COHORT STUDY

Silver Diamine Fluoride Helps Prevent Emergency Visits in Children with Early Childhood Caries

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Abstract: ***Purpose:*** *Early childhood caries remains a worldwide disease and often requires treatment under sedation or general anesthesia, with long waitlists. Silver diamine fluoride has been shown to arrest caries lesions. The purpose of this study was to determine whether silver diamine fluoride (SDF) application reduces emergency visits by waitlisted patients with early childhood caries (ECC).* ***Methods:*** *Waitlisted patients aged zero to 71 months with ECC who were treated with SDF were enrolled at the University of Florida's NCEF Pediatric Dental Center; their cumulative incidence of dental emergencies were compared with children who were waitlisted during the 16 months preceding the introduction of SDF. Data from patient records on demographics, dental visits, SDF placement, and caries arrest were abstracted. Bivariate analyses and multiple logistic regression modeling were performed.* ***Results:*** *Participants included 97 patients treated with SDF and 216 not treated with SDF. The cumulative incidence of dental emergencies was approximately 80 percent lower in the SDF group than in the comparison group (4.1 percent versus 17.6 percent; adjusted odds ratio equals 0.18; 95 percent confidence interval equals 0.06 to 0.54); 81 percent of SDF-treated surfaces were arrested at a follow-up visit.* ***Conclusions:*** *Silver diamine fluoride helps reduce emergency visits for children with early childhood caries while on treatment waitlists and confirms the effectiveness of SDF for caries arrest in primary teeth. (Pediatr Dent 2020;42(3):217-20) Received December 13, 2019 / Last Revision March 19 / Accepted March 23, 2020*

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Early childhood caries (**ECC**) is a disease affecting infants and preschool-aged children throughout the world.[1] ECC is defined by the American Academy of Pediatric Dentistry (**AAPD**) as "the presence of one or more decayed, missing, or filled tooth surfaces in any primary tooth in a child 71 months old or younger,[2] but the effects of ECC do not stop at the age of its defined termination. In fact, it is estimated that 60 to 90 percent of school-aged children experience dental caries worldwide.[3] ECC also has considerable consequences for those suffering from the disease, including decreased body weight, decreased growth, and decreased quality of life.[4]

Many ECC cases require treatment under sedation or general anesthesia due to the extent of the procedures needed as well as the inability of the young child to cooperate in a routine dental setting.[5] Due to increased demand and limitations on provider operating room time or sedation appointments, there are months-long waitlists for advanced sedation services and long delays in treatment. One study cited wait times up to two years in some jurisdictions in Australia.[6] As waitlists develop and increase, the patient's condition may progress, leading to symptoms of pain or acute infection before they are seen for definitive treatment.[7]

Silver diamine fluoride (**SDF**) is a caries-arresting agent with antibacterial and remineralizing properties.[8] It has had approval for use as a therapeutic agent in Japan since the 1960s and has also been used to treat dental caries in Argentina, Australia, Brazil, and China for many years.[9] In 2009, a study was published stating that SDF was a nonsurgical intervention that appeared to be almost twice as effective as fluoride varnish for caries arrest.[10] In 2014, the U.S. Food and Drug Administration approved the use of SDF in the United States.[11] A systematic literature review published in 2017 concluded that SDF showed potential as an alternative treatment for caries arrest,[12] and the 2017 AAPD Clinical Practice Guideline on SDF estimated that 68 percent of cavitated lesions in primary teeth would be expected to be arrested two years after SDF application.[11] In 2018, a systematic review and meta-analysis further confirmed SDF's ability to arrest cavitated carious lesions in primary teeth but stated that more studies were needed to fully assess its effectiveness.[13]

The purpose of this study was to determine whether the application of silver diamine fluoride reduced emergency visits, due to pain or acute infection, by zero- to 71-month-old patients with early childhood caries who were on a sedation or general anesthesia treatment waitlist.

Methods

This study used a prospective cohort design with a historic comparison group to compare differences in the cumulative incidence of dental emergencies associated with SDF application while young children were on a waitlist for dental treatment.

Treatment group. The University of Florida/Naples Children and Education Foundation (**UF/NCEF**) Pediatric Dental Center in Naples, Fla., USA, incorporated the use of

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SDF in the clinic in July 2016. For this study, the authors enrolled Pediatric Dental Center patients aged 71 months or younger who were diagnosed with ECC by clinical and radiographic examination in the clinic and who were placed on waitlists for treatment under oral sedation, intravenous sedation, or general anesthesia between July 21, 2016, and November 27, 2018. Patients with a history of previous dental restorations, medical complexities (ASA II-IV), or previous placement of SDF at another office were excluded from the study. The attending pediatric dental resident provided the parent with information regarding risks, benefits, and alternatives to the placement of SDF. After obtaining the parent's or legal guardian's informed consent for treatment, the resident applied SDF (38 percent SDF, Advantage Arrest, Elevate Oral Care, West Palm Beach, Fla.) on cavitated lesions that did not show clinical signs of pulpal involvement, per American Dental Association and AAPD guidelines.[11,14] SDF was applied following the University of Florida Department of Pediatric Dentistry's protocol, as shown in the Figure.

The participants were asked to return after three months and six months for follow-up examinations to evaluate caries arrest. SDF was reapplied at reevaluation appointments if caries was not arrested at that time unless clinical signs of pulpal involvement were noted. All reapplications were recorded in patients' records. Data on caries arrest status and SDF reapplication were recorded in patients' electronic dental records.

Parents who agreed to enroll their children in this study provided their informed consent to have data from the child's dental record included in data analysis. The authors abstracted data from electronic dental records on the patients' demographic characteristics (age, sex, and race/ethnicity), dental visits (treatment dates, dental diagnosis, reason for visit, presence of symptoms, surfaces where caries was present), SDF application, SDF reapplication, and caries arrest. The authors considered a visit to the Pediatric Dental Center to be an emergency visit if the chief complaint at that visit was related to dental pain or acute infection and was not related to trauma.

Comparison group. The authors compared the cumulative incidence of dental emergency visits following SDF application with the cumulative incidence of emergencies in a historical comparison group. The comparison group was comprised of children aged 71 months or younger placed on a waitlist for treatment under sedation or general anesthesia who had had their initial visit to the clinic between March 1, 2015, and July 8, 2016, 16 months before SDF was introduced in the Pediatric Dental Center. During that period, children typically returned to the clinic every three to four months for parental instructions and application of five percent sodium fluoride varnish.

I. Prophylaxis or cleaning (wet gauze) to remove residual food and debris. Carious tissue does not need to be removed.

II. Protect soft tissue during application with the placement of Vaseline as well as isolation with cotton rolls and gauze as needed.

III. Gently apply the SDF with a micro brush for one minute.

IV. Wipe off the excess SDF with wet gauze.

Figure. Silver diamine fluoride (SDF) protocol used in the University of Florida NCEF Pediatric Dental Center.

Data analysis. The authors conducted univariate and bivariate analyses to describe the demographic characteristics of the SDF treatment group and the comparison group and to test the association between SDF application and the cumulative incidence of dental emergencies while on a waiting list for treatment. Multiple logistic regression analysis was used to examine the association between SDF treatment and the occurrence of a dental emergency while on a waiting list for dental treatment, adjusting for age, sex, and race/ethnicity. We calculated mean wait times between the first clinic visit and the date of treatment completion under sedation or general anesthesia for the SDF-treated group and the historic comparison group.

This study was approved by the Institutional Review Board of the University of Florida, Gainesville, Fla., USA (protocols IRB201601449 and IRB201600290).

Results

Study participants in the SDF treatment group included 97 patients (46 females and 51 males) aged 13 to 71 months, with a mean age of 39.8 months (Table 1). The comparison group included 216 children in the same age range as the SDF treatment group, although the comparison group had a significantly higher mean age (47.4 months; $P<0.0001$). Reflecting the clinic's patient population, the large majority of patients in each group were Hispanic/Latino. There was no significant difference between the two groups on sex or race/ethnicity.

There was no significant difference between the groups in the number of days on the waiting list between initial examination and dental treatment under sedation or general anesthesia (196.5 versus 194.6; $P=0.93$). However, there was a large and statistically significant difference between groups in the

Table 1. SELECTED CHARACTERISTICS OF STUDY PARTICIPANTS, BY SILVER DIAMINE FLUORIDE TREATMENT STATUS

Characteristic	Silver diamine fluoride		No silver diamine fluoride		*P*-value*
	N	%	N	%	
Age (months)					<0.0001
13-36	40	41.2	46	21.3	
37-54	46	47.4	105	48.6	
55-71	11	11.3	65	30.1	
Sex					0.52
Female	46	47.4	94	43.5	
Male	51	52.6	122	54.5	
Race/ethnicity					0.07
Hispanic/Latino	80	82.5	156	72.2	
Black/African American, non-Hispanic	5	5.1	14	6.5	
White, non-Hispanic	7	7.2	39	18.1	
Other or not reported	5	5.1	7	3.2	
Total	**97**	**100.0**	**216**	**100.0**	

* Chi-square test.

Table 2. ASSOCIATION BETWEEN SILVER DIAMINE FLUORIDE (SDF) TREATMENT STATUS AND CUMULATIVE INCIDENCE OF DENTAL EMERGENCIES

Treatment group	No. of patients	Mean time on waitlist (days)	No. of dental emergencies while on waitlist	Cumulative incidence of dental emergencies (%)	Crude odds ratio (95% confidence interval)	Adjusted odds ratio* (95% confidence interval)
No SDF	216	196.5	38	17.6	1	1
SDF	97	194.6	4	4.1	0.20 (0.07, 0.58)	0.18 (0.06, 0.54)

* Adjusted for age, sex, and race/ethnicity in multiple logistic regression model.

cumulative incidence of dental emergencies presenting at the clinic while on the waiting lists: 17.6 percent of children who had been on the waiting list during the 16 months before SDF was introduced in the clinic experienced a dental emergency versus 4.1 percent of children who received SDF applications while on the waiting list (chi-square test; P=0.0001). Because of significant differences in the age distributions of the two groups, the authors also conducted a stratified analysis in which the bivariate analyses were stratified across three age groups (13 to 36 months, 37 to 54 months, and 55 to 71 months).

The association between SDF treatment status and dental emergencies was consistent within each age stratum and remained highly significant: the Mantel-Haenszel summary odds ratio (OR) and 95 percent confidence interval (**95% CI**) for the SDF group relative to the comparison group equals 0.19 (95% CI equals 0.06 to 0.56). The authors also used multiple logistic regression modeling to control for age (as an interval-level variable), sex, and race/ethnicity (Table 2). The findings were nearly identical to those from the stratified analysis: odds ratio equals 0.18; 95% CI equals 0.06 to 0.54).

Of the 97 children in the SDF treatment group, tooth surface-specific data for the SDF application was recorded for 53 children. Those 53 children had a total of 409 tooth surfaces treated with SDF. Of those surfaces, 331 (81 percent) were recorded as arrested at a follow-up visit.

Discussion

Aside from arresting caries, this study shows that when used as an interim treatment, SDF assists in reducing emergency visits due to pain or acute infection while patients wait for their definitive dental treatment. The authors observed a greater than 80 percent decline in the incidence of dental emergencies after adopting SDF in the Pediatric Dental Center compared with the period immediately preceding its adoption. There was a dramatic reduction in the number and rate of patients suffering from pain or acute infection while waiting for their treatment and a reduced need to frequently rearrange the waiting lists in order to prioritize acute problems. With waiting lists and ECC persisting, the results suggest that an effective, inexpensive, and minimally invasive strategy to managing ECC patients awaits more definitive treatment. This study's findings further support an AAPD listed indication of SDF being well-suited for "patients without access to or with difficulty accessing dental care,"[11] a category that is certainly applicable to patients on waiting lists without resources to expedite their treatment.

Furthermore, due to SDF's documented ability both to arrest caries and significantly reduce emergency visits, its use may be further considered not just as an interim treatment for those on a sedation waiting list but for young patients waiting to mature before performing the treatment in a routine dental setting rather than under sedation or general anesthesia. SDF also may be used to delay treatment under sedation or general anesthesia until all primary teeth have fully erupted to minimize multiple exposures to these agents in the highest risk patients. In some situations, caries management with SDF may replace waitlists and sedation for many young children altogether. However, SDF does not restore tooth structure that has been destroyed by dental caries. Cavitated caries lesions in the dentin will continue to collect food and plaque, and SDF may need to be reapplied periodically if caries becomes active once again. Consequently, SDF application does not necessarily eliminate the need for dental restoration, and children whose teeth were treated with SDF will still need routine diagnostic and preventive dental services.

The 2018 International Association of Paediatric Dentistry conference on early childhood caries highlighted the slow progress in the global prevention and management of ECC, stating that ECC continues to be highly prevalent throughout the world.[15] For this reason, in combination with often-limited operating room access and sedation appointment availability, it is not surprising that general anesthesia and sedation waitlists continue to persist for those requiring comprehensive dental treatment due to ECC. The length of wait time can vary. One study in England cited a six-month wait[16]; another in Australia had a wait time of up to two years,[6] while the present study had a mean wait-time of more than six months.

Unfortunately, the consequences suffered by ECC patients awaiting treatment are not insignificant, and many are associated with pain or discomfort that the patient may experience, including difficulties eating, loss of appetite and weight, irritability, and difficulty sleeping.[17] One study on the effects of a long wait for pediatric patients on a general anesthesia waitlist stated that it was clear that dental pain and infection were major issues while patients waited for treatment and reported 41 percent of subjects requiring analgesics, 28.5 percent losing sleep, one third having problems eating, and nearly half of patients being prescribed at least one round of antibiotics during their wait.[16] This information helps explain the data collected in this baseline present study before SDF was available, which showed that approximately 18 percent of patients required an emergency appointment due to pain or acute infection while waiting for treatment on a sedation or general anesthesia waitlist. With the persistence of treatment waitlists and a clear array of negative consequences, there is a definite need for a successful interim solution.

The results of the present study are consistent with prior studies regarding the ability of SDF to arrest caries.[10-13] In the present study, SDF application was associated with an 81 percent caries arrest rate, comparable to the findings in those prior studies. This emphasizes the aptitude of SDF to significantly aid in reducing the progression of caries in a simple, noninvasive fashion amenable for use in even the youngest of patients.

There are limitations to the present study that should be considered when interpreting its findings. In particular, this study used an observational study design rather than an experimental study design and employed a historic comparison group rather than a contemporaneous comparison group. Those decisions were based on considerations of ethics and feasibility. First, SDF has been determined as efficacious for caries arrest in young children by multiple systematic reviews[12,13] and evidence-based clinical guidelines.[11,14] At this point, it would not be considered ethical to randomize children to an inert placebo rather than SDF for the management of active caries. Second, once the caries management protocol had been adopted by the clinic, there was no practical way to establish a contemporaneous comparison group because nearly all children on the waitlists for sedation or general anesthesia received the same management protocol. The best that could be done under such circumstances was to compare the rate of dental emergencies after SDF had been introduced in the clinic with the rate that had been observed just before that time. It also should be noted that the previous management protocol for children on the waitlists was essentially the same before SDF was introduced, except that five percent sodium fluoride varnish was applied every three to four months instead of SDF.

Regardless of how the definitive treatment is completed, the data from our study should be included as a key part of the informed consent conversation. It is recommended to show parents clinical photos so that they may see examples of the appearance of teeth after placement of SDF and also to emphasize the ultimate goal of the definitive treatment that the placement of SDF may help support.[11] With a high caries arrest rate, a tooth will more likely be restorable at the time of the more definitive treatment. Additionally, placement of SDF means a significantly lower likelihood of needing an emergency appointment due to pain or acute infection; these are fundamental points when discussing potential placement of SDF with parents, especially as an interim treatment.

Conclusions

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

1. Silver diamine fluoride may be a viable solution to help reduce emergency visits for children with early childhood caries while on a sedation or general anesthesia waitlist.
2. This study is consistent with other studies in demonstrating that SDF is effective for arresting caries lesions in primary teeth.

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