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EVALUATION OF SILVER DIAMINE FLUORIDE AND SODIUM FLUORIDE VARNISH IN ARRESTING CARIES PROGRESSION ON PRIMARY TEETH: A COMPARATIVE CLINICAL STUDY

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ABSTRACT

Objectives: The aim of the present study was to compare the effectiveness of silver diamine fluoride (SDF) and sodium fluoride varnish in arresting caries progression on primary teeth. **Subjects and methods:** This study involved a total of 60 teeth categorized according to the restored primary teeth in two main groups; group A; Anterior teeth (n=30); group B; Posterior teeth (n=30). Then, the anterior teeth were subdivided into two subgroups (n=15); teeth restored with SDF alone (A1) or restored with NaF alone (A2) (n=15). While, the posterior teeth were subdivided into subdivided into two subgroups (n=15); teeth restored with SDF with ART "SMART" (B1) or restored with NaF with ART "SMART" (B2). The clinical and radiographic results in this study was evaluated after 3-months. **Results:** SDF showed significant clinical success when compared to NaF alone or when used under ART "SMART" technique. While, the anterior teeth showed better results than posterior teeth.the anterior teeth showed significant radiographic success when compared to posterior teeth. **Conclusion:** The use of SDF solution has better clinical and radiographic outcomes in caries arrest of primary teeth. SDF solution has better caries arrest outcomes in non-cavitated lesion than cavitated lesions in primary teeth.

KEYWORDS: Caries, primary teeth, silver diamine fluoride, sodium flouride, SMART.

INTRODUCTION

Dental caries is a localized chemical dissolution of dental hard tissues that is caused by acidic by-products of the metabolic processes of the biofilm (dental plaque) covering an affected tooth surface.

Traditionally, dental caries is treated by a surgical restorative approach. This requires sophisticated dental equipment and well-trained operators, and is relatively expensive. In recent years, remineralization of caries lesions has gained acceptance in the practice of minimally invasive dentistry and caries arrest treatment is being promoted as part of the basic package of oral care [(1)].

The prevalence of caries in children is high in families with low income, lower education level of parents, poor parental dental attitude and single parent families. Treatment of dental caries in young children is very challenging and it may require advanced skills of clinicians and high cost of general anesthesia for patient management. The prevailing methods adopted in industrialized countries for the prevention and treatment of dental caries are neither

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available nor affordable in developing countries where there are inadequate financial resources, dental manpower and facilities. The use of topical fluorides may be a useful meas ure to arrest caries lesions because fluorides used in various forms have proven to be effective in dental caries prevention [2].

Silver diamine fluoride (SDF) is used to prevent and arrest caries, and "silver diamine fluoride" is the most common spelling/keyword for this compound in the dental literature[3,4]. SDF has an intense antibacterial effect on cariogenic bacteria and can inhibit the growth of multi-species cariogenic biofilms on tooth surfaces[4]. SDF is a topical fluoride which is often used in high concentration (38%) for preventing and arresting dental caries [4,5].

SDF is an effective, efficient, equitable and safe caries-preventive agent appearing to meet the World Health Organization's Millennium Goals for 21st century medical care and clinical studies also showed the success of SDF in preventing and arresting dental caries.[6] Dentine surfaces treated with SDF had significantly less growth of *streptococcus mutans* (*S. mutans*) than did those without SDF treatment[7]. The purpose of the present study was to compare the effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting caries progression on primary teeth.

SUBJECTS AND METHODS

Study Design:

Prospective clinical study.

Study Setting and Population:

Sixty children were selected from patients attending the Outpatient Clinic of Pedodontics and Oral Health Department, Faculty of Dental Medicine, Al-Azhar University (Cairo, Boys). This study involved a total of forty carious primary teeth without pulp involvement.

Grouping:

This study was conducted on 60 children with primary anterior and posterior teeth indicated for caries removal. After subject selection and signed informed consent, the involved children were randomly divided into two main groups (n=30) based on tooth location; anterior (group A) or posterior (group B). Then each main group was further subdivided into two subgroups (n=15) based on the received treatment as follow: 5% sodium fluoride (NaF) varnish and 38% silver diamine fluoride (SDF) solution.

Eligibility criteria for patient selection:

Inclusion criteria:

1. Parents acceptance and cooperation.
2. The parent of the child understands the importance of SDF treatment to arrest prevent dental caries.
3. Children aged between 3 to 8 years.
4. Children with more than one carious tooth.
5. Vital primary anterior teeth with initial non-cavitated proximal carious lesion.
6. Vital primary posterior teeth with cavitated carious lesion.
7. Patient healthy appeared and free of any systemic diseases.
8. ICDAS-II criteria n detecting and assessing dental caries.

Exclusion Criteria:

1. Tooth with developmental dental abnormalities such as enamel defects.
2. Children with known silver or fluoride allergy.
3. Tooth with physiologic root resorption or close to exfoliation.
4. Presence of pulp involvement, pain, mobility, abscess, sinus, or fistula.

Sample Size:

Based on previously treated trial cases based on effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries [8]., we conducted a power analysis (G power version 3.1 statistical software, Franz Faul, Universität Kiel Germany). Proportions: Inequality, two independent groups (Fisher's exact test) was performed to compute the required sample size-given α, power, and effect size. The input parameters were α error probability of 0.05, Proportion p1=0.9400000 and Proportion p2=0.5, a power of 0.95 and number of groups was 2. The findings indicated a minimum sample size of n = 54 samples, (27 cases for each group) Considering a possible loss of about 10 % of patients, we used 60 cases, (30 cases for each group and by dividing each group into 2 subgroups then every subgroup will include 15 cases).

Ethical Consideration:

This study was conducted after approval of Ethical Committee, Faculty of Dental Medicine, Al-Azhar University (Boys, Cairo) with approval EC Ref. No. (508/2854).

Patient and parent Consent:

Before starting of this study, all selected children and his/her parents were informed about all the procedure used in this clinical study. Then, each parent was signed an informed consent having details about the whole clinical procedure.

Intervention Procedures:

Operative Procedures:

No effort was made to remove the caries or un-supported enamel for caries treatment in both the groups under cotton roll isolation. Initial cleaning of cavity was performed by using small cotton pellet followed by the application of single drop (0.1 mL) of either 5% NaF or 38% SDF. Technique for NaF varnish and SDF solution application: [9, 10] for primary anterior teeth (Fig 1).

Technique for NaF varnish and SDF solution application:

- Child was placed in supine position. The involved tooth surface was cleaned and dried using small cotton pellet.
- Application of NaF varnish (% sodium fluoride (NaF) varnish)
- Application of SDF solution was carried out with a disposable micro-applicator tip for 10 seconds and the cavity was closed with a cotton pellet for ten minutes.
- The child and parents were instructed not to drink water or eat food for at least 45 minutes.
- One micro applicator tip was used for each lesion and discarded after single use.
- Both the treatments were performed with single application and no repetition.

SMART technique:

In cavitated lesions, NaF varnish and SDF solution was applied and the cavity was then immediately restored or sealed with conventional GIC. The term "SMART restoration" has been used to describe this treatment. [11]

Steps of SMART technique: (Fig 1).

Steps of SMART technique was carried out as follows:

- Child was placed in supine position.
- The involved tooth surface was cleaned and dried using small cotton pellet.
- Application of NaF varnish and SDF solution was carried out with a disposable micro-applicator tip for 10 seconds and the cavity was closed with a cotton pellet for ten minutes.
- One micro applicator tip was used for each lesion and discarded after single use.
- Both the treatments were performed with single application and no repetition.

- After application of NaF varnish and SDF solution the cavity was sealed immediately with GIC.

Follow-up evaluation:

Follow-up examination was carried out by a single examiner who was involved in the provision of treatments and did not know the children's group assignment. The treated caries lesions were classified as either active or arrested according to the diagnostic criteria used at baseline. The involved teeth were assessed clinically and radiographically after 3 months of follow-up [9] (Fig 1)

Criteria for evaluation of active and arrested caries:

The clinical evaluation of active and arrested caries was carried out following a specially designed criteria, tactile and visual characteristics of enamel and dentinal lesion activity (active/ inactive) based on ICDAS-II classifications [12].

Statistical analysis:

The statistical analysis was carried out to clinically evaluate the effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries. Data were collected, checked, revised, and organized in tables and figures using Microsoft Excel. Data were fed to the computer and analyzed using IBM SPSS software package version 26.0. (Armonk, NY: IBM Corp). Significance of the obtained results was judged at the 0.05. The used tests were Chi-square test.

RESULTS

Clinical and radiographical evaluation after 3 months:

- **Group A:** In the anterior teeth, the clinical follow-up results of the all involved teeth in the both studied groups (A1 and A2) showed a statistically significant difference after 3-months (p=0.03090). Where, the group A1 recorded

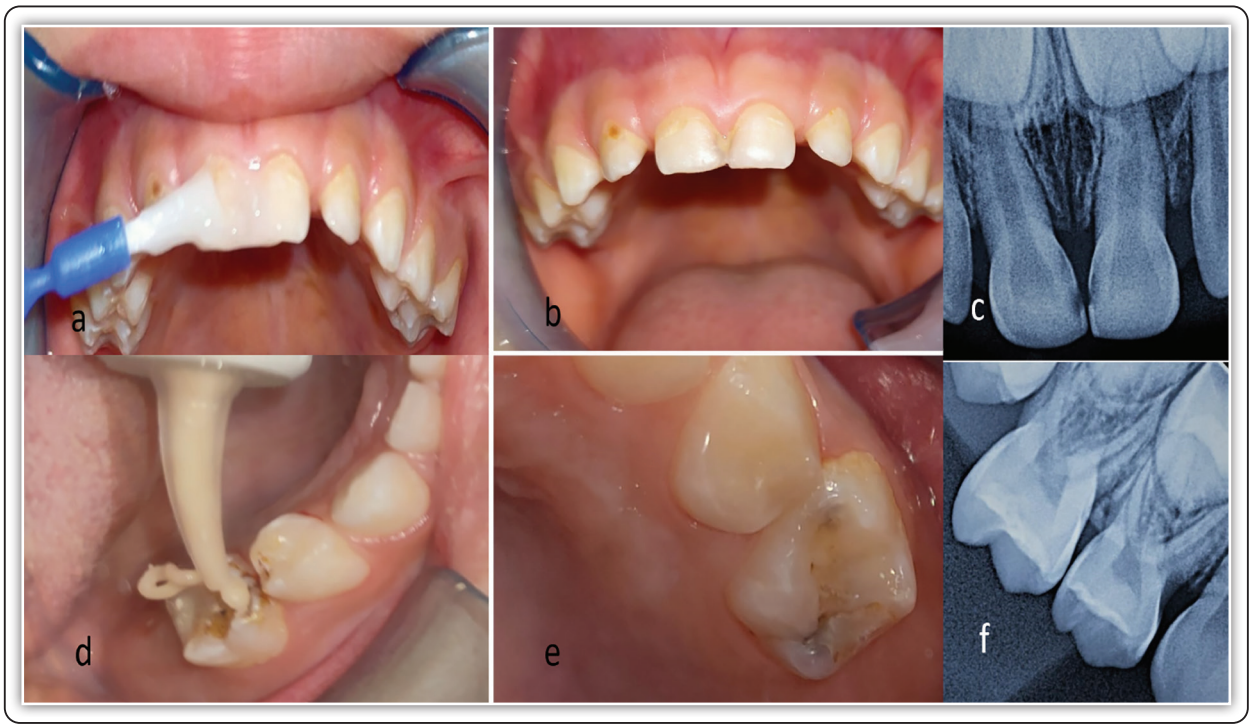

FIG (1) a: Application of NaF varnish in Group A, b: Follow-up clinical evaluation, c: Follow-up radiographic evaluation. d: Cavity restored with SMART technique Group B, e: Follow-up clinical evaluation, f: Follow-up radiographic evaluation.

success rate of (93.33%) and failure rate of (6.67%). While, group A2 recorded success rate of (60%) and failure rate of (40%). (Table 1)

- **Group B:** In posterior teeth, the clinical follow-up results of the all involved teeth in the both studied groups (B1 and B2) showed a statistically significant difference after 3-months (p=0.02013). Where, the group B1 recorded success rate of (86.67%) and failure rate of (13.33%). While, group B2 recorded success rate of (46.67%) and failure rate of (53.33%). (Table 2)

Radiographical evaluation:

- **Group A:** In the anterior teeth, the radiographic follow-up results of the all involved teeth in the both studied groups (A1 and A2) showed a statistically non-significant difference after 3-months (p=0.09864). Where, the group A1 recorded success rate of (86.67%) and failure rate of (13.33%). While, group A2 recorded success rate of (60%) and failure rate of (40%). (Table 1)
- **Group B:** In posterior teeth, the radiographic follow-up results of the all involved teeth in the both studied groups (B1 and B2) showed a statistically non-significant difference after 3-months (p=0.06544)). Where, the group B1 recorded success rate of (73.33%) and failure rate of (26.67%). While, group B2 recorded success rate of (40%) and failure rate of (60%). (Table 2)

ICDAS results (Active and arrested caries):

- **Group A:** The ICDAS clinical follow-up results of the enamel in the involved teeth in the both studied groups (A1 and A2) showed a statistically non-significant difference after 3-months (p=0.1336). Where, the group A1 recorded success number and rate of 9 (60%) and failure rate of 0 (0%) of the total involved teeth. While, group A2 recorded success number and rate of 7 (46.67%) and failure rate of 2 (13.33%) of the total involved teeth. The ICDAS clinical follow-up results of the dentine in the involved teeth in the both studied groups (A1 and A2) showed a statistically non-significant difference after 3-months (p=0.0789). Where, the group A1 recorded success number and rate of 5 (33.33%) and failure rate of 1 (6.67%) of the total involved teeth. While, group A2 recorded success number and rate of 2 (13.33%) and failure rate of 4 (26.67%) of the total involved teeth. (Tables 3)
- **Group B:** The ICDAS clinical follow-up results of the enamel in the involved teeth in the both studied groups (B1 and B2) showed a statistically non-significant difference after 3-months (p=0.0125). Where, the group B1 recorded success number and rate of 8 (53.33%) and failure rate of 0 (0%) of the total involved teeth. While, group B2 recorded success number and rate of 3 (20%) and failure rate of 4 (26.67%) of the total involved teeth. The ICDAS clinical follow-up results of the dentine in the involved posterior teeth in the both studied groups (B1 and B2) showed a statistically non-significant difference after 3-months (p=0.3980). Where, the group B1 recorded success number and rate of 5 (33.33%) and failure rate of 2 (13.33%) of the total involved teeth. While, group B2 recorded success number and rate of 4 (26.67%) and failure rate of 4 (26.67%) of the total involved teeth. (Tables 4).

TABLE (1) Comparative of clinical follow-up results after 3-months among the studied groups in the anterior teeth:

Variable		Anterior teeth		p-value
		Group A1	Group A2	
Clinical evaluation	**Success; n (%)**	14 (93.33%)	9 (60%)	0.03090*
	Failure; n (%)	1 (6.67%)	6 (40%)	
Radiographic evaluation	**Success; n (%)**	13 (86.67%)	9 (60%)	0.09864 ns
	Failure; n (%)	2 (13.33%)	6 (40%)	

**; significant at p < 0.05. ; non-significant at p >0.05. ns= non-significant.*

TABLE (2) Comparative of clinical follow-up results after 3-months among the studied groups in the posterior teeth:

Variable		Posterior teeth		p-value
		Group B1	Group B2	
Clinical evaluation	**Success; n (%)**	13 (86.67%)	7 (46.67%)	0.02013*
	Failure; n (%)	2 (13.33%)	8 (53.33%)	
Radiographic evaluation	**Success; n (%)**	11 (73.33%)	6 (40%)	0.06544 ns
	Failure; n (%)	4 (26.67%)	9 (60%)	

**; significant at p < 0.05. ; non-significant at p >0.05. ns= non-significant.*

TABLE (3) Comparative of clinical evaluation of active and arrested caries results after 3-months in the enamel of anterior teeth: (Group A) and in the enamel of posterior teeth: (Group B)

Variable	Enamel		p-value
	Active lesion(Rough)	Arrested lesion (Smooth)	
Group A1; n (%)	0 (0%)	9 (60%)	0.14880 ns
Group A2; n (%)	2 (13.33%)	7 (46.67%)	
Group B1; n (%)	0 (0%)	8 (53.33%)	0.0703 ns
Group B2; n (%)	4 (26.67%)	3 (20%)	

**; significant at p < 0.05. ; non-significant at p >0.05. ns= non-significant.*

TABLE (4) Comparative of clinical evaluation of active and arrested caries results after 3-months in the dentine of anterior teeth: (Group A) and in the dentine of posterior teeth: (Group B)

Variable	Dentine		p-value
	Active lesion (Soft)	Arrested lesion (Hard)	
Group A1; n (%)	1 (6.67%)	5 (33.33%)	0.14880 ns
Group A2; n (%)	4 (26.67%)	2 (13.33%)	
Group B1; n (%)	2 (13.33%)	5 (33.33%)	0.0703 ns
Group B2; n (%)	4 (26.67%)	4 (26.67%)	

**; significant at p < 0.05. ; non-significant at p >0.05. ns= non-significant.*

DISCUSSION

Untreated dental caries is a global pandemic in young children. However, the generalizability of using these alternative treatments in young children has been questioned since the success of a treatment for decayed primary teeth also depends on children's behaviors [13]. To date, there is a lack of scientific evidence for clinically-effective preventive caries management with topical fluoride such as SDF, NaF or SMART technique, focusing on primary teeth. Hence, this study was aimed to assess the effectiveness of SDF, NaF, and SMART technique as caries arrest tools in primary teeth.

The enrolled children in the present study were aged between 3-8 years as they represent ages who usually present a greater need for treatments with lower chair time [14].

In the present study the clinical and radiographic follow-up at 3-months was selected to estimate the efficacy of SDF, NaF and SMART restorations because of their clinical importance as a great deal for assessment of their clinical applicability. As SDF, NaF and SMART restorations as minimal invasive treatment may be the only treatment option for certain populations where resources are scarce or management is difficult [13, 14].

The higher clinical success rate "caries arrest" of SDF alone in the anterior teeth (93.33%) and the posterior teeth (86.67%) after follow-up for 3-month in this study may be because of the antimicrobial ability from silver in addition to the remineralization ability from fluoride in SDF solution. These results agreed with the results of Crystal and Fung, et al.,[15] results the SDF's effectiveness for caries arrest and prevention in primary dentition nearly from 80% to 90% of the treated lesions.

Also, the use of ART in combination with SDF "SMART technique" resulted in (86.67%) success rate after follow-up for 3-month in this study may be because of using SDF before restoration placement may reduce carious lesion progressing and irreversible pulpitis or dental infection ensuing. Moreover, it was found that the use of SDF at different concentrations with GIC can improve the antibacterial activity and the physical properties of the GIC as well as the bond strength of GIC to the tooth structure [16, 17].

Additionally, it has been found that the application of concentrated fluoride ions in fluoride varnish forms globules of calcium fluoride-like material on the tooth surface. These globules are stabilized by protein phosphate in the mouth. They are fairly insoluble and act as an insoluble reservoir of fluoride at neutral pH. [18-20] ; this could explain the results of NaF as caries arrest agent in the anterior and posterior teeth in the current study.

This study showed that the clinical success rate of NAF varnish alone in the anterior teeth were (60%) and the posterior teeth were (46.67%) after follow up for 3- months. These results agreed with Alice et al; who reported that the Caries arrest rate was signifcantly higher in the SDF groups compared to NaF [21].

Although both agents (SDF and NaF) have been widely studied and used clinically worldwide under different clinical conditions, the SDF showed the higher cariostatic effectiveness in comparison with NaF in the both anterior and posterior teeth either alone or in combination with ART. This may be because of fluoride varnish can be removed by the patient by tooth brushing, therefore, whenever possible, the varnish should be left on the teeth and brushing should be avoided on the day of application.[18, 20] This results in agreement with the results of existing reports of SDF trials support effectiveness in caries prevention and arrest, remineralization of deep occlusal lesions when compared to NaF in children [21].

Furthermore, the higher success rate of SDF when compared to NaF either alone or in combination with ART in the present study may be due to the application of both materials without

caries removal. As it was reported that before NaF application caries excavation is required to arrest the carious lesions, while, with SDF this step not required which indicate the efficacy of SDF over NaF in arresting the dental caries [22].

Moreover, the higher success rate of SDF when compared to NaF in this study could be attributed to application of both material for one time only as the previous studies showed that the NaF varnish can be removed by the patient during tooth brushing or even during mastication of foods, [18, 20] however, the application of SDF is recommended, at least annually and the greater effectiveness is achieved with biannual than annual application [23].

Moreover, the results of the present study showed that the restoration of cavitated lesions (dentine) showed higher failure rate when compared to the non-cavitated lesions (enamel) after clinical follow-up. This may be because of the loss of the GIC filling material which left open cavities in which carries progression occurred before replacement of the GIC sealant. [24] Moreover, the potential caries-preventive effect of GIC on dentine caries is claimed to be a result of its adhesive property to hard dental tissues; this is dependent on the ability of the material to hermetically seal cavities and prevent marginal leakage of the restoration, isolating the cavity from the external environment and reducing the chances of bacterial growth [25].

Moreover, the results of the present study showed that the use of SDF under ART in SMART technique showed better results in cmparison with NaF under ART in cavitated lesions. This because according to Tantbirojn, et al.,[26] the fluoride released by GIC would only be effective in preventing the progression of incipient carious lesions, which does not apply to lesions involving dentine. However, the presence of SDF under ART restoration in SMART technique improves the antibacterial activity and remineralization of GIC and help in enhancing the ability of ART to resist the caries progression.[27,28] The clinical result of the present study was confirmed by the radiographic results as the Kappa results revealed a fair agreement between the clinical and radiographic examinations after 3-months of follow-up with kappa index of 0.367.

CONCLUSION

The use of SDF solution has better clinical and radiographic outcomes in caries arrest of primary teeth. SDF solution has better caries arrest outcomes in non-cavitated lesion than cavitated lesions in primary teeth.

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