ORIGINAL RESEARCH article

Clinical evaluation of silver diamine fluoride for the prevention of dental caries in children

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Abstract: Dental caries remains one of the most prevalent chronic diseases worldwide and continues to pose a significant clinical and public health burden, particularly in regions where preventive strategies are inadequately implemented. Silver diamine fluoride (SDF) has emerged as a pharmacologically active topical agent with proven antimicrobial and demineralizing properties. A prospective clinical evaluation was conducted on 110 patients recruited from private dental clinics in Surman and Sabratha. Eligible participants presented with sound teeth or early non-cavitated carious lesions at baseline. A 38.0% silver diamine fluoride solution was applied to selected teeth following a standardized clinical protocol. Clinical assessments were performed at baseline and during follow-up visits to record the incidence of new carious lesions and the arrest of existing lesions. A statistical analysis was used to summarize the data, and Chi-square and paired comparison tests were applied to assess differences in caries incidence before and after SDF application. Among the 110 evaluated cases, a statistically significant reduction in the incidence of new dental caries was observed in the Libyan patients following SDF application. The proportion of teeth remaining caries-free increased from 62.7% at baseline to 85.4% at follow-up (p<0.001). Arrest of early carious lesions was recorded in 78.2% of treated teeth. No difference was found between patients treated in Surman and Sabratha clinics. No adverse clinical effects were reported during the study period. The SDF demonstrated a significant preventive effect against dental caries in Libyan children in private dental clinic settings. The significant reduction in caries incidence supports the clinical use of SDF as an effective, safe, and economical preventive agent within Libyan dental practice.

Introduction

Dental caries remains one of the most prevalent chronic oral diseases worldwide and continues to represent a significant clinical and public health challenge [1, 2]. It affects individuals across all age groups and socioeconomic backgrounds, leading to pain, tooth loss, functional impairment, and a reduced quality of life [3, 4]. According to reports from the World Health Organization, untreated dental caries is among the most common non-communicable diseases globally, with a particularly high burden observed in low- and middle-income countries where access to preventive oral health services is limited [5]. The development of dental caries is a multifactorial process involving complex interactions between cariogenic microorganisms, fermentable carbohydrates, host-related factors, and time. Acidogenic and aciduric bacteria, especially *Streptococcus mutans* and *Lactobacillus* species, play a key role in initiating enamel demineralization through

organic acid production following carbohydrate metabolism [6]. When early non-cavitated, lesions are not adequately managed, disease progression may result in cavitation, pulpal involvement, and the need for invasive restorative or surgical interventions. In Libya, dental caries remains a common clinical finding in public and private dental care settings [1]. Previous local and regional studies have reported a high prevalence of carious lesions among children and adults, which has been attributed to insufficient preventive dental programs, limited oral health awareness, irregular dental attendance, and increased consumption of refined sugars [7, 8]. Although restorative dental treatment is widely, practiced, preventive strategies are not consistently integrated into routine dental care, highlighting a gap between disease burden and preventive service delivery.

Fluoride has long been recognized as a cornerstone in the prevention of dental caries due to its ability to enhance demineralization, inhibit demineralization, and reduce bacterial activity within dental biofilms. Conventional fluoride delivery systems, including fluoridated toothpaste, mouth rinses, gels, and varnishes, have demonstrated substantial effectiveness in reducing caries incidence [9]. However, the success of these approaches often depends on patient compliance, repeated applications, and sustained behavioral adherence, which may be difficult to achieve in certain populations. Silver diamine fluoride (SDF) has emerged as an effective and minimally invasive topical agent for caries prevention and management. SDF combines the antimicrobial properties of silver ions with the demineralizing effects of fluoride, enabling it to inhibit cariogenic bacteria, suppress collagen degradation within dentin, and promote mineral deposition in demineralized dental tissues [2, 10]. These combined mechanisms allow SDF not only to arrest existing early carious lesions but also to reduce the risk of new lesion development. An increasing body of clinical evidence supports the effectiveness of 38.0% silver diamine fluoride in arresting dental caries in primary and permanent dentitions. Randomized clinical trials and systematic reviews have reported caries arrest rates ranging from approximately 65.0% to over 80.0%, depending on lesion characteristics and frequency of application [11, 12]. In addition to its clinical efficacy, SDF is considered safe, cost-effective, and easy to apply, requiring minimal chair side time and no advanced clinical equipment. These characteristics make SDF particularly suitable for use in private dental clinics and in resource-limited settings, such as those commonly encountered in Libyan dental practice. Despite its growing international acceptance, the clinical use of SDF in Libya remains limited, and locally generated clinical data evaluating its preventive effectiveness are scarce. Context-specific evidence is therefore essential to support the integration of SDF into routine preventive dental care. Accordingly, the present study aimed to evaluate the preventive effectiveness of 38.0% SDF in reducing the incidence of dental caries and arresting early non-cavitated lesions among patients attending dental clinics in Surman and Sabratha, Libya.

Materials and methods

Study design: This prospective clinical study was conducted between 5th January 2025 and 30th December 2025 in selected private dental clinics located in Surman and Sabratha, Libya. Patients were recruited during the study period based on predefined inclusion and exclusion criteria. The study was designed to evaluate the preventive effectiveness of 38.0% SDF in reducing the incidence of dental caries and arresting early non-cavitated carious lesions. The study was carried out over a defined follow-up period, during which patients were clinically examined at baseline and reassessed during subsequent follow-up visits.

Study population: A total of 110 patients were consecutively recruited from private dental clinics, aged 6-14 years old. Patients of both sexes and varying age groups were included in the study. Eligible participants presented with either sound teeth or early non-cavitated carious lesions at baseline examination. Patients with extensive cavitated lesions requiring immediate restorative or surgical intervention were excluded. Additional exclusion criteria included known allergy to silver or fluoride compounds, presence of severe periodontal disease, and patients who were unable or unwilling to attend follow-up visits.

Clinical examination: All the participants underwent a comprehensive clinical oral examination at baseline. Teeth were cleaned and dried prior to examination, and caries status was assessed using visual and tactile methods under standard dental unit lighting. Early non-cavitated carious lesions were identified based on changes in enamel opacity and surface texture without evidence of cavitation. Baseline data included demographic information, caries status of examined teeth, and clinic location (Surman or Sabratha).

Silver diamine fluoride application protocol: A commercially available 38.0% SDF solution was used in this study. The application protocol was standardized across all participating clinics. The selected teeth were isolated using cotton rolls and gently dried. A small amount of SDF was applied to the tooth surface using a micro-brush and allowed to remain in contact with the tooth for approximately one minute. Excess material was removed, and patients were instructed to avoid eating or drinking for at least 30 min following application. No additional restorative or sealing procedures were performed on the treated teeth during the study period.

Follow-up assessment: Follow-up clinical examinations were conducted to assess the development of new carious lesions in previously sound teeth and the arrest of early non-cavitated lesions treated with SDF. Lesion arrest was determined based on the absence of lesion progression and changes in surface hardness upon gentle probing. All the clinical assessments were performed using the same criteria applied at baseline to ensure consistency.

Ethical approval: This study was conducted in accordance with the international ethical principles, and the approval was obtained from the Institutional Review Board (Sabratha University, Libya, SU-2025). Participants were aged 6-14 years; therefore, informed consent was obtained from parents or legal guardians prior to enrollment, and they were informed about the purpose and procedures of the study, and written informed consent was obtained before enrollment. Participation was voluntary, and confidentiality and data anonymity were strictly maintained throughout the study.

Statistical analysis: Data were analyzed using the Statistical Package for the Social Sciences (*SPSS*) software. Descriptive statistics were used to summarize demographic data and caries status. Comparative analyses were performed to assess differences in caries incidence before and after SDF application by Chi-square test and paired comparison test was applied where appropriate to evaluate the statistical significance difference. A *p*-value of less than 0.05 was considered statistically significant.

Results

Table 1 summarizes the baseline sociodemographic characteristics and oral health-related behaviors of the study sample in the western part of Libya (n=110). The sample distribution of age indicates that the highest proportion of participants belonged to the 12-14 years group (43.6%), followed by the 9-11 years group (34.5%), while the 6-8 years group represented 21.8% of the sample. The gender distribution was nearly equal, with males comprising 50.9% and females 49.1% of the participants. Parental education level was predominantly at the secondary level (47.3%), with primary education reported in 25.5% and university education in 27.2% of cases.

In addition, in **Table 1**, regarding socioeconomic status of the participants, the majority of the participants were from medium-income families, representing 49.1%, while low-income and high-income groups accounted for 30.0% and 20.9%, respectively. Oral health behaviors at baseline showed variability. Tooth brushing frequency indicated that 56.4% of the participants brushed once daily, 34.5% brushed twice daily, and 9.1% did not report regular brushing. Use of fluoride toothpaste was reported by 63.6% of the sample, whereas 36.4% did not use fluoride toothpaste. Sugar consumption patterns revealed that 47.3% of the participants reported sugar intake 2-3 times per day, 25.5% reported intake of ≥4 times per day, and 27.3% reported sugar intake of ≤1 time per day. Dental attendance within the past year was reported by 40.0% of the participants, while 60.0% did not visit a dentist during that period.

Table 1: Children's sociodemographic characteristics and oral health-related behaviors at baseline

Variables	Category	Frequency	Percent
Age group (years)	6-8	24	21.8
	9-11	38	34.5
	12-14	48	43.6
Gender	Male	56	50.9
	Female	54	49.1
Parental education	Primary	28	25.5
	Secondary	52	47.3
	University	30	27.2
Family income	Low	33	30.0
	Medium	54	49.1
	High	23	20.9
Tooth brushing frequency	Once daily	62	56.4
	Twice daily	38	34.5
	Never	10	09.1
Use of fluoride toothpaste	Yes	70	63.6
	No	40	36.4
Sugar intake frequency	≤ 1 time/day	30	27.3
	2-3 times/day	52	47.3
	≥ 4 times/day	28	25.5
Dental visits in past year	Yes	44	40.0
	No	66	60.0

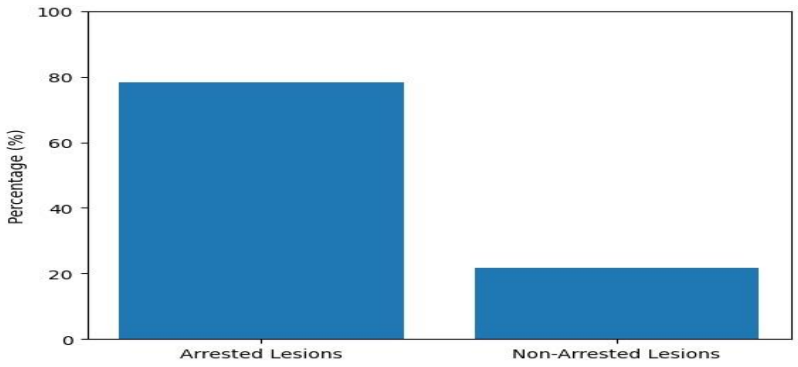
In **Table 2**, a total of 110 patients were included in the final analysis, all of whom completed the baseline and follow-up examinations. The evaluation focused on changes in caries incidence, arrest of early non-cavitated lesions, and comparison of outcomes between the two clinical settings. At baselines, clinical examination revealed that 69 teeth (62.7%) were free of dental caries, while 41 teeth (37.3%) presented with early non-cavitated carious lesions. Following the application of 38.0% silver diamine fluoride and during the follow-up period, a notable improvement in overall caries status was observed. The number of caries-free teeth increased to 94 (85.4%), whereas the number of teeth exhibiting active carious lesions decreased to 16 (14.6%).

Table 2: Distribution of dental caries status at baseline and follow-up

Caries status	Baseline, frequency (%)	Follow-up, frequency(%)
Caries-free teeth	69 (62.7)	94 (85.4)
Teeth with early carious lesions	41 (37.3)	16 (14.6)
Total	110 (100)	110 (100)

In **Figure 1**, among the 41 teeth diagnosed with early non-cavitated carious lesions at baseline, lesion arrest was observed in 78.2% during the follow-up examination. Arrested lesions were characterized by the absence of lesion progression and increased surface hardness upon gentle probing. The remaining nine teeth showed no clear clinical evidence of arrest (21.8%).

Figure 1: Illustrates the proportion of arrested and non-arrested early carious lesions at follow-up



In **Table 3**, a comparative analysis was conducted to assess whether clinic location influenced treatment outcomes. Patients treated in Surman and Sabratha clinics exhibited similar reductions in caries incidence and comparable lesion arrest rates. The statistical testing revealed no significant difference between the two locations (p=0.41).

Table 3: Comparison of caries outcomes between Surman and Sabratha clinics

Clinic location	Reduction in caries incidence	Lesion arrest rate	*p*-value
Surman	Comparable reduction	Comparable	
Sabratha	Comparable reduction	Comparable	
Between-group comparison	—	—	**0.41**

Discussion

The present study evaluated the preventive effectiveness of 38.0% SDF in reducing the incidence of dental caries and arresting early non-cavitated lesions among Libyan children attending dental clinics in Surman and Sabratha. The findings demonstrated a significant reduction in caries incidence and a high rate of lesion arrest, supporting the role of SDF as an effective preventive agent in routine dental practice. The observed increase in the proportion of caries-free teeth from 62.7% at baseline to 85.4% at follow-up reflects a strong preventive effect of SDF in limiting the development of new carious lesions. This result is consistent with the previous clinical and systematic reviews reporting that SDF is effective in preventing new caries, particularly in populations at increased caries risk when applied periodically [12]. The current findings suggest that SDF can maintain its preventive effectiveness even in private dental clinic settings, where preventive protocols and patient compliance may vary. The arrest rate of early non-cavitated lesions observed in this study (78.2%) is comparable to those reported in earlier investigations evaluating the caries-arresting potential of SDF. Rosenblatt and others [11] described SDF as a highly effective caries-arresting agent due to its combined antimicrobial and demineralizing actions. The present findings support this assumption, as the majority of treated lesions exhibited clinical signs of arrest, including increased surface hardness and lack of lesion progression.

Furthermore, the effectiveness observed in this study aligns with the well-documented biological mechanisms of SDF. The silver component exerts a potent antimicrobial effect against cariogenic microorganisms [2, 13], while fluoride enhances demineralization and inhibits the demineralization of dental hard tissues [9]. These synergistic actions contribute to both lesion arrest and caries prevention, which is consistent with the clinical outcomes observed in the present study. A notable finding of this study was the consistency of preventive outcomes across the two clinical locations. No significant difference was detected between Surman and Sabratha clinics, suggesting that the effectiveness of SDF is not strongly influenced by practice location when standardized application protocols are followed [14]. This observation has been reported in previous

multicenter clinical evaluations, highlighting the practicality of SDF in diverse clinical environments [15]. The safety profile observed in this study is in agreement with existing literature. No serious adverse effects were reported, and the commonly observed outcome was mild discoloration of treated lesions, which is an expected and well-documented effect of SDF application [10, 15]. The absence of soft tissue irritation, allergic reactions, or systemic complications further supports the suitability of SDF as a safe preventive agent for routine clinical use [16]. Despite its strengths, the present study recommends smore research incorporating longer observation periods and randomized controlled trial designs would help strengthen the evidence base [16]. The findings of this study support the use of 38.0% SDF as an effective and safe preventive agent for reducing dental caries incidence and arresting early lesions. The results are consistent with existing international evidence and indicate that SDF can be successfully integrated into preventive dental protocols within the Libyan clinical context [17-19].

Conclusion: The application of silver diamine fluoride in private dental clinics in was associated with a reduction in the incidence of new dental caries and a high arrest rate of early non-cavitated lesions. The proportion of teeth remaining caries-free increased markedly after silver diamine fluoride application, indicating its effectiveness as a preventive and minimally invasive intervention in clinical settings. Additionally, the treatment was well tolerated, with no serious adverse effects reported during the follow-up period.

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التقييم السريري لفلوريد ثنائي أمين الفضة للوقاية من تسوس الأسنان لدى الأطفال

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الملخص: لا يزال تسوس الأسنان أحد أكثر الأمراض المزمنة شيوعًا في العالم، ويشكل عبئًا كبيرًا على الصحة العامة والسريرية، لا سيما في المناطق التي لا تُطبَّق فيها استراتيجيات الوقاية بشكل كافٍ. وقد برز فلوريد ثنائي أمين الفضة (SDF) كعامل موضعي فعال دوائيًا، يتمتع بخصائص مضادة للميكروبات ومزيلة للمعادن مثبتة. أُجري تقييم سريري استباقي على 110 مرضى تم اختيارهم من عيادات أسنان خاصة في سورمان وصبراتة. كان المشاركون المؤهلون يتمتعون بأسنان سليمة أو آفات تسوس مبكرة غير متجوفة عند خط الأساس. تم تطبيق محلول فلوريد ثنائي أمين الفضة بتركيز 38.0% على أسنان مختارة وفقًا لبروتوكول سريري موحد. أُجريت تقييمات سريرية عند خط الأساس وأثناء زيارات المتابعة لتسجيل حدوث آفات تسوس جديدة وتوقف الآفات الموجودة. استُخدم التحليل الإحصائي لتلخيص البيانات، وطُبِّقت اختبارات مربع كاي واختبارات المقارنة الزوجية لتقييم الاختلافات في معدل الإصابة بالتسوس قبل وبعد تطبيق فلوريد ثنائي أمين الفضة. من بين 110 حالة تم تقييمها، لوحظ انخفاض ذو دلالة إحصائية في معدل الإصابة بتسوس الأسنان الجديد لدى المرضى الليبيين بعد استخدام فلوريد الفضة. وقد ارتفعت نسبة الأسنان الخالية من التسوس من 62.7% عند خط الأساس إلى 85.4% عند المتابعة ($p<0.001$). تم رصد توقف تسوس الأسنان في مراحله المبكرة لدى 78.2% من الأسنان المعالجة. ولم يُلاحظ أي فرق بين المرضى الذين عولجوا في عيادتي صرمان وصبراتة. ولم تُسجّل أي آثار جانبية سريرية خلال فترة الدراسة. أظهر فلوريد الفضة تأثيرًا وقائيًا ملحوظًا ضد تسوس الأسنان لدى الأطفال الليبيين في عيادات الأسنان الخاصة. ويؤكد الانخفاض الملحوظ في معدل الإصابة بالتسوس على الاستخدام السريري لفلوريد الفضة كعامل وقائي فعال وآمن واقتصادي في مجال طب الأسنان الليبي.