Efficacy of Silver Diamine Fluoride in Arresting Dental Caries in Primary Teeth

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Research Article

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Abstract

Background
This study was done to evaluate and compare the efficacy of silver diamine fluoride in arresting dental caries at different frequencies of applications.

Methods
Experimental study was conducted among ten preschool children of 3–5 years old with seventy-four active carious lesions taking teeth as a sample unit. Children were randomly allocated into two intervention groups. Group 1— application of 38% silver diamine fluoride solution at three consecutive weeks and Group 2— three applications of 38% silver diamine fluoride solution at monthly interval. Time taken of caries arrest was recorded. Data was collected and entered in Microsoft Excel sheet and analysis was done in Statistical Package for the Social Sciences (SPSS) version 16.

Results
Mean time taken for caries arrest for Group II (57.20 days) was found to be statistically longer than Group I (21.54 days) (p-value < 0.001). As the mean time taken for caries arrest for Group I was shorter, the weekly application was found to have higher efficacy than the monthly application.

Conclusions
Efficacy of Silver Diamine Fluoride was found to be more in Group I (weekly application) compared to Group II (monthly application).

Background
Dental caries has been recognized by the American Dental Association (ADA) as an important public health issue that causes many children to suffer from pain and infection [1]. Carious lesions can be both prevented and arrested using fluoride-based materials. A number of clinical studies have shown that progression of dental caries in young children can be arrested by the use of Silver Diamine Fluoride (SDF) solution. This non-invasive approach can halt the progression of carious lesions and it can be an alternative to control the burden of dental caries in children around the world for deciduous teeth [2] that is recommended by the American Academy of Pediatric Dentistry, that published a guideline, in 2017[3]. SDF is a colorless alkaline liquid containing 255,000 ppm of silver and 44,800 ppm fluoride ion that at pH 10. Its main composition is 25% silver, 8% ammonia, 5% fluoride, and 62% water. Each milliliter of product contains 380 mg (38 w/v%) of Ag (NH3)2F. This is referred to as 38% SDF. One drop of SDF liquid can be used to treat five teeth and has a Silver Diamine Fluoride content of 9.5 mg. SDF is safe to use because
doses used for treatment are one four-hundredth of the lethal dose, which is 520 mg/kg administered orally and 380 mg/kg administered subcutaneously. Various regimens of applications have been adopted like weekly application for three weeks, monthly application for three months, biannual or annual application [4-6]. The proportion of arrested caries increases with repeatedly application. To speed up the process of arresting the caries, it would be logical to reduce time interval. Thus, this study was conducted to evaluate and compare the efficacy of SDF in arresting dental caries at different frequencies of applications.

Methods

The comparative experimental study was conducted among 10 preschool children from pre-primary school and age of 3-5 years old with 74 active carious lesions taking teeth as a sample unit. Before commencement of the study, an approval letter was obtained from Nepal Health Research Council (NHRC Ref no 424). The study was conducted from July 2019 to August 2020 in department of Pediatric and Preventive Dentistry of People's Dental College and Hospital in Kathmandu, Nepal. Non-probability sampling technique was used to select the children who met the inclusion criteria: School children of 3-5 years old with cavitated lesion in endodontically healthy deciduous teeth, medically fit, healthy and free of any systemic diseases. (American Society of Anesthesiologist-II) and cavitated lesions belonging to ICDAS II, Score 4, 5 and 6 were included in the study. Tooth with caries lesion extending into pulp or symptomatic teeth suggesting teeth as non-vital such as tooth discoloration, mobility and abscess, Hereditary developmental defects such as Amelogenesis imperfecta and Dentinogenesis imperfecta were excluded and Children whose parents refused to give consent and Inability to cooperate for SDF treatment or return for recall visits at 3 months were not enrolled in the study.

Clinical Procedure: Case history was taken by trained doctor. Dental caries was checked according to DMFT/dmft criteria described by Gruebbl AO in 1944 [7]. For all selected teeth, numbering was done from 1-74. Participants with odd number were selected for Group I and with even number were selected for Group II. Total number of teeth selected for Group I were 39 and for Group II were 35. A written informed consent was taken from parents of the participants. Children were recalled in the hospital for application of the SDF. In Group I, three applications of 38% SDF at weekly intervals and in subjects of Group II, three applications of 38% SDF at monthly intervals was done. A disposable micro brush was used to apply the agent on each carious lesion in maxillary and mandibular teeth of both groups and rubbed for 10 seconds. After application, the child was asked not to drink or eat for at least 30 minutes. Non-fluoridated toothpaste was distributed to the children during study period. Subjects of Group I was recalled for three consecutive weeks for application of agent and after then recalled weekly for evaluation. Evaluation was done by another trained doctor to assess whether the treated lesion have become arrested or not. Cavities with smooth and hard surface were classified as arrested caries. The cavity which got arrested was marked as A. Time interval for each lesion in maxillary and mandibular teeth to get arrested was then recorded. Time to arrest of caries was the outcome measure of effectiveness. Similarly, subjects of Group II were recalled in second month and in third month for second and third application. After third application subjects of Group II were recalled weekly for evaluation of
caries arrest. In each visit required time interval to get the caries to be arrested was noted down. The evaluation was done until 3 months.

Results

The study was carried out in total of ten school children of age group 3–5 years. Out of which six (60%) males and four (40%) females with 74 active carious lesions. Figure 1 shows distribution of teeth according to the active caries lesion in which Group I included 35 teeth and Group II included 39 teeth.

In The Experimental Groups

Figure 2 shows the distribution of selected teeth with active carious lesions in the experimental groups. Group I included 39 teeth in which 6 Central Incisors (15.4%), 6 Lateral Incisors (15.4%), 6 Canines (15.4%), 9 First Molars (23.1%) and 12 Second Molars (30.7%) were involved. Group II included 35 teeth; Central Incisors 6 (17.1%), Lateral Incisors 5 (14.3%), Canines 4 (11.4%), First Molars 11 (31.5%) and Second Molars 9 (25.7%). Total number of teeth included in the study were Central Incisors 12 (16.2%), Lateral Incisors 11 (14.9%), Canines 10 (13.5%), First Molars 20 (27%) and Second Molars 21 (28.4%). Total of 33 (44.6%) anteriors and 41 (55.4%) posteriors. Total teeth in maxillary arch were 26 and in mandibular arch were 13 for Group I and for Group II 21 in maxillary arch and 14 in the mandibular arch.

Figure 3 shows the distribution of selected teeth surfaces with active carious lesions in the Group I. Of the 6 Central Incisors with active carious lesions, 4 (66.7%) had the lesions on labial surface and 2 (33.3%) had the lesions on mesial surface. Similarly, among 4 Lateral Incisors (66.7%) with active carious lesions 2 had lesion on labial surface and 2 on mesial surface (33.3%) respectively; 6 Canines (100%) had active carious lesion on labial surface; 9 (100%) First Molars on occlusal surface; 2 Second Molars (16.7%) on buccal surface and 10 Second Molars (83.3%) on occlusal surfaces. In total, 16 (41%) teeth had the lesion on labial or buccal surface, 4 (10.3%) had the lesion on mesial surface and 19 (48.7%) had the lesion on occlusal surface.

Figure 4 shows the distribution of selected teeth surfaces with active carious lesions in Group II. Of the 6 Central Incisors with active carious lesions, 2 (33.3%) had the lesions on labial surface, 2 (33.3%) had the lesions on mesial surface and 2 (33.3%) had the lesions on distal surface. Of the 5 Lateral Incisors, 2 Lateral Incisors (40%) had active carious lesions on labial surface, 2 Lateral Incisors (40%) had active carious lesion on mesial surface and 1 Lateral Incisor (20%) had active carious lesion on distal surfaces respectively. Similarly, among 4 Canines (100%) all had active carious lesion on labial surface. Among 11 First Molars 1 (9.1%) had active carious lesion on buccal surface and remaining 10 First Molars (90.9%) had active caries lesion on occlusal surfaces, and in 9 Second Molars (100%) had active carious lesion on occlusal surfaces. In total, 9 (25.7%) teeth had the lesion on labial or buccal surface, 4 (11.4%) had the lesion on mesial surface, 3 (8.6%) had the lesion on distal surface and 19 (54.3%) had the lesion on occlusal surface.
Table 1
Distribution of the teeth in the experimental groups according to time of caries arrest

<table>
<thead>
<tr>
<th></th>
<th>Group I (Weekly)</th>
<th>Group II (Monthly)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After 2 weeks</td>
<td>After 3 weeks</td>
</tr>
<tr>
<td>n (%)</td>
<td>13 (33.4)</td>
<td>10 (25.6)</td>
</tr>
</tbody>
</table>

In Group I during the first evaluation, caries arrest was not seen in any teeth. Caries arrest was seen in 13 teeth during the second evaluation (after 2 weeks), in 10 teeth during the third evaluation (after 3 weeks) and in 16 teeth during the fourth evaluation (after 4 weeks) for the same group. In Group II, caries arrest was not seen in the first, second, third and fourth evaluation. Caries arrest was seen in nine teeth during the fifth evaluation (after 5 weeks), in 19 teeth during the ninth evaluation (after 9 weeks) and in seven teeth during the tenth evaluation (after 10 weeks) in the same group. (Table 1)

Mean time taken in Group I was 21.54 days for caries arrest and for Group II was 57.20 days. The minimum time taken for caries arrest in Group I was 14 days and in Group II was 35 days while the maximum time taken for Group I was 28 days and for Group II was 70 days. (Table 2)

Table 2
Mean time taken to arrest the caries

<table>
<thead>
<tr>
<th></th>
<th>Mean time (days)</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (Weekly)</td>
<td>21.54</td>
<td>6.09</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Group II (Monthly)</td>
<td>57.20</td>
<td>13.53</td>
<td>35</td>
<td>70</td>
</tr>
</tbody>
</table>

Mean time taken to arrest the caries for Group II (57.2 days) was found to be longer than Group I (21.54 days). This difference in mean time taken was found to be statistically significant (p-value < 0.001). As the mean time taken for caries arrest for Group I was shorter, weekly application was found to have higher efficacy than monthly application.
Table 3
Comparison of efficacy of Silver Diamine Fluoride according to frequency of application among the experimental groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean time (days)</th>
<th>t-value</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Group I (Weekly)</td>
<td>21.54</td>
<td>-14.35</td>
<td>-40.67</td>
<td>-30.66</td>
</tr>
<tr>
<td>Group II</td>
<td>57.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Monthly)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Independent Samples t-Test, p-value < 0.05 statistically significant

Table 3 shows that mean time taken for caries arrest for Group II (57.2 days) was found to be longer than Group I (21.54 days). This difference in mean time taken was found to be statistically significant (p-value < 0.001). As the mean time taken for caries arrest for Group I was shorter, weekly application was found to have higher efficacy than monthly application.

**Discussion**

SDF offers an easy and highly efficient non-surgical alternative treatment to traditional restorative dental treatment in young children and has great potential to aid the dental public health community to address dental caries in at risk populations. SDF have anti-bacterial properties and anti-caries properties. Anti-bacterial property inhibits biofilm formation and interferes with the enzyme activity of glucosyl transferase (GTF), which causes decreased sugar synthesis, resulting in the reduction of plaque formation [7, 8]. While fluoride changes hydroxyapatite into fluorapatite (Ca10(PO4)6F2), which is more resistant to acidic environments, it limits cariogenic bacteria and enhances remineralization of demineralized tooth structure, resulting in caries arrest. There are no published recommendations for the frequency of SDF applications. Some have used single application and recalled after 3 weeks and at 3 months [5] whereas some study has 3 weekly application [9], monthly application, biannual [10] and annual application [5]. The commonly adopted regimen for frequency of application of SDF is either once a year or every 6 months for arresting caries in primary teeth. In this study the efficacy of 3 consecutive weekly applications and 3 consecutive monthly applications was compared.

This study demonstrated that 3 consecutive applications of SDF whether weekly and monthly was effective as all teeth were arrested which was similar to the studies conducted by Zhi Q et al [11] and Fung M et al. [8].

Similarly, Duangthip D et al in 2016 [12] conducted a study which reported that caries rate in both annual or three consecutive weekly applications of SDF solution was equally effective. The present study also showed similar results as the number of caries arrested was similar in both Group I and Group II.
In this study, caries arrest on labial/buccal surface of the teeth involved showed higher caries arrest in both groups. These finding were consistent with those from an earlier study by Zhi QH et al in 2012 [11] which found that lesions in the anterior teeth or buccal/lingual surfaces had a higher chance to become arrested as these surfaces bathed more directly in saliva than others or that surfaces exposed to light resulted in more active silver precipitation. Zhi QH et al in 2012 and Fung MHT et al in 2016 stated posterior teeth and large cavities had less chances of arrest with one-time application [11, 13] which was also seen in this study as the total time required to arrest carious lesion in anterior teeth was shorter in both Group I and II, as compared to the posterior teeth which had larger lesions. The reason behind this could be the increased accessibility of anterior lesions for cleaning. This is in line with the general recommendation that high-risk children should receive more frequent topical fluoride applications [14, 15].

Limitations of the study

1. A more elaborate study has to be done, as this study might not represent the whole population of this age group.

2. The current study was short term, where the children were followed for a couple weeks to a few months period. It would be useful to monitor arrested lesions for a longer term to assess if arrest persists over time.

3. As it is difficult to assess arrest clinically, it would also be useful to track these treated lesions radiographically over time to determine if the lesion progresses or not.

Conclusions

Caries arrest is seen in both weekly application and monthly application of SDF but time taken to arrest caries for weekly application is shorter thus it is concluded that three consecutive weekly application is more effective. With this result, this study could be a valuable contribution to formulate regimen of frequency of application especially in primary teeth where caries occurrence and rate of caries progression is fast.

Declarations

Ethics approval and consent to participate.

Written informed consent was obtained from legal guardian(s) or from parents. Ethical Approval from ethical review board of the Nepal Health Research council (417/2019) were obtained before the clinical examinations. This study complies with declaration of Helsinki.

Consent for publication
No information or images that could lead to identification of a study participant is included in the manuscript. Consent to publication is not applicable.

**Competing interests**

The authors declare that they have no competing interests.

**Availability of data and materials**

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

**Funding**

There was no funding to support this study.

**Authors’ Contributions**

NG is the principal investigator of this study. SS, BKS, ND contributed to the study design, methods and writing of the trial protocol. NG undertook data collection, led the analysis and writing of the manuscript with major contributions from SS, BKS and ND. NG and SS data cleaning and monitoring aspects of the protocol. All authors read and contributed to the writing of the paper and have read and approved the final manuscript.

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**References**


**Figures**
Figure 1

Distribution of the teeth in the experimental groups according to time of caries arrest.

Figure 2

Distribution of selected teeth with active carious lesions.
in the experimental groups

Figure 3

Distribution of selected teeth surfaces with active carious lesions in Group I
Figure 4

Distribution of selected teeth surfaces with active carious lesions

in the Group II