 12-month follow-up period.⁹ There remains a lack of literature on effectiveness of SDF as it relates to arresting interproximal lesions on primary molars and permanent first molars, specifically with a focus on incipient lesions.

Objectives

Primary: evaluate the radiographic success of SDF in arresting interproximal incipient lesions on primary molars and permanent first molars

Exploratory: assess factors which may affect the efficacy of SDF

Study Design / Method

This study was conducted as a retrospective chart review. The review was conducted by a single study personnel. Study subjects were patients 4 - 9 years of age, who were seen at the Montefiore Medical Center Pediatric Dentistry Clinics, and received SDF treatment during the period of July 1, 2020 to July 1, 2021. The patients were further filtered according to the following inclusion and exclusion criteria:

Inclusion Criteria

- Complete record of treatment
- Initial SDF application occurred between July 1, 2020 to July 1, 2021 and SDF was placed on interproximal incipient lesion(s) of primary molar(s) and/or permanent first molar(s)
- Pre-treatment radiographs taken during initial SDF application visit
- Post-treatment radiographs taken at least 6 months after initial SDF application
- Pre and post treatment radiographs were bitewings

Exclusion Criteria

- Primary molar(s) and/or permanent first molar(s) with interproximal cavitated lesions at the time of pre-treatment radiographs
- Primary molar(s) and/or permanent first molar(s) with adjacent interproximal lesions at the time of pre-treatment radiographs
- Primary molar(s) and/or permanent first molar(s) with occlusal, buccal, or lingual cavitation at the time of pre-treatment radiographs
- Incipient interproximal lesion restored or tooth exfoliated before post-treatment radiographs
- Radiographs were not diagnostic
- Post-treatment radiographs were unavailable for assessment due to patient not returning for follow-up
- Patient was prescribed fluoride containing product for at home use (e.g. 1.1% sodium fluoride toothpaste, such as *PreviDent 5000*) prior to post-treatment radiographs

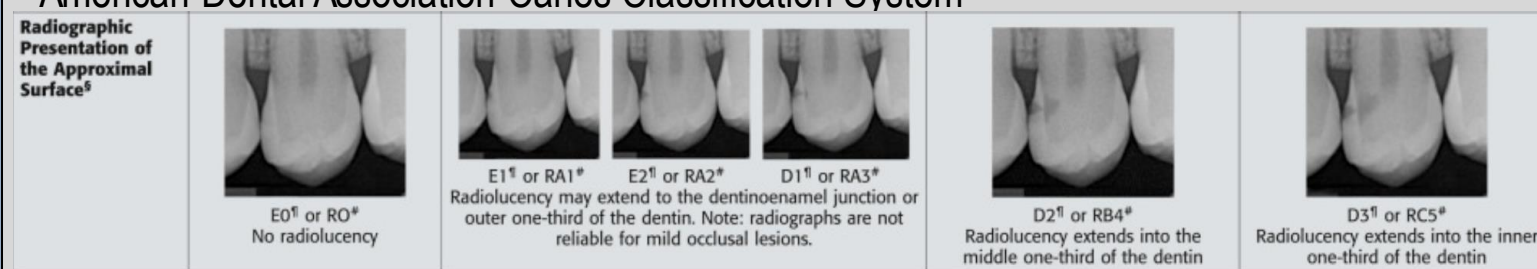
Behavior rating and oral hygiene rating were collected for each patient. Behavior was assessed and recorded using the Frankl behavior rating scale where Frankl scores are defined as follows: 1- definitely negative, 2- negative, 3- positive, or 4- definitely positive. Frankl scores of 1 and 2 were grouped together, as were 3 and 4. Oral hygiene was indicated by poor, fair or good; fair and good were grouped together.

The frequency of SDF applications between pre and post treatment radiographs was noted. The number of months between pre and post treatment radiographs was noted.

Pre and post treatment radiographs were assessed and compared. Interproximal incipient lesions of permanent first molars and primary first and second molars on pre-treatment radiographs were classified according to the American Dental Association Caries Classification System using E0, E1, E2, D1, D2, or D3 designation (see below).¹⁰ If a lesion fell between two classifications, the higher designation was selected. The caries was re-evaluated in post-treatment radiographs and re-classified according to the same classification system. Remaining the same caries classification constituted success; a higher caries classification signified failure.

The data was analyzed to determine the radiographic success rate of SDF and to assess the effect of selected patient characteristics on overall radiographic success rate. Descriptive statistics was employed to characterize the study population, mean or median for continuous variables, and frequency (%) for discrete variables.

American Dental Association Caries Classification System¹⁰



Tables

Table 1. Overall distribution

Variable	N = 65
Age	6 (5, 7) ^[IQR] ¹
Frankl Score	
1 or 2	11 (17%)
3 or 4	54 (83%)
Oral Hygiene	
poor	8 (12%)
fair or good	57 (88%)
Tooth	
primary first molar	25 (38%)
primary second molar	40 (62%)
permanent first molar	0 (0%)
Pre-SDF treatment	
E1	30 (46%)
E2	35 (54%)
Post-SDF treatment	
E1	18 (28%)
E2	38 (58%)
D1	6 (9.2%)
D2	2 (3.1%)
D3	1 (1.5%)
Outcome	
Success	47 (72%)
Failure	18 (28%)
Frequency	
1	50 (77%)
2	15 (23%)
Months	10 (8, 15)

¹Median (IQR); n (%)

Table 2. Association between selected patient characteristics and treatment success.

Variables	OR [†]	95% CI [†]	p-value
Frankl Score			
1 or 2	—	—	
3 or 4	^[IQR] 1.25	(0.45, 3.46)	0.7
Frequency			
1	—	—	
2	0.78	(0.23, 2.59)	0.7
Oral Hygiene			
poor	—	—	
fair or good	2.42	(0.72, 8.17)	0.2
Months			
≤ 10	—	—	
> 10	0.70	(0.24, 2.04)	0.5

[†]OR = Odds Ratio, CI = Confidence Interval

Results

A total of 1,453 dental records were reviewed. Of the 1,453 records, 51 patients met the inclusion and exclusion criteria, which included 65 teeth. Median age of the patients was 6 years; 25% of the patients were younger than age 5 and 75% were younger than age 7. Majority of the patients had fair or good oral hygiene (n=57, 88%) and were given Frankl scores of 3 or 4 (n=54, 83%). (Table 1)

Of the 65 teeth, 25 (38%) were primary first molars, 40 (62%) were primary second molars, and 0 (0%) were permanent first molars. There was a similar amount of E1 (n=30, 46%) and E2 (n=35, 54%) lesions in the pre-treatment radiographs. A median of 10 months passed between pre and post treatment radiographs; 25% was less than 8 months and 75% was less than 15 months. Majority of the teeth had one application of SDF between pre and post treatment radiographs (n=50, 77%), while the remainder had two applications (n=15, 23%). (Table 1)

Overall success rate of treatment was 73.4% (95% CI: 62.4%, 82.0%). Treatment success rate restricted to primary first molar was 84.7% (95% CI: 65.7%, 94.1%). Treatment success rate restricted to primary second molar was 67.4% (95% CI: 52.0%, 79.8%).

Caution should be observed in interpreting the exploratory results in Table 2. None of the selected patient characteristics were significantly associated with treatment success rate (significance claimed at $\alpha=0.05$ level). The confidence intervals are wide (covering both positive and negative associations). The results entail a high degree of uncertainty.

Discussion

Overall success rate of the treatment was high (73.4% ; 95% CI: 62.4% , 82.0%). A higher success rate was observed for primary first molars (84.7% ; 95% CI: 65.7% , 94.1%) compared to primary second molars (67.4% ; 95% CI: 52.0% , 79.8%). No permanent first molars met the criteria to be included in the study. The majority of patients received only one application of SDF (n=50, 77%) with an overall median of 10 months between pre and post treatment radiographs. The success rate was high even for only one application of SDF.

None of the selected patient characteristics were significantly associated with treatment success rate (significance claimed at $\alpha=0.05$ level) (Table 2). The confidence intervals were wide and covered all possibilities from negative to positive associations. Therefore, one should be cautious of interpreting the exploratory results in table 2. However, Frankl scores of 3 or 4 and oral hygiene ratings of fair or good were positively associated with successful treatment (OR=1.25, 2.42, respectively). There was a negative association between the number of months (when > 10) between pre and post treatment radiographs and treatment success (OR=0.70). There was also a negative association between frequency of SDF application and treatment success (OR=0.78), which was counter-intuitive because one would expect increased frequency of application to increase odds of success.

Limitations of the study include a relatively small sample size, inter-operator differences in caries diagnosis and procedural preference(s) (e.g. some providers may prefer to apply fluoride varnish after SDF application; the standard is to apply interproximal SDF with *Superfloss* at Montefiore), inability to control for changes in home oral hygiene practices (*PreviDent 5000* was excluded), potential differences in degree of interproximal contacts (lower age limit of 4 years was set when posterior contacts are likely closed; mandibular primate space), and variations in angulation of bitewings which may have affected interpretation of the radiographic lesions.

Conclusion

SDF showed to be effective in arresting interproximal incipient lesions, even though the majority of patients received only one application of SDF, with an overall median of 10 months between pre and post treatment radiographs. Future research studies should target a much larger sample size and can assess efficacy of SDF in arresting interproximal incipient lesions on permanent first molars too, as well as SDF efficacy over a longer duration of time, and with different frequency of application.

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