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# Role of Silver Diamine Fluoride in Permanent Tooth Caries Management: A Narrative Review

**Anshul Arora[1*], Shalini Garg[2], Mamta Singla[3]**

[1]Ph.D Scholar, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India

[2] Professor, Department of Pediatric and Preventive Dentistry, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India

[3]Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India

***Corresponding Author**: **Anshul Arora** Ph.D Scholar, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, SGT University, Gurugram, Haryana, India

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**KEYWORDS**

Silver Diamine Flouride, SDF, Permanent Dentition

**ABSTRACT:**

**Introduction:** Silver Diamine Fluoride is vastly used in preventive and therapeutic management of deciduous dentition. It includes its utilization as a fissure sealant, for arresting carious lesions and as a pulp capping agent. However, its use in permanent dentition is limited. Hence, the present narrative review has been conducted in order to assess SDF use in permanent dentition.

**Methodology:** Present review was conducted to evaluate role of SDF in permanent tooth caries management. A rigorous literature search was conducted utilizing various databases suchas PubMed, Scopus, Web of Science, Cochrane Database, and CTRI (Clinical Trial Registry - India). The search period was defined to be last 10 years, that is, from 1st January 2012 to 31st December 2021. Terminologies "Silver Diamine Fluoride," "SDF," "Permanent Dentition" were included. The terminologies were combined using Boolean Operations "AND" and "OR".

**Results:** 7 studies were identified after following inclusion and exclusion criteria. The included studies were evaluated for study design, nature of trial along with its type, materials compared and procedure performed along with the results. Various uses of SDF were identified such as fissure sealant, in root caries management, in proximal or occlusal caries management along with its use as indirect pulp capping agent.

**Conclusion:** Although SDF use in primary dentition is widely acknowledged. Its use in permanent dentition is still limited. Hence more clinical trials need to be carried out for better understanding of this material.

## 1. Introduction

In dentistry minimally invasive procedures (MIP), offers a substitute to manage carious lesions in a conservative & effective way, bringing about greater maintenance of tooth structure & stopping development of cariogenic biofilm.[1,2] In order, to provide standard care with regards to management of carious lesions along with reducing discomfort during the treatment, non-restorative caries treatment (NRCT) also named as non-restorative cavity control (NRCC) is a recent concept, involving no caries removal.[3]

The aim of nonrestorative, non-invasive & micro invasive caries treatment is to bring about the process of removal of carious hard tissue, reducing the damage to sound tooth anatomy and dental caries arrest that can encounter the necessity of oral health objectives globally due to the notable returns like reasonable cost and ease to implement treatment. These NRCC approaches are advantageous in providing treatment to patients with uncooperative behavior, having immature cognitive functioning, disability, or any other medical conditions.[4-6]

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When it comes to prevention, epidemiologic studies indicate that when the bacterial challenge is high or the salivary components are lacking, natural remineralization or that aided by fluoride products can be insufficient in preventing or arresting the caries. Hence we need more effective, affordable, accessible, and safe treatments that are easy to implement in different settings, and are available to the most vulnerable populations.[7,8]

Silver diamine fluoride (SDF) is a material which fulfils all the above requirements. It is a material which combines antibacterial effects of silver and the remineralizing effects of fluoride. It is a therapeutic agent which can be utilised for both prevention and treatment of dental cares.[8-10] Arrest by silver diamine fluoride occurs because of bactericidal "Zombie effect" of silver which interferes with biofilm & loss of mineral content whereas fluoride inhibits biofilm and facilitates apatite nucleation in addition to remineralization. SDF occludes dentinal tubules and prevent the invasion and acid diffusion.[11,12] Dentin treated with SDF improved resistance to collagenase and trypsin. Hence, preventing demineralization leading to further arrest of carious lesion.[13,14]

The present review aims to understand and evaluate the usage of SDF in permanent teeth. The review also aims to evaluate the various dental treatment protocols where SDF can be used as a material of interest

## 2. Methodology

The present review was carried out using the framework provided by Arksey H et al (2005)[15] and Levac D et al (2010)[16]. A rigorous search was carried out using five electronic databases: PubMed, Scopus, Web of Science, Cochrane Database and CTRI (Clinical Trial Registry – India). The search period was defined to include literature for last ten years i.e. from 1st January 2012 till 31st December 2022. Terminologies "SDF", "Permanent Molars", "SMART" were included in the search. The Boolean operation "OR" and "AND" were applied to combine the terminologies.

**Inclusion and Exclusion Criteria**

The title and abstract of the searched articles were evaluated by the main author, in order to identify the studies that met with the inclusion criteria of the review. Studies which were experimental (both randomised or non-randomised clinical trials), in-vivo, which used SDF as material, whose text was available in English language, which were published between January 2012 to December 2022 were included in review.

Systemic reviews, case reports, guidelines, incomplete registered trials, trials conducted on MIH (Molar Incisor Hypomineralization) affected teeth and trials conducted on primary teeth and in vitro studies were excluded. The studies were not restricted via specified age group. After the initial screening a manual search was executed in the reference list of included studies. Studies which were accessible through more than one database were considered only once.

Data from the included studies was extracted and assembled in a table form under various headings: study details (author(s), year of publication), participants (number and age group), methodology (study design, procedure performed along with type), materials compared and results (Table 1). If any clarification was required, it was sought out either directly by contacting the corresponding author (through email) or indirectly through the editor of the journal.

## 3. Results

**Study Selection**

The search was conducted using various databases (PubMed, Scopus, Web of Science, Cochrane Database and CTRI), resulted in identification of 268 articles. After removal of duplicates 75 records remained. The articles not related to the topic of this review were excluded via screening of title and abstract and the literature came down to 29. Adding the time constrain (2012-2022) the number of included literatures reduced to 15. Further on reviews, meta-analysis, editorials, letter to editors, questionnaire studies, case reports and incomplete registered trials whose results were unknown were excluded bringing down the included literature number to 4. Further, on analysis of the reference list of included articles 3 articles were identified and added to the list. Therefore, a total of 7 studies were found to be fulfilling the criteria and were included in this review (Figure 1).

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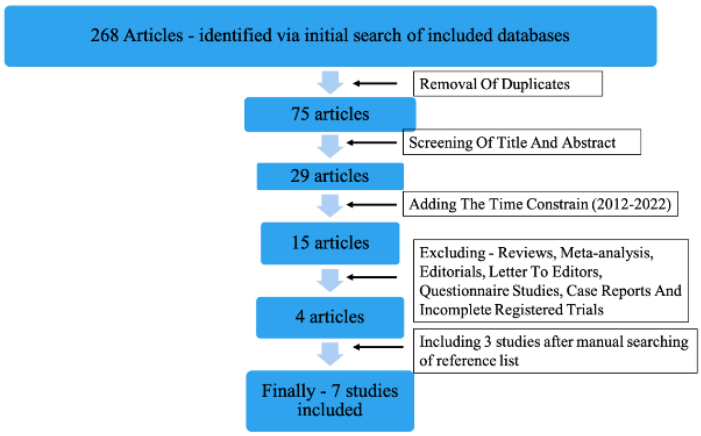


Figure 1 : Flowchart Demonstrating Selection of Studies

**Study Characteristics**

The characteristics of the included studies are mentioned in Table 1.[17-23] From the 7 studies included, 6 were progressive randomized trial and 1 was a retrospective study. Dividing the trials on basis of the treatment provided, 2 were where preventive treatment was provided and 5 where therapeutic treatment was conducted. Out of the 6 clinical trials, one was conducted in community setting. All the included trials evaluated different dental procedures wherein one evaluated SDF as Indirect pulp capping agent, 2 as occlusal sealant, 2 dealt with management of caries wherein 1 evaluated SDF for progression of incipient caries on proximal surface and 1 with management of caries in specially abled children. 2 trials dealt with management of root caries.

When utilizing SDF as a preventive agent, Monse B et al (2012)[17] and Liu BY et al (2012)[18] evaluated SDF as a sealant for application in permanent molars. Wherein, Monse B et al (2012) compared SDF with ART sealant and daily school-based fluoride toothpaste brushing (control group). And concluded that both SDF and sealant groups have lower cares increment as compared to the non-treatment group.[17] Liu BY et al (2012) compared SDF with resin sealant and NaF varnish and concluded that all three treatment had lower risk of carious cavity development.[18]

Study by Mendiratta M et al (2021) evaluated SDF for caries management in permanent molars wherein SDF was compared with GIC as an agent. In the study SDF was observed to have higher caries arrest rate as compared to GIC.[23]

The study by Baraka M et al (2022) have compared SDF with RMGIC and SDF+KI as indirect pulp capping agents and have highlighted that there was significant difference among the three groups in terms of pulpal response of the tooth and restoration margins and lustre.[21]

Polacek J et al (2021) assessed the progression of incipient approximal carious lesions with or without SDF application in permanent molars. It was a retrospective study in which significant difference was observed with respect to increase in number of lesions between the two groups.[22]

Zhang W et al (2013 ),Li R et al (2016) evaluated SDF as agent for root caries management. In both studies SDF showed better arrest rates of root caries as compared to other interventions.[19,20]

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**Table-1 Characterstics of Included Trails**

| **Author** | Monse B, Heinrich-Weltzien R, Mulder J, | Liu BY, Lo EC, Chu CH, Lin HC. (2012)[18] | Zhang W, McGrath C, Lo EC, Li JY. (2013)[19] | Li R, Lo EC, Liu BY, Wong MC, Chu CH. (2016)[20] | Baraka M et al (2022)[21] | Polacek J et al (2021)[22] | Mendiratta M et al (2021)[23] |
|---|---|---|---|---|---|---|---|
| **Nature of Trial** | Prospective Community | Randomized controlled trial | Randomized clinical trial | Randomized clinical trial | Randomized Controlled | Retrospective Analysis | Randomized controlled trial |
| **Trial type** | Preventive | Preventive | Therapeutic | Therapeutic | Therapeutic | Therapeutic | Therapeutic |
| **No of individuals** | 704 children | 501 children | 266 elderly subjects | 83 elders with 157 active carious lesion on root | 108 permanent molars in 49 children | 131 lesions from 68 subjects | 82 |
| **Age group/ mean age** | 6-8 years old | Mean age 9.1 | - | - | 6 - 9 years | 9.6 years | permanent posterior teeth with Nyvad score |
| **Materials Compared** | 3 Groups: SDF application, ART sealant and daily school-based fluoride toothpaste brushing | Resin sealant (single placement); 5% NaF varnish (semi-annual application);38 % silver diamine fluoride (annual | Control group - received oral hygiene instructions (OHI) annually; Group 2- received OHI and silver diamine | Gp1 -annual application of soda water (placebo control); Gp2- SDF solution (annual application); Gp3- SDF solution immediately | SDF plus KI, SDF, and RMGIC | With/without SDF application | experimental arm (38% SDF) (n = 41) and control arm (GIC along with FV) (n = 41 |
| **Procedure** | Fissure sealant | Fissure sealant | Root caries management | Root caries management | Indirect pulp capping | Progression of incipient approximal | Dental caries management |
| **Results** | Caries increment in the SDF treatment group and the sealant group was lower than the non-treatment group | Fissures in any of the three treatment groups had significantly lower risks of carious development into dentin than did controls (p | mean numbers of arrested root caries surfaces in groups 1, 2 and 3 were 0.04, 0.28 and 0.33, respectively ($p < 0.01$). | arrest rates of root caries were 45%, 90%, and 93% in Gp1 (control), Gp2 (SDF) and Gp3 (SDF/KI), respectively ($p<0.001$) | There were no significant differences ($p = .26$) among the groups when comparing for secondary caries, postoperative pain, tooth | Lesions in the control group increased more per month compared to the study group ($p<0.001$) | Caries arrest rate was 94.5% with SDF and 90.1% with GIC and FV ($p = 0.405$) |

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## 4. Discussion

The minimally invasive methods along with non-invasive approaches have minimized the need for traditional restorations. It has benefits as it emphasizes on maximum conservation of healthy tooth structure, aiding caries arrest without complete decay excavation and preserve affected dentin that can be re-mineralized. Also, they are less time taking & related with less intraoperative dental apprehension and uneasiness, hence proven to be more cost-effective in the long term. Non-restorative caries control (NRCC) includes methods of no caries removal or minimal caries removal approaches which includes use of Silver Diamine Fluoride and Atraumatic Restorative Treatment, fluoride varnishes, sealants etc.[24]

Caries arrest by SDF therapy was officially accepted and guidelines were issued by American Academy of Pediatric Dentistry in 2017.[25] Similarly, World Health Organization in 2021 established SDF to be one of the safe, most effective, and was economical for achieving the main needs in an adult & children health system.[26]

Wakhloo T et al (2021), Schwendicke F et al (2021) highlighted benefits of SDF stating that it is an economical and easy to apply material which requires no additional cavity preparation and can be an alternative for patients with behavioural issues, who are suffering from medical conditions especially patients undergoing radiation therapy.[27-28] Another advantage is the drop in prevalence of new carious lesions when using SDF. Various authors have found SDF to be 89% effective for arresting carious lesions in primary dentition when compared to other procedures.[27-31]

Evaluating the caries preventive effect of SDF. In our review SDF was found to be have similar caries preventive effect as resin based and GIC sealant. Similar findings have been reported by Llodra JC et al (2005) who evaluated SDF for new carious lesion development and reported lesser lesions in SDF group (0.4 new lesions) as compared to control group (1.1. new lesion).[32] Similarly, Crystal YO (2019) in a review concluded that the overall preventive fraction for SDF is 70.3% wherein having more than 60% on permanent teeth and more than 70% on primary teeth.[8] In another review by Horst JA et al (2019) SDF reportedly prevented new lesion formation by 61% for both primary and permanent dentition. He also suggested SDF to be a cost effective approach for permanent molar caries prevention especially in cases where distal surface of second primary molar is carious.[33]

Evaluating the effect of SDF for root caries arrest Zhang W et al (2013) and Li R et al (2016) compared SDF with SDF followed by application of KI and patients who received oral hygiene instructions.[19,20] It was reported that SDF and SDF+KI has better caries arrest rate as compared to placebo group (soda water) and patients who received oral hygiene instructions. Similar results have been reported by McReynolds D et al (2018) who reported 100% rate of caries arrest with SDF application as compared to placebo group after 30-month time period.[34] And in a review by Chan AKY et al (2022) overall arrest rate of root caries was 42% after use of SDF at 24 months interval.[35]

## 5. Conclusion

From the current review it can be concluded that although SDF is being widely used for primary dentition. Its use is still limited in permanent dentition. More clinical trials need to be conducted with respect to the permanent dentition.

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