ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 4, Issue – 6, December - 2021, Page No. : 188 - 196

To compare the efficacy of annual biannual and triannual topical application of silver diamine fluoride solution in treatment of dentinal caries in primary molar teeth using diagnodent pen

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Citation of this Article: Dr. Rachel Gupta, Dr. Yusuf Chunawla, Dr. Vanishree B K, Dr. Abhinav Talekar, "To compare the efficacy of annual biannual and triannual topical application of silver diamine fluoride solution in treatment of dentinal caries in primary molar teeth using diagnodent pen", IJDSIR- December - 2021, Vol. – 4, Issue - 6, P. No. 188 – 196.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Objective: This study aimed to compare and evaluate the effectiveness of annual, biannual and triannual topical application of silver diamine fluoride solution on deciduous dentinal caries molar teeth using DIAGNOdent pen.

Materials and Methods: 150 primary molars divided into three groups of 50 teeth each in a children age group 5-10 years were included in the study as per inclusion criteria. Using DIAGNOdent (kavo) pen before and after application of silver diamine fluoride all children was examined. Annually, biannually and triannually SDF was applied using micro brush in a scrubbing motion, allowed to absorb for 1 minute and told not to eat or drink for 30 minutes. Follow-up examination was carried out by DIAGNOdent pen on carious molar teeth at 1-month intervals for a period of one year. Clinical evaluation of SDF solution application was done by International caries classification and management system up to one year.

Result: Significant caries arrest was seen in all three application protocols of silver diamine fluoride at the end of 9 and 12 months but triannually was most effective in caries arrest than biannual and annual application of SDF.

Conclusion: Silver diamine fluoride serve as an alternative approach to the conventional restoration in young uncooperative children.

Keywords: Dental caries, SDF, DIAGNOdent pen, ICCMS, Triannual.

Introduction

Dental caries is a complex multifactorial microbial diseases affecting mankind that results from the interplay of the principal factors: the host, micro flora, the diet or substrate and time [1]. Progression of dental caries can lead to pain, infection, loss of function and difficulty in mastication etc. Incipient and advanced carious lesion may become arrested if there is significant shift in oral environmental conditions to slow the caries process [2].

Arrest of caries technique (ACT) aims to minimize children's discomfort and problems due to caries and to slow down caries progression. It includes stannous fluoride, low viscosity glass ionomer cement, silver fluoride, tooth brushing using fluoride, silver diamine fluoride [3] and aims to arrest decay but not to restore the damaged tooth structure.

Silver diamine fluoride (SDF) has 38% w/v with Molecular formula: Ag (NH3)2 F was introduced in Japan and has been used as an effective caries arresting agent [4]. It is a colorless liquid containing 8% ammonia, 25% silver and 5% fluoride with pH 10^{-4}. Ammonia stabilizes high concentration in solution with fluoride concentration 44,800 ppm of fluoride ion, fluoride promotes remineralization and silver as anti-caries. Silver diamine fluoride arrest lesions 150 microns thick. SDF is minimally invasive and preserves tooth structure [5,6]. Once the caries lesion is arrested may not require a dental restoration to maintain health unless the patient wants to improve form, function or esthetics.

Different techniques for direct and indirect mineral quantification are transverse micro radiography, Scanning electron microscopy, Diagnodent pen, Surface Micro hardness, Digital subtraction radiography, laser light methods like Digital imaging, Fiber-optic Trans illumination (DFOTI), Quantitative light induced fluorescence etc.

Diagnodent used for diagnosis of occlusal caries as visual examination which is based on the principle that when Diode laser of 655nm wavelength is irradiated on dental surface it is absorbed by metabolites of intraoral bacteria and emit a red fluorescence. Fluorescence reflected by the dental surface numbered between 0 and 99 on the screen of the device. Greater numbers indicates more decay area which provides a quantitative and non-invasive method for the diagnosis of dental caries [7,8].

After demineralization, Diagnodent pen fluorescence values were greater due to increase in the surface porosity of the enamel, increase in organic content in the presence of biofilm and light scattering. Hence, Diagnodent pen and International Caries Detection and Assessment System (ICDAS II) is used for the detection and assessment of caries in this study [9].

Different stages of dental caries on the basis of histological extent and activity is assessed by ICDAS, is therefore recommended to classify various stages of carious process extending from early clinically visible changes in enamel to wide cavitation [10] and also used in the four domains of clinical practice, education, research and public health and provides all stake holders a common language for classifying dental caries.

Studies regarding effectiveness of above material and frequency of application in arresting dentinal dental caries are very less in India. Hence, present study was conducted to compare and evaluate the effectiveness of annual, biannual and triannual topical application of silver diamine fluoride (SDF) solution on deciduous dentinal caries molar teeth using DIAGNOdent pen.

Materials and Methods

150 primary molars divided into three groups of 50 teeth each in children were included in the study as per

inclusion criteria. From 150 primary molars, 124 molars had ICDAS II score 4 (82.7%) while 26 molars had ICDAS II score 5 (17.3%) (Graph1).

For recording oral hygiene and dental caries status, plaque and dmfs index was used. The screening was done with mouth mirror and probe. Five surfaces in each posterior tooth were evaluated. Status of dentinal caries was assessed according to the criteria recommended by ICDAS II Coordinating Committee.

Inclusion criteria

1. Teeth with active dentinal caries.
2. Deciduous molar teeth will be included.
3. Written consent from their parents.
4. No significant medical history.
5. No known history of allergy against silver.

Exclusion criteria

1. Children not willing for dental treatment.
2. Teeth with more than one third of the crown missing, or pulp-ally involved.
3. Presence of an abscess and hyper mobility.
4. Patient with history of spontaneous pain.

Methodology

All children were examined by Diagnodent (kavo) pen before and after application of SDF. Air blown and dried the tooth surfaces before the measurement and device was calibrated with sound tooth structures as needed. For fissure caries and smooth surface caries Tips A and B was used. The measurement was done by keeping the tip at right angle to the tooth surface. Diagnodent values were obtained through their average by measuring the teeth three times at maximum value.

Teeth isolation was done with the help of cotton rolls and gauze. The carious surface was desiccate with air. SDF was applied with stiff micro brush using a scrubbing motion and allowed to absorb for one minute. After applying SDF, petroleum jelly is applied in contact with the caries lesion.

SDF application done as follows:

Group 1: SDF solution applied annually (One time in a year).

Group 2: SDF solution applied biannually (Two times in a year).

Group 3: SDF solution applied triannually (Three times in a year).

After application of SDF all children were told not to eat or drink for 30 minutes. Follow-up examinations were carried out by Diagnodent pen on carious molar teeth at 1-month intervals up to one year. Clinical evaluation of SDF solution application was done by ICCMS up to one year by following criteria below (Table 1)

Statistical evaluation

Data were analyzed using Statistical Packages for Social Sciences (SPSS) ver. 12.0 for MS windows and entered into database on Microsoft Excel. Chi-square test and ANOVA test were used, between the three groups of children. Statistical significance was P-value < 0.05.

Results

- According to ICDAS code, all the active dentinal caries in primary molar of 5- 10 years children were in ICDAS extensive stage where dentin is shiny and hard on probing. No clinical side effects were seen.
- According to intergroup comparison (ANOVA), Group 3 more effective in caries arrest ($p < 0.01$) in primary molar at than Group 2 and Group 1 in 12 months follow up.
- According to Post hoc pair wise comparison, A mean difference of 5.280 between group 1 and 2 was statistically significant $p < 0.01$ in 9 months follow up (Table 2). A mean difference of 2.580 between group 1 and 2 was statistically significant $p<0.01$ in 12 months follow up (table 3). Group 2 was more

effective in caries arrest in deciduous molar than Group 1 in 9 and12 month intervals.

- According to intergroup comparison (ANOVA) and Post Hoc Pair test, Group 1 shows least Dentinal caries arrest as compare to Group 2 and Group 3
- All the three Groups shows dentinal caries arrest in all time interval. The mean active caries at baseline in all three groups were significantly reduced at 9 months and further at the end of 1 year (Graph 2)

Discussion

Interest in SDF is on: (1) pain and infection control (2) ease to use and simple (3) reasonableness of material (4) less personnel time and training (5) non-invasive [11]. SDF arrest and prevent progression of caries by converting the more acid soluble hydroxyapatite to the less soluble fluorapatite, killing the causative bacteria, depositing a layer of protective silver phosphate that resists further decay, [12]. Studies showed that silver interacts with sulfhydryl groups of proteins and DNA, cell wall synthesis, and cell division, DNA unwinding, altering hydrogen bonding and inhibiting respiratory processes [13]. Radiographic, Visual and tactile are commonly used methods for caries detection. Also Laser-induced fluorescence (Diagnodent), Digital Imaging Fiber Optic Trans illumination Imaging (DIFOTI), and conventional radiography etc are light-based methods used for caries detection. [14-16]. In present study, Diagnodent Pen and ICDAS II were used for the caries detection of primary molar in school children.

Diagnodent pen device was more effective in detecting demineralization and remineralization on surface of caries and was superior to that of radiography. In vitro evaluation by ElzbietaLuczaj-Cepowicz (2019) showed that, both Diagnodent pen device and ICDAS II was better in detecting occlusal surfaces caries [17]. ICDAS is used in present study, to get good quality information to make decisions about prognosis, clinical management of dental caries and diagnosis at both individual and public health levels. ICDAS criteria have good reproducibility for detection of noncavitated lesions in clinical applications.

Laboratory studies showed that SDF could increase the hardness of treated dentine caries, preserve collagen from degradation in demineralized dentine and inhibit demineralization [18]. SDF's ability to prevent formation of new caries and pause caries process that makes SDF different from other caries-preventive agents, like stannous fluoride (2% to 8%) and sodium fluoride (5%). A systematic review by ZO Tolba et al (2019) showed that 38% SDF was effective in arresting dentine caries in deciduous teeth compared to 12% SDF and overall caries arrest rate for SDF was 81% in a meta-analysis [19,20]. Therefore; in present study used a high concentration of 38% SDF because of higher caries arrest.

The regimen for application of SDF is either once a year or biannual for arresting caries in deciduous teeth. By reducing time intervals between SDF applications, caries arrest rate increased dramatically [21]. If treated lesions do not appear arrested then reapplication of SDF may be indicated. In present study, application of SDF was annually, biannually, triannually and found that triannual application of a 38% SDF solution was more effective in hardening deciduous caries molar than biannually and annually at 12 months follow up. At end of 6 months, 9 months and 12 months there was significant reduction in the mean number of active caries surfaces in all the three groups. From this we infer that all three treatment protocols of SDF were effective in caries arrest. But statistically no significant difference between inter groups comparison of active surface caries for all pair of three groups at the end of 6 months was seen probably due to

short follow up. These outcomes are in parallel with the study done by S. Daga (2020) [22].

According to intergroup comparison (ANOVA), Group 3(8.22) more effective in caries arrest in primary molars than Group 2(17.06) and Group 1 (19.64) in 12 months follow up ($p<0.01$). Post hoc analysis results showed that Group 3 was significantly more effective in caries arrest than group 2 and group 1 due to more frequency of application of SDF. Similar study by MHT Fung et al 2018 and Zhi et al 2012 showed that increasing the frequency of applications could increase the caries arrest rate and cause decrease in active carious lesions.

According to Post hoc pair wise comparison in 9- and 12-month interval, Group 2 was more effective in hardening deciduous caries molars than Group 1. Findings reported by Zhi and coworkers (2012) supported the results of our study that biannual application could increase the proportion of surfaces that became arrested after 18 months at the surface level than annual application of SDF. According to intergroup comparison (ANOVA) and Post Hoc Pair test, Group 1 shows least Dentinal caries arrest as compare to Group 2 (biannual) and Group 3 (triannual). Results of our study supported the finding reported by MHT Fung et al 2016 that SDF is more effective in arresting deciduous dentinal caries teeth of preschool children at 38% concentration than 12% concentration when applied biannually than annually of 18 months follow up.

In our study, application regimens of SDF which have not been reported in any other study, that is group 3 triannual application. In group 2 biannual application and in group 1 annual application of SDF which is frequently reported in literature [23]. We observed a remarkable caries arrest rate when SDF was applied at triannual as compared to biannual and annually at the end of 1 year, which indicated that increasing the frequency of applications showed an increase in caries arrest rate.

The positive outcomes of this study at the end of one year due to regular reinforcement of oral hygiene practices and the sustained release of silver and fluoride explained by "Zombie effect" [24]. In study we found blackish discoloration is the only side effect of SDF treated teeth. It has been assessed that each application of 38% SDF solution contains 0.2 mg fluoride, which is below probably toxic dosage of 5 mg/kg [25]. During 12-month follow-up there was no side effects seen in our study.

Based on metabolism of fluoride, plasma fluoride levels increase rapidly after ingestion and reaches peak within 20–60 min finally drop to baseline within 3-11 hours, depending on the amount ingested [26]. Risk of fluoride overdose in triannual and biannual is small due to rapid absorption and excretion of fluoride. Data on adults showed the risk associated with silver ingestion after use of 38% SDF was below the concentration associated with toxicity [27]. There are no data on young children, hence needs to pay attention on safety aspect when applying high concentration fluoride and silver agents. Hence the treatment protocol for application of 38% SDF appears to be safe in our study group which comprised of school children.

Limitation of our study was, the follow up period could have been longer duration to evaluate the effect of SDF. We recommend triannual application of SDF can be accepted when a non-restorative treatment approach is selected. The general recommendation is that frequent application of topical fluoride is advised in high-risk young uncooperative children can be alternative treatment to the conventional restorative approach. This study shows frequent topical application of 38% SDF can arrest active dentinal caries. Apart from frequent application and concentration of SDF, treatment effectiveness were

also associated with other factors like the age of starting tooth brushing, lesion site, plaque on lesion, VPI score, lesion size, main caretaker, mother's education and tooth position [28,29].

Effective measure contributing to the control of caries progression and affecting the success rate of SDF is by disturbance of dental plaque should be highlighted. After SDF treatment a protective layer formed may dissolve therefore, the lesions cannot be arrested [30]. Therefore, further oral hygiene practice education should be highlight.

Conclusion

Significant caries arrest was seen in all three application protocols of SDF at the end of nine months as well as one year follow up. Tri-annual application of SDF was most effective in caries arrest followed by biannual application and annual application. Further long-term study with large sample is recommended to evaluate the effect of SDF.

This paper is important to paediatric dentists:

- To assess the effectiveness of silver diamine fluoride (SDF) solution on deciduous molar dentinal caries teeth.
- To compare the effectiveness of silver diamine fluoride solution on deciduous molar dentinal caries teeth using Diagnodent pen.
- To assess effectiveness of annual, biannual and triannual topical application of silver diamine fluoride solution on deciduous molar dentinal caries teeth using Diagnodent pen.

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Legend Tables

Table 1: ICDAS scoring system

ICDAS Code	Characteristics of Lesion	
	Active Lesion	Inactive Lesion
ICDAS Initial and moderate stage	Surface of enamel is whitish/yellowish; opaque with loss of luster; Feels rough when tip of the probe is moved gently across the surface. Lesion is in plaque stagnation area i, e. in the entrance of pits and fissures, or near the gingival, and in approximal surfaces below or above the contact point. The lesion may be covered by thick plaque prior to cleaning	Surface of enamel is whitish, brownish or black. Enamel may be shiny and feels hard and smooth when the tip of the probe is moved gently across the surface. For smooth surfaces, the caries lesion is typically located at some distance from the gingival margin. Lesion was not covered by thick plaque prior to cleaning
ICDAS Extensive stage	Dentin feels soft or leathery on probing	Dentin is shiny and hard on probing

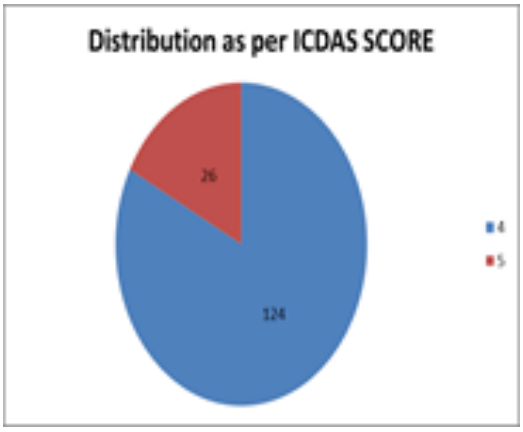
Table 2: Intergroup Comparison of Values from Month 9 Using Tukey'S Post HOC Test

Dependent Variable	(I) group	(J) group				95% Confidence Interval	
			Mean Difference (I-J)	Std. Error	p value	Lower Bound	Upper Bound
M9	1	2	5.280*	.329	.000**	4.50	6.06
	1	3	5.400*	.329	.000**	4.62	6.18
	2	3	.120	.329	.929#	-.66	.90

Table 3: Intergroup Comparison of Values from Month 12 Using Tukey'S Post HOC Tests

Dependent Variable	(I) group	(J) group				95% Confidence Interval	
			Mean Difference (I-J)	Std. Error	p value	Lower Bound	Upper Bound
M12	1	2	5.280*	.613	.000**	1.13	4.03
	1	3	11.420*	.613	.000*	9.97	12.87
	2	3	8.840*	.613	.000*	7.39	10.29

Graph 1: Destruction as per ICDAS SCORE



Graph 2: Inter group comparison of values for M1 to M12