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Silver Diamine Fluoride - Is Silver The New Gold Standard In Caries Prevention ? - A Narrative Review

Review Article

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Abstract

Dental Caries remains one of the most prevalent chronic diseases affecting people across all nationalities. Fluoride has been established as a material of choice for the effective prevention of caries when used in various forms. Silver diamine fluoride (SDF) has shown promise both in arresting existing lesions and preventing new ones. This review article highlights on the effect on SDF in prevention of dental caries.

Keywords: Dental Caries; Prevention; Silver Diamine Fluoride; SDF.

Introduction

Dental Caries remains one of the most prevalent chronic diseases affecting people across all nationalities, races with no distinction of age or sex [1]. Although the prevalence of dental caries is now reducing in many countries, Early childhood caries (ECC) is frequently encountered phenomena in our communities. ECC presents unique challenges for its management when dealing with children especially the very young. When left untreated, these lesions are responsible for much pain and dysfunction requiring expensive interventions and loss of school hours in children.

Limited finances, fear of dentistry, distance from the clinic and scheduling difficulties are among the potential barriers to dental care for the child [2]. Children with behavioral issues, the very young, medically compromised children or those with special needs are another category of patients that require but may not always have access to quality dental care.

Fluoride has been established as a material of choice for the effective prevention of caries when used in various forms such as professionally applied varnishes and gels [3]. However regular fluoride treatment modalities prevent new carious lesions but have limited efficacy on existing lesions. When coupled with the fact that current methods of early preventive care do not appear to inhibit caries development [4] there is a need for new or alternate approaches to control dental caries in children. In recent times Silver diamine fluoride (SDF) has shown promise both in arresting existing lesions and preventing new ones. Thereby proving to be an affordable way of managing dental decay among disadvantaged sections of the society, children or those with limited access to regular dental care [5].

Research Question

RQ1 - Is SDF effective in preventing new caries lesion when compared to controls/ other active treatments?

History

The use of silver for the prevention of dental caries have been reported in Japan since a 1000 years [6]. The direct application of silver nitrate to carious teeth for the sterilization of dentinal tissue was reported in 1917 [7]. 40% Silver Fluoride was used for the arrestment of deep dental caries in deciduous teeth at school dental care services in Western Australia [8].

Although SDF was established as a therapeutic agent by the Central Pharmaceutical Council of the Ministry of Health and Welfare in Japan for dental treatment since the 1960s, its use outside Asia was limited [8]. The US Food and Drug Administration approved the use of SDF for the management of dental hypersensitivity in 2014. Since then it has also been used off label for caries prevention in the US [9].

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In the last few decades, SDF has been used widely all over the world in Australia , Nepal and China [10-12]. Over the years, SDF has been demonstrated to be effective across varied clinical situations from arresting caries in primary anterior teeth in children to successful prevention of new lesions and arrest of root caries in the elderly and also the prevention of pit and fissure caries in young permanent molars [13, 14].

Randomized control trials continue in different parts of the world to establish the efficacy, safety and acceptance of SDF for community based caries management for children and the elderly.

Search Methodology

A search was conducted on the Pubmed database using the appropriate Medical Subject Headings. The actual terms used were ((("silver fluoride" [Supplementary Concept]) OR "silver diamine fluoride" [Supplementary Concept]) AND "Dental Caries/prevention and control" [Mesh]. A total of sixty-seven articles were identified. The search was then restricted to Clinical Trials, Randomized Control Trials, Systematic Reviews and Meta Analysis published in the last ten years. The literature was restricted to articles in the English language. This provided a total of 16 articles which were further screened to eliminate duplicates. The full text of all sixteen articles were retrieved and after screening included in this review.

Mechanism Of Action

The exact mechanism of action of SDF in the prevention of new carious lesions is still unknown [15] We can however review the evidence regarding the mechanisms of action of SDF in the arrest of caries from its interactions and effects on the following[$]

1. Cariogenic bacteria
2. Mineral content of enamel and dentine
3. Dentine organic matrix

Action of SDF on Cariogenic bacteria

Dentinal surfaces treated with SDF had comparatively less growth of Streptococcus mutans suggestive of the inhibitory action of SDF on the growth of micro-organisms when in close proximity [16, 17]. SDF has anti-microbial activity against monospecies strains of Streptococcus mutans and Actinomyces naeslundii which were reduced after application of SDF, with very few bacteria being alive. The pH values in the SDF treatment group were also found to be higher when compared to controls [18]. Another study demonstrated lower CFU counts using multispecies cariogenic biofilms of S. mutans, Streptococcus sobrinus, L. acidophilus, Lactobacillus rhamnosus and A. naeslundii, after treatment with SDF [19]. SDF has an inhibitory effect on adherence of Streptococcus mutans on the surface of the tooth [20].

Action of SDF on mineral content of enamel and dentine

The application of SDF on demineralised tooth surfaces led to a reduction in lesion depth and also slowed lesion progression [16, 21]. Surface micro hardness was also increased up to a depth of 150 microns with similar hardness in arrested surfaces and soft lesions at a depth of 225 microns [22]. Calcium absorption was promoted and demineralization or calcium loss from enamel was inhibited [23].

Demineralised enamel surfaces showed significantly less mineral loss when treated with SDF as demonstrated by photo microscopy using polarized light [24]. Fluoride uptake was also significantly higher in dentin samples treated with SDF compared to controls [25]. Scanning electron microscopy studies also demonstrated dense precipitates on tooth surfaces treated with SDF [26, 27].

Action of SDF on dentine organic matrix

Immunolabeling techniques have revealed more intact collagen remaining on the dentinal surface after treatment with SDF when compare to control (Water) [28].

The liberation of hydroxy proline which is an result of collagen degradation is also comparatively less when dentin is treated with SDF [29]. SDF inhibits matrix metalloproteinases (MMPs), which play a vital role in the enzymatic degradation of collagen, by inhibiting the proteolytic activities of MMP-2, MMP-8 and MMP-9 [30].

Therefore, the mechanism of action of SDF may be attributed to reduction in the growth of cariogenic bacteria, protection of collagen from degradation, inhibition of demineralisation and promotion of remineralization of enamel and dentin.

Clinical Applications

1. Arrest of caries in young children, socially vulnerable and uncooperative children [31].
2. Control of root caries in the elderly [13]
3. Control of pit and fissure caries in the first permanent molars [15]
4. Management of dentinal hypersensitivity [32]
5. Antimicrobial root canal irrigant or inter-appointment dressing [33, 34].

Adverse Effects And Acceptance

The hypothesized but as yet unreported adverse effects are toxicity (both chronic and acute) gingival inflammation and allergy and discomfort (burning sensation and metallic taste) [9].

Reported adverse effects included:

1. Minor mildly painful white lesion due to inadvertent mucosal contact during SDF application which resolved in 48 hours without need for any treatment [35].

SDF is not recommended for use in cases of known allergy to silver compounds. A meticulous technique to avoid mucosal contact and dispensing correct quantity of SDF is encouraged to avoid toxicity especially in the very young [9, 19].

Another disadvantage is the Blackish discoloration of the active caries lesion which is an esthetic concern rather than an adverse reaction.

Parental acceptance of the black discoloration was studied in a

clinical trial of Chinese children, where 7% of parents expressed dissatisfaction with the child's appearance [36, 37]. Cultural considerations prevent extrapolation of these findings on other population groups in different countries.

In a web based survey in the US parents reportedly were more accepting of black staining of the posterior teeth when compared to anterior teeth. In an interesting observation, a majority of the parents preferred the anterior staining when compared to more advanced behavioural management techniques such as sedation or general anesthesia [38].

SDF And Dental Caries

Efficacy of SDF in the primary dentition

Branca Heloisa Oliveira et al in their systematic review of controlled clinical trials evaluated the effect of SDF in preventing new caries in primary dentition when compared to placebo and other active treatments [15]. There were two trials comparing SDF to no treatment (NT), one where SDF was compared to placebo and sodium fluoride varnish (FV) and another compared SDF to high viscosity glass-ionomer cement (GIC). All studies showed either an unclear or high risk of bias. At a 2 year follow up, in comparison to placebo, NT or FV, SDF applications significantly reduced the development of new dentin caries lesions. GIC was more effective than SDF at 12 months follow up although these findings were not statistically significant. It is pertinent to note here that the application of GIC would require more time, resources and effort when compared to SDF. Hence on a community level and for those with lack of access to dental care, SDF may be a more viable alternative.

Milgrom Peter et al conducted a randomized control trial to test efficacy of SDF in arrest of caries in preschool children [39]. This double blind superiority trial compared 38% SDF to placebo and tested for lesion arrest at 14-21 days after the intervention. The average proportion of arrested lesion was higher in SDF group than placebo and the suitability of the SDF application in primary care practice to reduce disease burden was established.

M.H.T. Fung et al in a randomized clinical trial compared the effectiveness of 2 concentrations (12% and 38%) SDF and 2 periodicity of application (Annual vs semiannual) in arresting cavitated dentin lesions in primary teeth over a 30 month follow up period [40]. Children were randomly allocated into 4 groups for intervention. Group 1 had 12% SDF applied annually, group 2 had 12% SDF applied bi-annually, group 3 had 38% SDF applied annually, and group 4 had 38% SDF applied semiannually. The study confirmed SDF at 38% concentration was more effective than 12% in arresting active caries in primary teeth and concluded that in children with poor oral hygiene, caries arrest rate of SDF treatment can be increased by increasing the frequency of application from annually to semiannually.

Violeta Contreras et al in their systematic review concluded 30% and 38% SDF showed potential for caries preventive in primary teeth and permanent first molars. They recommended the development of Standardized SDF protocols must be developed to allow meaningful study comparisons and establish treatment guidelines [41].

S.S. Gao et al in their systematic review of clinical trials, pointed out the absence of any significant complication of SDF use among children. They confirmed the effectiveness of SDF at 38% in arresting dentine caries in the deciduous dentition among children [42].

Mattos-Silveira J et al conducted A randomized double blinded placebo-controlled trial to establish the use of SDF v/s Resin infiltration in enamel approximal caries. Cost-efficacy, Patient discomfort, Parent and patient satisfaction will be assessed. The hypothesis being tested is that SDF is the most cost-efficacious option among the tested interventions. If confirmed, the use of SDF in private and public contexts could represent an easier and effective option in the treatment of enamel approximal caries in children/adolescents [43].

Valdeci Elias dos Santos Jr et al investigated the effectiveness of a new caries control agent namely Nano silver fluoride (NSF) . This prospective controlled clinical trial used an annual application to arrest caries in children. At 12 months followup NSF formulation was found effective to arrest active dentine caries and did not stain teeth [44].

Bella Monse et al assessed and compared the effect of a single application of 38% SDF with ART sealants v/s no treatment in preventing dentinal caries lesions on occlusal surfaces of permanent first molars in school children This prospective community clinical trial with a daily school-based fluoride toothpaste brushing program was conducted over a period of 18 months [45]. A one-time application of 38% SDF on the occlusal surfaces of permanent first molars is not an effective method to prevent dentinal (D3) caries lesions. ART sealants significantly reduced the onset of caries over a period of 18 months.

A randomized controlled trial by B.Y. Liu et al compared between resin sealant, single placement, 5% NaF varnish, semi-annual application, 38% SDF solution, annual application and placebo. The study concluded that placement of resin sealant, semi-annual application of NaF varnish, and annual application of SDF solution are all effective in preventing pit and fissure caries in permanent molars [46].

Efficacy of SDF for root caries

A systematic review [46] evaluated root caries prevention and arrest and reported caries prevention for SDF at 71% in a three-year study and 25% in a two-year study in comparison to placebo. The prevented fraction of caries arrest for SDF was 725% greater in a 24-month study and 100% greater than placebo in a 30-month study. There were no severe adverse effects reported.The review concluded that existing trials for SDF support effectiveness in root caries prevention and arrest, remineralisation of deep occlusal lesions and the management of hypersensitive dentine.

Another controlled clinical trial investigated the effectiveness of SDF combined with oral health education in the prevention and arrest of root caries among the elderly. Comparisons were made between group 1 (control) which received oral hygiene instructions (OHI) annually; group 2 which received OHI and an annual application of SDF and group 3 was given OHI and SDF application annually, plus an oral health education (OHE) program every 6 months. Group 3 and group 2 had a greater number of active

root caries surfaces which became arrested. Once yearly application of SDF together with biannual OHE was found effective in preventing new root caries and arresting existing root caries among community-dwelling elderly subjects [13].

H.P. Tan et al., in a randomized control trial on Root caries noted that are common in institutionalized elders, and effective prevention methods are required to manage this sub group of the population. They compared the effectiveness of four different methods in preventing new root caries. These methods were (1) Individualized oral hygiene instruction (OHI), (2) OHI and applications of 1% chlorhexidine varnish every 3 months, (3) OHI and applications of 5% sodium fluoride varnish every 3months and (4) OHI and annual applications of 38% SDF solution. The study confirmed SDF, sodium fluoride varnish, and chlorhexidine varnish were more effective in preventing new root caries than providing OHI alone [47].

Conclusion

Multiple randomized controlled trials and systematic reviews have confirmed the efficacy of SDF especially when used at a concentration of 38% in the prevention of root caries and in primary teeth. Although blackish discoloration of treated lesions is an esthetic concern, it is accepted among many when weighed against the advantages and ease of use of SDF.

SDF treatment being noninvasive, cost effective, easily delivered with minimal to no adverse effects is another treatment modality that holds potential to manage dental caries at the community level. SDF can definitely be considered a promising strategy to manage dental caries in young children, elderly and those with special needs.

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