



REVIEW ARTICLE

NANO SILVER FLUORIDE FOR PREVENTING AND ARRESTING DENTAL CARIES IN PRIMARY MOLAR OF AGE 6 TO 10 YEAR CHILDREN

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ABSTRACT

Aim: Aim of the study is to investigate the effectiveness of a new anticaries agent, Nanosilver fluoride (NSF), preventing and arresting caries in children. **Materials and methods:** A total of 52 deciduous molars, both maxillary and mandibular, were randomly selected from a group of 26 children aged 6 to 10, who were randomly assigned to the NSF experimental group or the saline control group. Teeth were clinically diagnosed and treated by a masked examiner, and they were followed up on at 7 days, 3 months, and 6 months by another calibrated examiner who was blind to the type of treatment. The ICDAS II criteria were used to determine the activity of the lesion and the diagnosis of caries. During the various follow-up examinations, the Pearson's Chi-square test was used to compare the groups. **Results:** The prevalence of caries was maximum in the age group of 9-10 years. At base line ICDAS score 4 was seen in 8 children (30.2%) in NSF group and in 5 children (19.2%) of saline group. For ICDAS score 4, at 6 months arrest was seen in 19.2% cases of NSF group and 11.2% in saline group and the difference was statistically significant. Soft caries was seen in all cases in both groups at baseline, however at 6 months, 24 (92.17%) cases in the NSF group and 3 case (11.5%) in saline group showed conversion to hard caries and the difference was again statistically significant. **Conclusions:** From our observations we concluded that NSF can be used as an effective tool for the arrest of carious lesions.

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INTRODUCTION

One of the most common chronic childhood diseases is dental caries¹. The prevalence of dental caries is particularly high in children of lower socioeconomic status or income; treatment becomes unaffordable for them as a result of their socioeconomic status, and the lack of dental manpower and sophisticated dental equipment required makes conventional restorative care a difficult way to address the caries problem². Untreated carious lesions may progress to cause pain, infection to spread, and malnutrition due to trouble feeding³. In the developed world, restorative treatment for dental caries frequently involves the use of sedation and general anaesthesia; this results in high costs, may pose a health risk, and may not be the most effective method of preventing the recurrence of lesions. As a result, caries treatment is now focused on preventing and stopping disease processes⁴. The current theory claims that fluoride's ability to prevent tooth decay is due to its constant presence in the oral cavity, which notably aids by directly influencing the demineralization/remineralization process.

Despite its efficacy, topical fluoride application is costly, technique dependent, and requires multiple applications per year; thus, alternative preparations that provide additional benefits may be of interest⁵. Based on its economic and scientific potential, nanotechnology is increasingly regarded as a critical emerging 21st-century technology, and it is experiencing rapid growth with numerous potential applications in dentistry⁶. Anticaries agents containing silver nanoparticles (AgNP) are non-irritating and have a bactericidal effect on *S. mutans* dynamic biofilm. These new products have better aesthetic and antimicrobial qualities than conventional silver fluoride products, which is supported by their properties, which point to their promise as an efficient cariogenic biofilm inhibitor⁷. Nano silver fluoride (NSF), a new experimental formulation containing AgNPs, chitosan, and fluoride, combines preventive and antimicrobial properties and has been developed as an effective anticaries agent. Nano-silver fluoride has already been tested clinically, and it proved to be effective in arresting caries in the enamel and dentin without staining the teeth⁸. The aim of this controlled clinical trial is to

investigate the efficacy of NSF, a new anticaries agent, preventing and arresting caries in children.

MATERIALS AND METHODS

Preparation of Nano Silver Fluoride: 1.0 g of chitosan was dissolved in 200 mL of 2% (V/V) acetic vinegar to create the colloidal silver. After being agitated all night, the solution was vacuum-filtered. After that, 4.0 mL of the chitosan solution was added to a solution of silver nitrate 0.012 mol/L and stirred for 30 minutes before the addition of sodium borohydride. An aliquot of 60 mL of the chitosan solution was then put in an ice bath. AgNO₃ and NaBH₄ were added in dropwise fashion while maintaining their 1:6 mass ratio. The solution quickly went from colourless to light yellow to brownish, signalling the start of the reduction of Ag⁺. The silver nanoparticles were generally 3.2–1.2 nm in size and spherical in form. Only after the trial was complete was fluoride (NaF) added, improving the solution's stability. Each component's amounts, measured in micrograms per millilitre, were as follows: Sodium fluoride (5028.3 g/mL), Ag⁺ (376.5 g/mL), and chitosan (28,585 g/mL)⁸.

Clinical Trial: The present *in vivo* study was conducted in the Department of Pedodontics and Preventive Dentistry, Saraswati Dhanwantari Dental college and Hospital, Parabhani. A total of 52 deciduous molars, both maxillary and mandibular, were randomly selected from a group of 26 children aged 6 to 10. A randomised, controlled, and double-blind trial was used for this study's methodology. One trained examiner chose the teeth and handled them clinically. The follow-up exams were conducted by another calibrated examiner who was unaware of the type of treatment. Inclusion criteria, Children between the ages of 6 and 10 who had at least one primary tooth with an active caries lesion matching code 05 of the International Caries Detection and Assessment System II, where the tooth exhibits a distinct cavity with visible dentin. To avoid bias for reduced salivary flow and caries with pulpal exposure or fistula and swelling, children with syndromes or undergoing medical treatment for chronic or acute diseases were excluded from the study.

The randomization method was used to maintain a similar distribution of the number of teeth in each group.

- Group I: Experimental group—NSF ($n = 50$).
- Group II: Control group—saline ($n = 50$)

Using cotton rolls to separate the teeth from saliva, the caries was treated without attempting to remove the caries or unsupported enamel. The selected tooth in the experimental group received two drops of NSF with a microbrush applicator tip, which is equivalent to a dose of 10 mg of the solution. In the control group, the selected tooth received two drops of saline with a microbrush applicator tip for caries treatment.

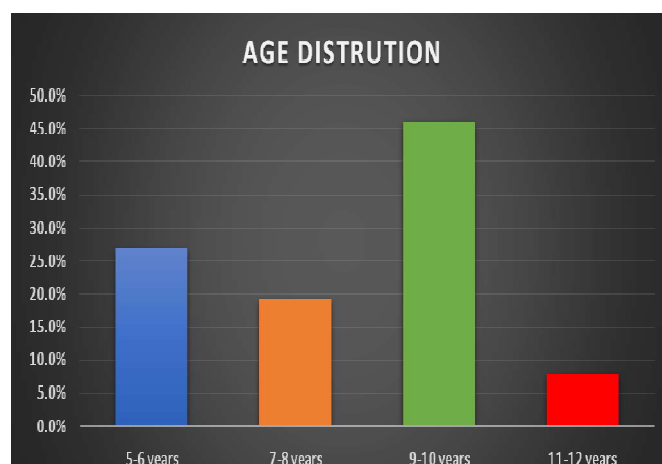
In the control group, the selected tooth received two drops of saline with a microbrush applicator tip for caries treatment. In the control group, the selected tooth received two drops of saline with a microbrush applicator tip for caries treatment. For two minutes, the tooth surface was in touch with the NSF solution and saline. In a 12-month period, only one of each therapy was administered.

RESULTS

The current study included 52 children ranging in age from 5 to 12 years; 13 were female and 13 were male. All of the teeth were primary and mixed posterior both maxilla and mandible, and 66% of the carious lesions involved only one carious surface, whereas 34% involved two or more.

Table 1. Age distribution of study population

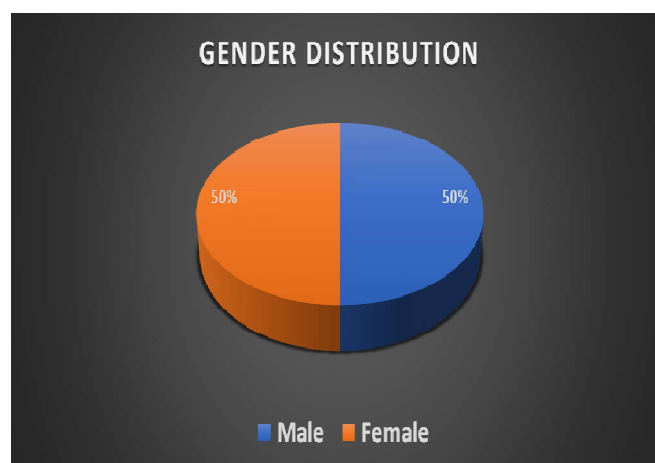
	Frequency (n)	Percentage (%)
5-6 years	7	26.9 %
7-8 years	5	19.2%
9-10 years	12	46.1%
11-12 years	2	7.8%
Total	26	100%



Graph 1 shows age distribution

Table 2. Gender distribution of study population

	Frequency (n)	Percentage (%)
Male	13	50%
Female	13	50%
Total	26	100%



Graph 2. Shows Gender Distribution

Table 3. Comparison of dentition status in study population

	Frequency (n)	Percentage (%)
Primary	7	26.9%
Mixed	19	73.1%
Total	26	100%

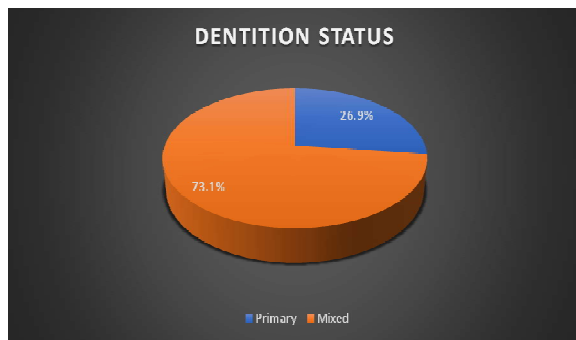
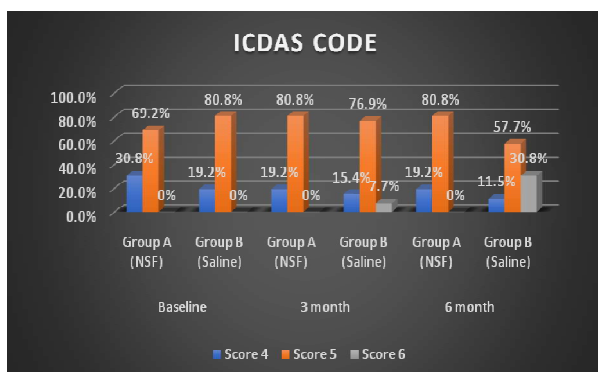


Table 4. Comparison of ICDAS code between Group A (NSF) and Group B (Saline) respectively

Baseline	Group A(NSF)	Group B(Saline)	Chi square test, P value
Score 4	8 (30.8%)	5 (19.2%)	Chi = 0.923, p = 0.337
Score 5	18 (69.2%)	10 (38.4%)	
3 month	Group A(NSF)	Group B(Saline)	Chi square test, P value
Score 4	5 (19.2%)	4 (15.4%)	Chi = 2.136, p = 0.344
Score 5	21 (80.8%)	20 (76.9%)	
Score 6	2 (7.7%)	0 (0%)	
6 month	Group A(NSF)	Group B(Saline)	Chi square test, P value
Score 4	5 (19.2%)	3 (11.5%)	Chi = 9.5, p = 0.009*
Score 5	21 (80.8%)	15 (57.7%)	
Score 6	0 (0%)	8 (30.8%)	

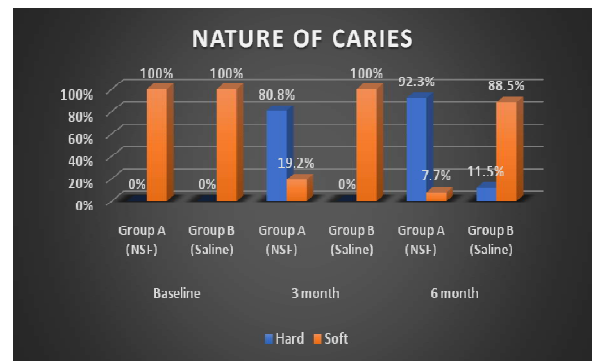


Graph 4. Shows Comparison of ICDAS code between Group A (NSF) and Group B (Saline) respectively

At base line ICDAS score 4 was seen in 8 children (30.2%) in NSF group and in 5 children (19.2%) of saline group. For ICDAS score 4, at 6 months arrest was seen in 19.2% cases of NSF group and 11.2% in saline group and the difference was statistically significant.

Table 5. Comparison of nature of caries between Group A (NSF) and Group B (Saline) respectively

Baseline	Group A(NSF)	Group B (Saline)	Chi square test, P value
Hard	0 (0%)	0 (0%)	Chi = 0.0, p = 1.000
Soft	26 (100%)	26 (100%)	
3 month	Group A(NSF)	Group B(Saline)	Chi square test, P value
Hard	21 (80.8%)	0 (0%)	Chi = 35.226, p < 0.001**
Soft	5 (19.2%)	26 (100%)	
6 month	Group A(NSF)	Group B(Saline)	Chi square test, P value
Hard	24 (92.3%)	3 (11.5%)	Chi = 33.973, p < 0.001**
Soft	2 (7.7%)	23 (88.5%)	



Graph 5. Shows Comparison of nature of caries between Group A (NSF) and Group B (Saline) respectively

Evaluation of the effectiveness of the treatments in the arrest of decay, After 3 months, analysis revealed that the majority of the participants in the NSF group (80.8%), i.e., decayed teeth, showed hard arrested dentine at 3 months, while all the participants in the control group showed no caries arrest at 3 months of evaluation. However at 6 months, 24 (92.17%) cases in the NSF group and 3 case (11.5%) in saline group showed conversion to hard caries, showing that majority of the participants among NSF group still retained caries arrest status after 6 months while some of the participants in the control group showed caries arrest and the difference was again statistically significant.

DISCUSSION

Dental caries is known as an infectious microbiological disease of calcified teeth tissues characterized by demineralization of inorganic portion and degradation of the tooth's organic substance⁹. Disrupting plaque biofilm formation is essential for successful dental caries management and prevention¹⁰. Due to extreme limited financial resources, inadequate access to basic oral care, and high cost of restorative therapy, children from low-income nations have their overall health, social well-being, and educational opportunities that are impaired by untreated dental caries. Arresting caries treatment (ACT) has been introduced to handle untreated dental caries in children from deprived communities¹¹. Recently, a new formulation of NSF containing chitosan was developed. The combination of AgNPs, fluoride, and chitosan in NSF's formulation works synergistically to effectively arrest dental cavities¹². Silver is normally utilized to generate antimicrobial effects in the form of nitrates, but when AgNPs are used, the surface area accessible for exposure to the bacterium is substantially increased¹². Sondi I states that AgNPs can anchor and penetrate the bacterial cell wall, inducing structural alterations in the cell membrane such as membrane permeability and cell death. On the cell surface, "pits" form, and nanoparticles are deposited¹³. Various studies suggest that chitosan and silver nanoparticles have antibacterial efficacy against the primary microorganisms responsible for the onset and progression of carious lesions, *mutans streptococcus* and *lactobacillus*, respectively¹⁴. Furthermore, the NSF nanoparticles' small size (3.2-1.2 nm) and spherical forms enhance the antibacterial action by expanding the contact surface¹⁵. Chitosan, a polysaccharide consisting of glucosamine copolymers and N-acetyl glucosamine, is the potential agent used in the present caries arrest formulation⁶. Chitosan is produced chemically by the controlled N-deacetylation of chitin, a linear polysaccharide

derived predominantly from arthropod exoskeletons such as marine crustaceans. The resulting polycation can be connected in the presence of polyvalent anions such as phosphates and is soluble in aqueous solutions of minor organic acids such as acetic acid and lactic acid¹⁶. Chitosan can inhibit *Streptococcus mutans* during the adhesion process and shown strong antibacterial and plaque reduction action at different stages of accumulation, indicating that chitosan is effective. In vitro studies have revealed that chitosan inhibits mineral element release by interfering with demineralization of dental enamel. The mechanism of action of the third element fluoride in the current formulation is to prevent demineralization of enamel¹⁷. Fluoride's mechanism of action is explained by numerous theories, which include its effects toward demineralisation, promotion of remineralisation, and prevention of bacterial activity in the plaque. The silver nanoparticles are a promising component for combating remaining bacteria in dental cavities and invading bacteria near the restoration margins¹⁸. Thus, Zhang et al. (2013) suggest the use of silver nanoparticles in adhesives, composites, cements and sealants to inhibit biofilms and caries¹⁹.

In the current study, ICDAS II criteria was used as the inclusion criteria as well as during the follow-up assessment to determine caries activity. ICDAS is a diagnostic grading system used to diagnose and evaluate dental caries¹⁶. It has been designed for use in dentistry education, diagnostic procedures, epidemiological investigations, and data analysis. This scoring system, like many others, may be utilized on coronal and root surfaces to identify and assess lesions for enamel caries, dentine caries, and noncavitated lesions¹⁶. Targino et al. (2014) compared Nano Silver Fluoride to chlorhexidine and silver diamine fluoride for antibacterial and cytotoxic activities against *Streptococcus mutans*²⁰. The NSF was discovered to be a bacteriostatic and bactericidal chemical, with MIC and MBC values of 33.54 14.52 g/mL and 50.32 g/mL for the ATCC (25,175) strains, respectively. The NSF was not toxic at any concentration tested for any type of erythrocyte and is more biocompatible than SDF¹⁸.

Vasquez et al. (2012) performed a pilot investigation on the pharmacokinetics of silver fluoride due to the increased interest in its application²¹. The results indicate that serum fluoride and silver concentrations following topical administration of SDF provide no toxicity risk when used in adults²¹ and block demineralisation and preserve collagen from breakdown in demineralised dentine²². Additional studies are needed when a routine application is withdrawn to assess long-term effectiveness after 2–3 years. SDF must be used in accordance with the manufacturer's dosing recommendations based on body weight. The researchers suggested 1 drop per 10 kilos of body weight every therapy session. It establishes the Environmental Protection Agency's short- and long-term objectives²³. The most important advantage of SDF in reducing dentine caries is its effectiveness. It is affordable and so widely available in many countries. The process of treatment is quick and does not require expensive equipment or infrastructure support¹⁷. A drawback of using SDF to prevent caries is that it discolors the lesions. When SDF comes into touch with the tissues, it leaves a metallic taste on the oral mucosa and causes reversible white sores. Mei et al. recommended using chemicals like potassium iodide or AgNPs to improve the esthetic outcome and overcome the SDF drawbacks²⁴.

Application of this new anti-caries agent once a year showed similar efficacy (66.7%) to that of silver diamine fluoride (SDF) 30% (66.9%)²³. Moreover, the agent had the benefit of not discoloring the tooth tissue black²⁵. When nano-silver compounds come into contact with oxygen in the medium, they do not form oxides. Furthermore, unlike SDF, the NSF solution did not have a metallic flavor²⁶. NSF application is inexpensive and thus can be afforded by most communities. In the present study, a single application of NSF resulted in positive caries arrest rates, which differed from the results of Duangthip, who examined the efficiency of 30% SDF vs fluoride varnish in caries arrest rates²⁷. According to Santos et al., Lo et al., and Chu et al., the study concluded that NSF can successfully arrest the carious lesion.

CONCLUSION

The present study concluded that NSF acts as an anticaries agent and provides a noninvasive option for caries arrest and treatment.

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