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Comparison of Different Fluoride Solutions Application on Dentin Caries Lesions in Primary Teeth

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ABSTRACT

Aim: *The aim of this clinical study was to evaluate the effectiveness of four different topical fluoride agents in arresting primary active dentin caries lesions.*

Methods: *Children aged 3-5 years who had at least one active dentin caries lesion were included in this study for a period of 24 months. Teeth were randomly allocated into 4 groups: Group (1): 38% silver diamine fluoride (SDF), Group (2): 5% sodium fluoride (NaF), Group (3): amine fluoride (1250 ppm) and Group 4: 1,23% acidulated phosphate fluoride (APF). Children were evaluated every 6 months to assess whether the treated lesions had become arrested.*

Results: *A total of 124 children (male: 66, female: 58) with 1120 tooth surfaces with dentine caries received treatment at baseline. After 24 months, 122 children with 1115 dentin caries lesions remained in the study. The carries arrest rates at tooth surface level were 55%, 43%, 34% and 26% for Groups 1, 2, 3 and 4, respectively. This study showed that SDF application could arrest more dentine caries lesions compared with the NaF, AmF and APF application. Presence of plaque on lesion, tooth type, tooth surface and other variables including demographic background, oral health related behaviours, and baseline caries experience had no statistically significant effects on caries arrest rates.*

Conclusion: *SDF appliation is more effective in arresting dentine caries lesions in primary teeth than NaF, AmF and APF application.*

Keywords

Fluorides, Dentine caries, Primary teeth, Clinical trial, Caries arrest.

Introduction

Dental caries is one of the most prevalent chronic diseases in childhood (aged 2-5 years) with varying degree of severity [1]. Dental caries is common among children with lower socioeconomic status [2]. Pharmalogical behaviour management techniques, including sedation and general anesthesia are used for the treatment of dental caries in children under the age of 3 years because of their young age and uncooperative behaviours [3]. This technique is very expensive for patients managenent and requires surgical equipment, special dental equipment and advanced skills of clinicians [4]. Fluoride agents containing 1000 ppm of fluoride have been recommended for all age groups due to its effectiveness in reducing caries [5].

Fluoride is the most commonly used compound to promote remineralization by forming fluorohydroxyapatite crystals [5,6]. A number of dental researchers have demonstrated flüoride prevents and arrests dental caries lesions [7]. Non-invasive intervention with, fluoride agents, such as toothpaste, gel, foam, mouth rinse, solution, varnish, drops and tablets, has been used to prevent and arrest dental caries lesions over the past 25 years [8,9]. It is cost effective and easily operated [11]. Different fluoride formulations,

such as sodium fluoride (NaF), sodium monofluorophosphate (Na_2PO_3F), acidulated fluorophosphate (APF), stannous fluoride (SnF_2), titanium tetrafluoride (TiF_4), amine fluoride (AmF), and silver diamine fluoride (SDF) are used as topical fluoride products in dentistry [9-11].

High-concentration topical fluoride agents, such as 5% sodium fluoride (NaF) varnish containing 22,600 ppm fluoride and 38% silver diamine fluoride (SDF) solution containing 44,800 ppm fluorid, have been used to arrest caries. Clinical studies have indicated encouraging results after topical application of SDF solution or NaF varnish [12].

Silver diamine fluoride (SDF) is a translucent solution used for professional topical fluoride application in several countries since 1969 [1,10]. There are several studies indicating application of SDF arrest or stop progression of dental caries lesions in a high percentage of cases (30%-70%). It is also suggested that repeated applications increase the caries lesion arrest rate. Treated caries lesions become hard and black when the application is succesful. In some cases, arrested caries lesions may become caries active. The application of SDF prevent or delay surgical intervention until after the age of 3 years; therefore, it is an alternative treatment to managing caries in the very young pediatric population [1].

Different concentrations of SDF solutions (12%, 30% and 38%) are commercially available [11]. SDF at a concentration of 38% contains 25% silver, 5% fluoride, 8% amine and 62% water [13]. SDF 38% solution has the highest fluoride concentration (44,800 ppm) and it is about twice 5% NaF varnish (22,600 ppm) [14,15]. Randomized clinical trials have reported that SDF is more effective than 5% sodium fluoride (NaF) varnish in arresting dental caries [16]. SDF at 38% has been used to arrest dentin caries of primary teeth in children, prevent pit and fissure caries of the erupting permanent molars and prevent root caries in elderly people. SDF is also used to treat tooth hypersensitivity and sterilise infected root canals [17]. However, SDF has some adverse effects such as metallic taste, staining the caries lesion and mucosal irritation [13,18].

Arrested dentin caries shows no tendency to progress further because it is exposed to the oral cavity, it has a high fluoride content and become hypermineralized owing to continuous remineralization from oral fluids. The lesion in arrested dentin caries has a brown-black pigmentation and is hard on clinical probing. However, clinical diagnosis of arrested dentin caries substantially depends on the examiner's subjective assessment [12]. Many in-vitro studies have been performed to evaluate the hardening of dentin lesions after different topical fluoride application. So far, there is no published study which investigates the efficacy of SDF, NaF, AmF and APF application in arresting dentin caries in primary teeth of 3-4 years children. This study therefore aimed to evaluate the effectiveness of four different topical fluoride agents (38% silver diamine fluoride (SDF), sodium fluoride (NaF), amine fluoride (AmF) and acidulated phosphate fluoride (APF)) in arresting primary active dentin caries lesions.

Materials and Methods

This study was approved by Ethics Committee of the Faculty of Dentistry, University of İstanbul Medipol. The purpose and procedures of this study were explained to the parents of the children involved and their written consent was obtained before the investigation. Parents were also provided information about SDF, follow-up instructions, oral hygiene instructions, and diet education. A total of 96 children (male: 78, female: 58) who had at least one tooth with untreated active dentin caries not involving pulp were invited to participate in the study. The children were healthy by medical history.

Baseline examinations of the children were performed by a dentist using an disposable dental mirrors and intra-oral LED light. After the examination, children who had at least one tooth with untreated active dentin caries not involving pulp were invited to participate in the trial. Tooth with pulp exposure, more than one third of the crown missing, spontaneous or elicited pain from caries, presence of an abscess, tooth mobility and hereditary developmental defects, such as amelogenesis imperfecta, dentinogenesis imperfecta were excluded. Only children with written consent from their parents were accepted.

Dentin caries lesions was assessed by visual inspection and a sharp probe. If the dentin lesion cavity wall or floor was easily penetrated by probe, it was diagnosed as active caries. Cavities with smooth and hard surfaces which could not be penetrated by the probe were classified as arrested caries. If the cavity wall or floor was soft and easily penetrated by probe, it was diagnosed as active caries. Five surfaces in each posterior tooth (occlusal, buccal, lingual, mesial and distal) and four surfaces in each anterior teeth were assessed.

After the examination, children were put into two strata according to the number of carious tooth surfaces they had, 1 to 3 surfaces and >3 surfaces. They were then allocated by a stratified randomization method using a computer to 1 of the following 4 treatment groups.
Group 1: 38% silver diamine fluoride (SDF)
Group 2: 5% sodium fluoride (NaF)
Group 3: amine fluoride (1250 ppm)
Group 4: 1,23% acidulated phosphate fluoride (APF)

A dentist who was not involved in the examination of the children applied the fluoride agents according to the child's group allocation. Dental intervention was not made to remove the carious tissued before fluoride application. The teeth were isolated from saliva with cotton rolls and a disposable microbrush was used to apply the agent onto each carious lesion and rub for 10s. After application, the children were informed to drink or eat for at least 30 minutes.

The follow-up examinations were conducted by the same examiner at 6, 12, 18 and 24 months. The intraexaminer reliability of caries assessment and oral hygiene assessment was conducted through reexamining a 10% random sample of children on the same day. A parental questionnaire was applied at baseline and 24 months follow-up visits about their child's demographic background,

oral health-related behaviours, oral hygiene status and caries experiences was collected. Data were entered into computer and analyzed using the software SPSS 20.0 for Windows (SPSS Inc., Chicago, USA). Chi-square test and ANOVA were used, when appropriate, to assess the differences between the four groups of children regarding their demographic background, baseline oral-helth related habits and dmfs score rates. Statistical significance level was set at 0.05 for all tests.

Results

A total of 124 children (male: 66, female: 58) with 1120 tooth surfaces with active dentin caries received treatment at baseline. At baseline, their mean age was 40±5 months. There were 31 children in Groups 1, 2, 3 and 4, respectively, and the respective numbers of treated tooth surfaces with active dentin caries lesions in the four groups were 280. Most of the children (75%) brushed their teeth with fluoridated toothpaste once a day or more often. Approximately three-fourths of the carious lesions were in upper anterior teeth and most commonly involved surfaces were mesial surfaces (37%) and occlusal surfaces (22%). Their mean dmft and dmfs scores were 4.6 ± 3.4 and 6.6 ± 6.9, respectively. There were no statistically significant differences among the children in the 4 study groups regarding their demographic background, oral health related behaviours, oral hygiene status and caries experiences (X^2 test and ANOVA with (p>0.05) (Table 1).

		Group 1 SDF	Group 2 NaF	Group 3 AmF	Group 4 APF
No of children (lesions)		31	31	31	31
Tooth brushing	Less than once a day	23%	24%	23%	23%
	Once a day	39%	38%	40%	39%
	Twice or more a day	38%	38%	37%	38%
Fluoride toothpate	Yes	79%	81%	77%	82%
	No				
Family monthly income	Low	65%	69%	69%	67%
	Middle	22%	20%	21%	23%
	High	13%	11%	10%	10%
Visible plaque index		61%	62%	60%	62%
Dental caries status	Mean dmft (SD)	4.8 (3.6)	4.4 (3.2)	4.6 (3.4)	4.6 (3.4)
	Mean dmfs (SD)	6.8 (7.2)	6.4 (6.6)	6.6 (6.9)	6.8 (7.1)
Tooth type icluded	Anterior teeth	78%	77%	77%	77%
	Posterior teeth	22%	23%	23%	23%
Tooth surfaces included	Occlusal	22%	23%	22%	22%
	Proximal	47%	49%	47%	48%
	Buccal/lingual	31%	28%	31%	30%

Table 1: Background information of children in the four study groups at baseline.

After 24 months examination, 122 children remained in the study, 31, 30, 31, 30 children in Groups 1, 2, 3 and 4, respectively. The drop-out rates among the four groups were similar (X^2 test, p>0.05). There were no statistically significant difference in the parameters between children at baseline and 24 months examination, respectively (p>0.05). Intra-observer reliability was good with Kappa statistic values greater than 0.9 in the baseline and follow-up examinations.

The 24-month caries arrest rates of the treated lesions were 55%, 43%, 34% and 26% in Group 1 (SDF), Group 2 (NaF), Group 3 (AmF) and Group 4 (APF) respectively (p<0.05). At the 24 month examination, there was statistically significant difference in the caries arrest rates of the treated lesions among the 4 treatment groups (Group 1 (SDF), Group 2 (NaF), Group 3 (AmF), Group 4 (APF)) (p<0.05) (Table 2).

	SDF	NaF	AF	APF	1p
	n (%)	n (%)	n (%)	n (%)	
First visit	160 (%100)	160 (%100)	160 (%100)	160 (%100)	
6.month	70 (%43,8)	50 (%31,3)	37 (%23,1)	29 (%18,1)	0,000*
12.month	78 (%48,8)	60 (%37,5)	41 (%25,6)	34 (%21,3)	0,000*
18.month	84 (%52,5)	66 (%41,3)	50 (%31,3)	40 (%25)	0,000*
24.month	88 (%55)	69 (%43,1)	55 (%34,4)	42 (%26,3)	0,000*
First-6th M ^{2}p	0,000*	0,000*	0,000*	0,000*	
First-12th M ^{2}p	0,000*	0,000*	0,000*	0,000*	
First-18th M ^{2}p	0,000*	0,000*	0,000*	0,000*	
First-24th M ^{2}p	0,000*	0,000*	0,000*	0,000*	
6th M-12th M ^{2}p	0,008*	0,002*	0,125	0,063	
12th M-18th M ^{2}p	0,031*	0,031*	0,004*	0,031*	
18th M-24th M ^{2}p	0,125	0,250	0,063	0,500	

[1]Ki-kare test, [2]McNemar Test, * p<0.05

Table 2: Caries arrest rates of dentine caries at 6-,12-,18 and 24-month follow-up in the four treatment groups.

Children who treated with SDF (Group 1) had more arrested caries than did the children in other groups. There was statistically significant difference in the caries arrest rates of the treated lesions between Group 1 (SDF) and Group 2 (NaF), Group 3 (AmF), Group 4 (APF) after 6, 12, 18 and 24 months (p<0.05). There was statistically significant difference in the caries arrest rates of the treated lesions between Group 2 (NaF) and Group 3 (AmF), Group 4 (APF) after 6, 12, 18 and 24 months (p<0.05). Moreover, there was no statistically significant difference between Group 3 (AmF) and Group 4 (APF) after 24 months (p>0.05) (Table 3). There were statistically significant increase in arrested dentin caries lesions between baseline with that of 6, 12, 18 and 24 months in Group 1, 2, 3 and 4 (p<0.05).

	SDF	NaF	AF	APF	1p
	n (%)	n (%)	n (%)	n (%)	
First visit	280 (%100)	280 (%100)	280 (%100)	280 (%100)	
6.month	110 (%39,3)	85 (%30,4)	40 (%14,3)	29 (%10,4)	0,000*
12.month	122 (%43,6)	101 (%36,1)	52 (%18,6)	40 (%14,3)	0,000*
18.month	138 (%49,3)	104 (%37,1)	72 (%25,7)	59 (%21,1)	0,000*
24.month	148 (%52,9)	110 (%39,3)	87 (%31,1)	62 (%22,1)	0,000*

First-6th M [2]p	0,000*	0,000*	0,000*	0,000*	
First-12th M [2]p	0,000*	0,000*	0,000*	0,000*	
First-18th M [2]p	0,000*	0,000*	0,000*	0,000*	
First-24th M [2]p	0,000*	0,000*	0,000*	0,000*	
6th M-12th M [2]p	0,000*	0,000*	0,000*	0,001*	
12th M-18th M [2]p	0,000*	0,250	0,000*	0,000*	
18th M-24th M [2]p	0,002*	0,031*	0,000*	0,250	

[1]Ki-kare test, [2]McNemar Test, * $p<0.05$.

Table 3: Caries arrest rates of dentine caries lesions at 6-,12-,18- and 24-month follow-up in the four treatment groups.

Lesions treated by SDF in anterior and posterior teeth and those in occlusal, proximal and buccal/lingual surfaces had a higher chance to become arrested. Four variables, namely treatment group, presence of plaque on lesion, tooth type and tooth surface affected the time to arrest of active caries, while the other variables including demographic background, oral health related behaviours, and baseline caries experience were not statistically significant.

Discussion

In the present study, caries arrest rates of the treated lesions was investigated comparing 4 different fluoride solutions. Compared to baseline active caries lesions counts decreased at all the 6 month follow-up visits in all the four groups. Considering the intergroup significance, significant reduction was found in active dentine caries lesions in teeth which treated with SDF. SDF seems to have higher potential in reducing of active dentine caries lesions compared to other three agents (NaF, AmF, APF) due to high fluoride content and also the antibacterial potential of silver providing an additive effect on reduction of S. mutans counts [19]. These findings are consistent with earlier clinical findings of recent review which investigate the effectiveness of SDF in arresting dentine caries in children [20]. Laboratory studies found that SDF could inhibit demineralization, preserve collagen from degradation in demineralized dentine and increase the hardness of treated dentine caries [12,21].

The outcomes of 24-month fluoride application on both anterior and posterior primary dentine caries showed that; application of SDF, NaF, AmF and APF solutions is effective in arresting dentine caries lesions, but the effectiveness decreases over time. Blackening and hardening of dentine caries lesions occured not only in children receiving SDF solution applications but also in children receiving NaF, AmF and APF solutions after 24 months.

Application of fluoride solution every 6 months recommended frequency of recall visits for high risk patients [22]. Better results in managing dental caries in young children can be expected if fluoride solution is applied onto the carious lesions every 6 months regularly. This would be an appropriate alternative treatment to conventional restorative approach in young children who are uncooperative. In this study, every 6 months fluoride application increased the proportion of active dentine caries that had become arrested.

SDF has been used as a cariostatic agent in recent years. Reports of its effect in deciduous teeth follow classic studies which had reported its utility in the treatment and prevention of caries in these teeth. It releases fluoride and helps in the deposition of silver phosphate to restore the mineral content, resulting in rehardening of the tooth structure. The fluoride released from silver diamine can penetrate better into dentin than into enamel due to greater amount of protein substrate, carbonates and phosphates in dentin for reaction [23]. Yamaga et al. have reported SDF use in the treatment and prevention of caries in deciduous teeth. Yamaga et al. attributed the increased hardness of dentin to deposition of silver phosphate in SDF [24]. Llorda et al. documented its caries preventing efficacy in permanent first molars [18]. In the present study, SDF increased the caries arrest rates of primary active dentin caries lesions. Russo et al., however, warned about possible pulpal injury associated with SDF [25]. In the present study, two of the patients reported symptoms of irreversible pulpits after application of SDF. However, there could be an error in case selection, as clinical findings and histological picture do not always necessarily coincide.

The advantages and disadvantages of SDF application have been elucidated in previous research [26-29]. The black discoloration of the dentine surface after SDF application, was found in the SDF groups in the present study. The staining may be eliminated by the application of potassium iodide (KI) after SDF application [30]; however further studies are needed to investigate the clinical effectiveness of KI. Some side effects such as dental fluorosis, chronic and acute toxic after the application of SDF has been debated [31,32]. In the present study, besides the black staining, no adverse effects were observed during the 24-month follow-up.

Russo et al. [25] reported possible toxicity to the pulp after SDF solution application. In the present study, there was no patients who show symptoms of irreversible pulpitis after application of SDF soluion. Yamaga et al. [24] have predicted reversible lesions in oral mucosa through inadvertent contact with SDF solution. This mucosa lesions was detected in two patients in this study, with the appearance of a small, mildly painful white lesions in the mucosa, which dissappeared at 48 hours without treatment.

Conclusion

The 24-month results of this study showed that the every 6 months application of SDF solution is more effective in arresting dentine caries in primary teeth than NaF, AmF, APF soluions. Further studies are needed to investigate alternative protocols, different age groups, and high-risk groups, to evaluate longer term outcomes, and to evaluate the efficiency of this approach.

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