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Effectiveness of Nano - Silver Fluoride Varnish in Prevention of Early Childhood Caries

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Abstract: ***Aim: To evaluate the efficacy of Nano - silver fluoride varnish in prevention of Early Childhood Caries in children. Method: A total of 16 children aged 2 - 4 years diagnosed with Early Childhood Caries were selected. Initially, nyvad index was recorded of the children who were selected for the study and tooth with scores 0, and 1 were selected. Initial cleaning of cavity was performed by using small cotton pellet. Two drops of Nano - silver fluoride varnish was applied with a disposable micro - applicator tip for 10 seconds and left for 4 minutes on the tooth selected. The child was instructed not to drink water or eat food for at least 45 minutes. Second fluoride application, not proceeded by a prophylaxis was scheduled at an interval of 6 month. Teeth were assessed clinically using NYVAD index at an interval of 7 days, 5 month, and 9 months. The data obtained from the study was tabulated and then subjected to statistical analysis. Results: The status of carious lesion at 7 days follow - up showed that there were 100% non - reversal of lesions in both test and control groups. The status of carious lesion after 5 months follow - up showed that there were 57.6% reversal of initial caries. After 9 months of follow - up, the status of carious lesion showed that there were 62% reversal of lesions. Conclusion: Recent advancement of nano silver fluoride varnish has the superior property of arrest of caries and its reversal without any staining of the applied surfaces of tooth. So nano silver fluoride varnish can be used in prevention of early childhood caries.***

Keywords: fluoride, NSF, reversal, white spot lesion, prevention

1. Introduction

ECC affects over half of all children worldwide, with prevalence rates varying between 2.1% and 85.5% in both rich and developing nations.1 The most prevalent condition in young children, early childhood caries can range in severity from beginning soon after tooth emergence. Therefore, using preventative strategies to slow the rapid spread of caries is one of the main goals in paediatric practise. Therefore, in cases of early childhood caries, identification and reversal are imperative.

Key risk factors for dental caries, the progression of dental caries, and accessible therapies, such as fluorides, can all be used to personalise preventive measures. The use of fluoride has been regarded as the most significant non - invasive therapeutic and preventive management of caries, with its mechanism of action primarily topical by incorporating fluorapatite crystals in the tooth enamel, making it more resistant to acid dissolution and thereby promoting the remineralization of early carious lesions (therapeutic effect) as well as inhibiting demineralization of dental hard tissues (preventive effect).[2]

Fluoride is the cornerstone for both treatment and prevention of caries. Fluoride varnish is a topical fluoride solution that is applied to the teeth and hardens when it comes into contact with saliva.3This treatment method has the benefit of being well - tolerated by young children and their parents

Using silver, fluoride, and ammonia as its main ingredients, silver diamine fluoride is a noval fluoride agent. Active dentine caries are effectively stopped when silver and fluoride are combined in an alkaline solution but side effects, like ulceration and oral mucosa discoloration, have restricted its use.4 Parents did not consider the black stain as being acceptable and it detracted from the treatment's aesthetic appeal.

Newer agents like Nanosilver Fluoride (NSF), an experimental formulation including silver nanoparticles, chitosan, and fluoride, have now been developed to solve the shortcomings of SDF.5The cytoplasmic membrane's permeability may be increased and the bacterial envelope may be ruptured as a result of the silver ions released by NSF. Silver ions can deactivate respiratory enzymes and stop the synthesis of adenosine triphosphate after they have entered the cell membrane. Additionally, protein synthesis and DNA replication can also be blocked by silver ions. Silver nanoparticles have a self - killing capacity in addition to the release of silver ions. The pits that emerge on the cell wall as a result of the silver nanoparticles' anchoring to the cell surface can become clogged with silver nanoparticles. By minimising the demineralizing impact and the acids that the biofilm produces, silver nanoparticles can stop caries from occurring. Silver nanoparticles can connect to hydroxyapatite crystals inside carious lesions. In addition, dental hard tissue exposed to silver ions produced by silver nanoparticles may produce insoluble silver chloride. Dental hard tissue has a higher mineral density due to precipitated silver nanoparticles and insoluble silver chloride.

The degradation of the exposed collage in the carious tooth is caused by enzymes that can be inhibited and deactivated by silver nanoparticles. The mineral crystal can then be deposited on the conserved collagen, and the diffusion of calcium and phosphate can be stopped.6Therefore, silver nanoparticles help regulate the formation of biofilm, are efficient against infections, particularly Streptococcus mutans, and aid in the remineralization of early caries[7, 8]. The size of silver nanoparticles enhances the contact surface, which is crucial for silver's antibacterial properties,

eliminates tooth stains, and lowers toxicity. According to studies for haemolytic activity, NSF does not damage the human erythrocyte membrane, making it less toxic than silver diamine fluoride.9, [10]This is supported by the fact that NSF has no cytotoxic effects. Hence the need of the study is to evaluate and compare the efficacy of Nanosilver fluoride varnish and sodium fluoride varnish in children with Early Childhood Caries.

Aim

To evaluate the efficacy of Nano - silver fluoride varnish in prevention of Early Childhood Caries in children.

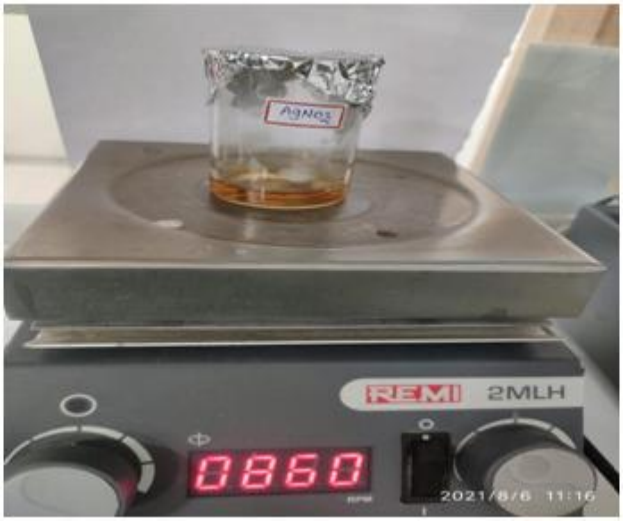
Objective

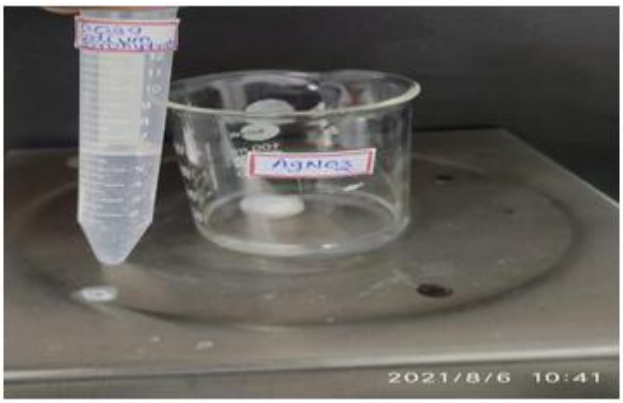
To evaluate the efficacy of Nano - silver fluoride (NSF) varnish in prevention of Early Childhood Caries.

2. Methodology

Preparation of Nanosilver fluoride varnish

1.0 g of chitosan was dissolved in 200 mL of 2% (V/V) acetic acid to create the colloidal silver. After being agitated all night, the solution was vacuum - filtered. After that, a 60 mL aliquot of the chitosan solution was poured into an ice bath while being agitated, and 4.0 mL was added to a silver nitrate solution that contained 0.012 mol L1 of silver 30 minutes before the sodium borohydride was added. AgNO3 and NaBH4 were added dropwise while maintaining their 1: 6 mass ratio. The solution quickly went from colourless to light yellow to reddish, signalling the start of the reduction of Ag+. The AgNPs were spherical in form and ranged in size from 3.2 to 1.2 nm. Only at the end of the experiment was sodium fluoride (NaF) 0.05 ppm added, which increased the solution's stability. Chitosan concentration was 28, 585 micrograms per millilitre, Ag+ concentration was 376.5 micrograms per millilitre, and sodium fluoride concentration was 5028.3 micrograms per millilitre.





Silver nano particle preparation

Study Design

In this study, a total of 16 children diagnosed with stage I Early Childhood Caries aged 2 - 4 years was selected

Inclusion criteria

- Children aged 2 - 4 years with stage 1 Early Childhood Caries
- Children with stage I incipient lesion with a white spot along the neck of the deciduous maxillary anterior teeth.
- Children with high risk of Early Childhood caries

Exclusion criteria:

- Teeth without intact enamel
- Children allergic to metals like silver
- Children who are from fluoride belt area.
- Children undergoing radiation therapy
- Children who are medically compromised

The study was conducted after the approval from Ethical Committee of KVG Dental college and hospital sullia. A total of 16 children aged 2 - 4 years diagnosed with Early Childhood Caries reporting to the out patient Department of pedodontics and preventive dentistry were selected.

The parent / local guardian of selected subject was explained about the study in English or native language and informed written consent was obtained.

A detailed Medical history and Drug history of the child is recorded. The procedure was explained to both the child and the parent

Initially, NYVAD INDEX was recorded of the children who were selected for the study and tooth with scores 0, and 1 were selected.

Initial cleaning of cavity was performed by using small cotton pellet

Two drops of Nano - silver fluoride varnish was applied to the tooth with a disposable micro - applicator tip for 10 seconds and left for 4 minutes.

The child was instructed not to drink water or eat food for at least 45 minutes.

Second, fluoride application, not proceeded by a prophylaxis, was scheduled at an interval of 6 month

Teeth were assessed clinically using NYVAD index at an interval of 7 days, 5 months, and 9 months

The data obtained from the study was tabulated and then subjected to statistical analysis.

Descriptive statistics were derived as mean, standard deviation, minimum, maximum, median values, frequency distribution and percentages.

This study was conducted to evaluate the efficacy of Nano - silver fluoride varnish in prevention of Early Childhood Caries in children. The study was conducted from August 2021 to November 2022. Data regarding demographic characteristics, scores of Nyvad index at baseline, 7th day, 5 months and 9 months following a fluoride varnish therapy using nano silver fluoride varnish and sodium fluoride varnish were entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 20 (IBM Corp., Armonk, N. Y., USA). Data was investigated for normality using the **Kolmogorov - Smirnov test and it showed that the data significantly deviate from normal distribution.** Descriptive statistics were derived as mean, standard deviation, minimum, maximum, median values, frequency distribution and percentages. . The intragroup mean of Nyvad index scores at baseline, 7th day, 5th month and 9th month within each group was analysed using Friedman Test. The status of carious lesion (reversal or non - reversal) at 7th day, 5th month and 9th month was analysed between the two fluoride varnish groups using Chi - square test. The level of statistical significance was determined at $p<0.05$.

Table 1: Demographic characteristics of the study population

Demographic characteristics		Nano Silver Fluoride varnish (n = 16)
Age (years) [n (%)]	2	2 (12.5)
	3	4 (25)
	4	10 (62.5)
	5	0
	Mean + SD	3.50 + 0.73
Gender [n (%)]	Male	7 (43.8)
	Female	9 (56.2)

Interpretation: The mean age of the study population is 3.50 years in Nano Silver Fluoride varnish. There were about 12.5%, 25%, and 62.5% individuals aged 2, 3, and 4 years in Nano Silver Fluoride varnish. The study population has 43.8% males and 56.2% females in Nano Silver Fluoride varnish group.

Table 2: Intragroup comparison for Mean of Nyvad Index Scores within test and control group

Nyvad Index Score		n	Mean + SD	Minimum	Maximum	Mean Rank	Friedman test value (p - value)
Nano Silver Fluoride varnish	Baseline	16	1.38 + 0.50	1	2	3.06	27.000 (0.000) *
	After 7 days	16	1.38 + 0.50	1	2	3.06	
	After 5 months	16	0.81 + 0.98	0	2	1.94	
	After 9 months	16	0.81 + 0.98	0	2	1.94	

*Statistically Significant ($p<0.05$)

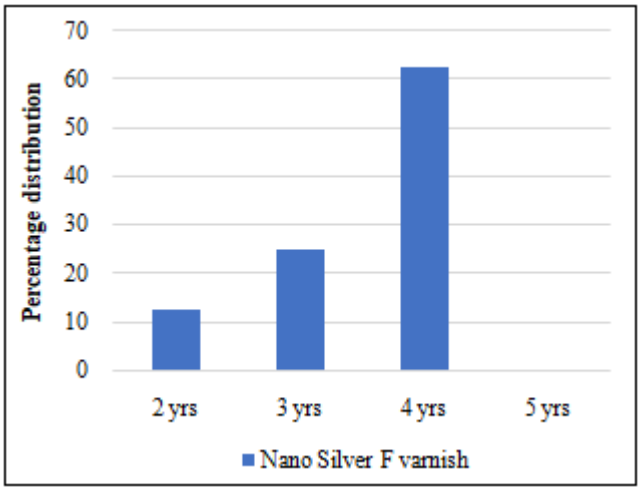
Interpretation: Based on Nyad Index, the mean scores in Nano Silver Fluoride varnish group at baseline, after 7 days, after 5 months and after 9 months were 1.38, 1.38, 0.81 and 0.81 respectively.

Table 3: Evaluation of effectiveness of treatment based on reversal of lesions

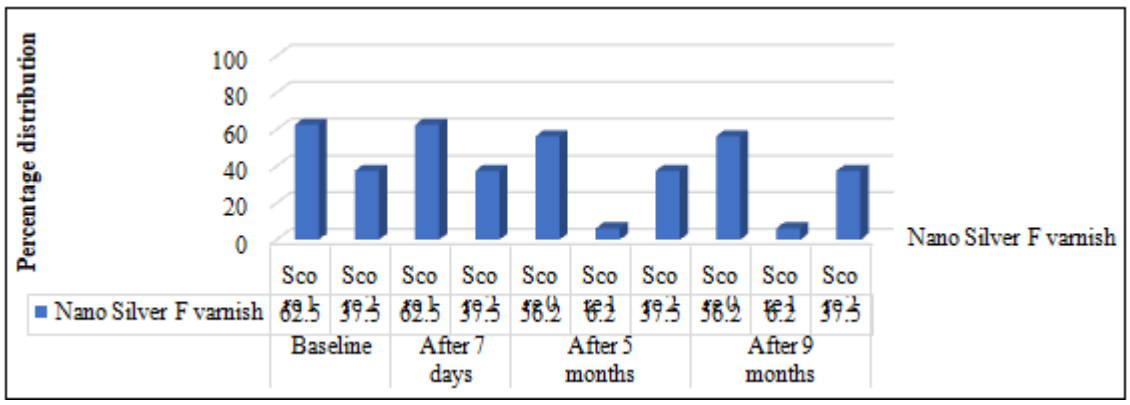
Evaluation of effectiveness of treatment based on the reversal of carious lesions (Number of teeth = 188)			Nano Silver Fluoride varnish (n = 92)
Status of Carious Lesion at 7 days follow - up	Non - reversal of carious lesion	Count (n)	92
		% within 7 days	48.9%
		% within Groups	100.0%
		% of Total	48.9%
	Reversal of carious lesion	Count (n)	0
Status of Carious Lesion at 5 months follow - up	Non - reversal of carious lesion	Count	39
		% within 5 months	42.9%
		% within Groups	42.4%
		% of Total	20.7%
	Reversal of carious lesion	Count	53
		% 5 months	54.6%
		% within Groups	57.6%
		% of Total	28.2%
Status of Carious Lesion at 9 months follow - up	Non - reversal of carious lesion	Count	35
		% within 9 months	40.2%
		% within Groups	38.0%
		% of Total	18.6%
	Reversal of carious lesion	Count	57
		% within 9 months	56.4%
		% within Groups	62.0%
		% of Total	30.3%

Interpretation: The status of carious lesion at 7 days follow - up showed that there were 100% non - reversal of lesions, The status of carious lesion after 5 months follow - up showed that there were 57.6% reversal of lesions. After 9 months of follow - up, the status of carious lesion showed that there were 62% reversal of lesions.

Interpretation: This graph shows that the mean age of the study population is 3.50 years in Nano Silver Fluoride varnish. There were about 12.5%, 25%, and 62.5% individuals aged 2, 3, and 4 years in Nano Silver Fluoride varnish.

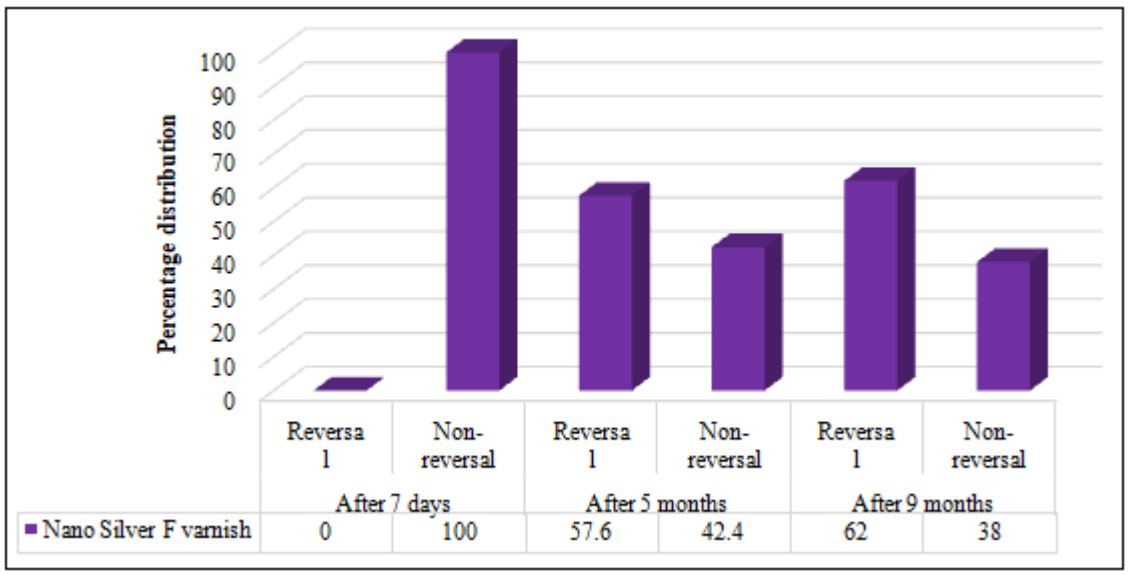


Graph 1: Age distribution of study participants



Graph 2: Distribution of patients based on Nyvad Index scores

Interpretation: The graph shows that active caries with intact surface at baseline and after 7 days of evaluation is 62.5% and the proportion of active caries with surface discontinuity is 37.5% at 5 months and 9 months.



Graph 3: Effectiveness of treatment based on remineralization of carious lesions

Interpretation: The graph shows that there were 100% non reversal of caries at 7 days follow up and 57.6% reversal of lesions by Nano Silver Fluoride varnish. At 9 months of follow - up, the status of carious lesion showed that there were 62% reversal of lesions.

3. Discussion

Early childhood caries (ECC) is a chronic form of caries occurring in children under 71 months of age, develops on smooth surfaces, and progresses fleetly. For the purpose of preventing ECC, several strategies have been proposed. The ECC's preventive actions include educating and counselling mothers, fluoridating water, promoting good oral hygiene, offering food recommendations, and taking corrective action.9The most practical method of applying topical fluoride to preschoolers has been suggested to be fluoride varnishes due to their ease of use and widespread acceptance.1^{0}A covering of pellicle proteins and secondary phosphates contributes to the extended retention of fluoride in varnishes. A low pH causes the pellicle coating to lose adhesion during a caries attack, releasing calcium fluoride. These fluoride reservoirs release fluoride gradually into dental plaque, saliva, or the apatite structure of the tooth when the pH decreases.[11]

Dynamic balance between demineralizing and remineralizing factors determine the eventual outcome of dental caries and manifested as a continuum of disease ranging from subclinical atomic level of demineralization to frank cavitation. Initially, ECC is observed as dull, white spot lesions (WSL) on the cervical margins of the maxillary primary incisors which advance to cavitated enamel surfaces in a short span of time. White spot lesion is caused by demineralization of enamel with subsurface porosity that can be reversed if detected at this stage.1^{2}The hunt for a method and material that guarantees caries control through a less invasive and more economical approach that can stop the caries in a child with ECC is ongoing. Caries arresting therapies such as resin infiltration, fluoride varnishes, a traumatic restorative treatments are alternate and useful way to lessen the suffering of children with caries and any repercussions that may result from it. It works by slowing down the spread of caries.

The goal of the current study was to compare the effectiveness of Nano - silver fluoride varnish with that of Sodium fluoride varnish in preventing Early Childhood Caries, as well as to assess the efficacy of both varnishes.

In our study we found that more instances of ECC were in the mean age group of 3.50+ 0.73 although there was a nearly similar distribution of cases among boys and girls. According to **Chopra A. et al**., one possible explanation for the problem is that caries is a long - term condition that gets worse as people age. The longer the dentition is exposed to the caries' causal factors without receiving proper care, they hypothesise, the more severe the caries will probably be.1^{6} According to a study by **Ramos - Gomez Fj et al**., boys between the ages of 8 months and 7 years old are much more affected than girls in terms of ECC prevalence. This finding is in line with that study's findings. .[14]

In the present study we found that both boys and girls are more or less equally affected by ECC with 50% boys and 50 % girls. This indicates that there were no statistically significant differences in the ECC prevalence between the genders. This is consistent with the finding of a study done by **Mingshan Liu et al.**[15]

In our study we used the Nyvadindex to assess the reversal and arrest of caries as there is discrete values for the initial white spot lesions of ECC provided by this criteria. The Nyvad criteria for caries diagnosis were the first classification to explicitly specify the activity assessment of both cavitated and non cavitated lesions. In order to evaluatecaries lesion activity at each of the three stages of progression—the non – cavitated stage, the enamel discontinuity stage, and the cavitated stage—the Nyvad criteria is based on visual and tactile diagnosis. The subject of the current investigation is a non - cavitated white spot lesion that is easily recognised by the Nyvad index.[13]

Current study looked at the effectiveness of Nano - silver Fluoride (NSF) varnish in preventing Early Childhood Caries with nyvad. **At the 7 - day checkpoint, there was no change in the index score, but at the 5 - and 9 - month checkpoints, there was a decrease in the mean score of the Nyvad index from 1.38 to 0.81 with level of significance p value 0.000,** indicating that then anosilver fluoride varnish is stopping and reversing ECC white spot lesions.

Future studies examining the histologic characteristics, such as the enamel hardness of primary teeth after application of nano silver fluoride varnish, would be intriguing. Due to the fact that ECC is a complex disease with numerous known risk factors, such as dietary history, dental hygiene habits, and salivary flow, prevention of the condition cannot be fully achieved with topical treatment. Future researches are required to examine the dose - response of NSF in situ as well as its relationship to other anticaries drugs.

4. Conclusion

Early childhood caries is one of the chronic diseases of the primary dentition which can be arrested and reversed if detected at the initial stage of white spot lesion. Fluoride containing products such as fluoride varnish plays a crucial role in preventing caries. Recent advancement of nano silver fluoride varnish has the superior property of arrest of caries and its reversal as compared to sodium fluoride varnish and SDF without any staining of the applied surfaces of tooth.

Our study concluded that:

Nano silver fluoride varnish is effective in arresting white spot lesions of stage 1 of ECC and its reversal

In conclusion, within the limitations of this study nano silver fluoride varnish can be used in prevention of early childhood caries as an alternative to sodium fluoride varnish.

Further studies with much larger sample size are required to substantiate our results.

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