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ROLE OF SILVER DIAMINE FLUORIDE (SDF) IN DENTISTRY: NARRATIVE LITERATURE REVIEW

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Abstract
Caries is one of the most prevalent diseases in world. It occurs most commonly in early childhood; thus, early childhood caries not only affect the individual's oral health but has psychological impact as well. Children cooperation for dental procedure is always questionable therefore minimum invasive procedures gain quick popularity in pediatric dentistry. Silver di amine fluoride (SDF) plays a pivotal role in arresting early childhood caries.

Keywords: fluorides topical, silver compounds, dental caries, dental cavity, tooth demineralization

Introduction

Maintaining oral condition is a crucial part of overall health, especially in children, as it significantly affects their lives and future development[1]. Early Childhood Caries (ECC) is characterized by the occurrence of one or more decayed, missing (due to caries), or filled tooth surfaces in a child below the age of six[2]. If left untreated, ECC can progress into a more severe form, leading to nutritional issues that adversely affect the child's general health. Additionally, treating advanced caries can be a costly endeavor[3]. Dental caries is a widespread global issue, with many low- and middle-income countries lacking adequate treatment for children. Even in high-income countries, addressing caries in children under six is often limited.[4]

Restorative intervention of young children presents challenges due to their tender age and often uncooperative behavior. Furthermore, limited access to dental care resources compounds the issue, resulting in a public health challenge where decayed primary teeth often go untreated[5]. Recognizing the concern, there is growing need for new caries management strategies to alleviate the burden on

the healthcare system. Silver Diamine Fluoride (SDF) has emerged as a favorable substitute to the traditional 'drill and fill' approach for caries management. In contrast to conventional restorative methods, SDF is cost-effective option that does not necessitate surgical tooth preparation and therefore results in better patient co-operation.[6]

Existing literature highlights various studies demonstrating the effectiveness of various topical fluoride products, such as SDF, sodium fluoride (NaF), novel nano-silver fluoride (NSSF), silver nitrate ($AgNO_3$) and glass ionomer cement (GIC), in halting the progression of caries. Notably, present available findings suggest that SDF provided to be an effective agent in arresting dental caries[7]. Since SDF is also economical, it can be used as an alternative to the topical fluoride products in managing dental caries[8].

Numerous systematic reviews provide substantial evidence about SDF's effectiveness not only in arresting caries in primary teeth, but also preventing and halting new root caries lesions. The only reported disadvantage is the black staining of the lesion due to precipitation of silver byproducts in dental structure restricting its use in anterior teeth.[9]

This literature review aims to critically evaluate the existing evidence on Silver Diamine Fluoride (SDF), considering its effectiveness, safety, and feasibility as a preventive agent for Early Childhood Caries (ECC). The study aims to contribute valuable insights to inform dental healthcare practices and policies, particularly in resource-constrained settings, and assess the potential of SDF as a viable alternative to traditional preventive and restorative interventions.

2. METHODLOGY

A thorough analysis of the effectiveness of Silver Diamine Fluoride in preventing caries was conducted, utilizing resources from the Islamabad Dental Hospital library and online databases, including PubMed, and Google Scholar. The literature reviewed spans from 2016 to 2022, focusing on English-language studies. The analysis specifically emphasizes the use of Silver Diamine Fluoride in preventing caries. We evaluated - peer reviewed literature.

3. DISCUSSION

HISTORY OF SDF

The application of silver nitrate to prevent tooth decay was promoted in the early 1840s. Several in vivo and in vitro studies conducted in the late 20th and early 21st centuries showed that silver fluoride compounds worked well in halting carious lesions. This led to the commercial use of fluoride products in Mexico, Australia and Japan[10]. Professor Misuho Nishino, formulated 38% SDF as part of his doctoral thesis at Osaka University, Japan, in 1969. She and her supervisor, Professor Reichi Yamaga, specified the clinical uses of SDF in 1972. Later, "silver diamine fluoride" was accepted by the Central Pharmaceutical Committee of the Ministry of Health in Japan. It is now sold as an antibacterial plus anti-inflammatory agent and is marketed under the trade name Saforide.[11]

Mechanism of action

SDF was approved by the FDA in 2014 and is currently available in the US market.[12] SDF is an alkaline, colorless, odorless, material with a pH value of around 9 to 10. It can stain skin, clothing, countertops, floors and tools. SDF solution is commercially available at 10%, 12%, 30%, and 38% concentration. In a clinical study it was found that 12% solution of SDF was less effective than 38% in arresting caries. Therefore 38% concentration is widely accepted and commercially available in many countries.[13] A solution of 38% SDF typically contains 24.4-28.8% (w/v) silver and 5.0-5.9% fluoride, with pH 10. [14] Upon application, SDF induces the formation of a hyper mineralized layer, leading to a reduction in dentinal sensitivity. This hyper mineralized layer also plays a crucial role in halting the progression of caries by providing resistance against acid dissolution. Additionally, silver ions present in SDF can denature proteins, including enzymes. Enzymes involved in the breakdown of dentin collagen, such as matrix metalloproteinases (MMPs), are sensitive to denaturation by silver ions. When these enzymes are denatured, their activity is inhibited, which prevents further degradation of the dentin matrix.[15]

Figure 1: SDF bottle with applicator brush.

Properties of SDF

A comprehensive review has determined that Silver Diamine Fluoride (SDF) is a stand out preventive measure against caries, meeting the criteria of effectiveness, efficiency, equity, and safety, aligning with the standards set by the US Institute of Medicine and the Millennium Goals of the World Health Organization. SDF aligns with the six quality aims set by the US Institute of Medicine by: [16]

1. Ensuring Safety: Clinical trials involving more than 3800 individuals have reported no serious adverse events.
2. Demonstrating Effectiveness: It effectively arrests approximately 80% of treated lesions.
3. Efficient: Health professionals can administer it in diverse health care and community sites with minimal preparation in less than one minute.
4. Timely: Its straightforward application enables its use as an intervention agent as soon as the problem is diagnosed.
5. Patient-focused: It is minimally invasive and painless, catering to the immediate needs of both children and adults within a single treatment session.
6. Equitable: Its application is equally effective and economically viable, with a cost of less than $1 per application, making it a feasible treatment option for lower-income groups.

Silver Diamine Fluoride in Arresting Caries among Children

Pediatric Dentistry studies show that tooth decay has a negative impact on lifelong oral health and is also associated with poor functioning on the oral health related quality of life (QHRQoL) scale (measured by different measures), as reported by children with dental caries and their caregivers. Early childhood caries comm0nly presents as carious lesions on multiple teeth as known as rampant caries (Fig 2). Additionally, children's academic performance can be affected due to poor oral health. [17]

As tooth decay and other health problems becomes understood, dentist makes a shift from surgery to prevention and minimal intervention in treating dental disease.[18] Most of the GDP believed that SDF is a good intervention for the patients for arresting caries, saving treatment time and cost (Fig 3).[19,22] SDF application is a simple and painless procedure that does not require complex equipment or technology for its use as caries removal is not required. It is also indicated for patients with special needs or children presenting with caries on primary teeth (fig 4).[20,23] According to research 38% SDF application every six months is the best treatment option to prevent dentin caries in **preschool children.**[21]

Figure 2: Pre-treatment intraoral frontal view of rampant caries

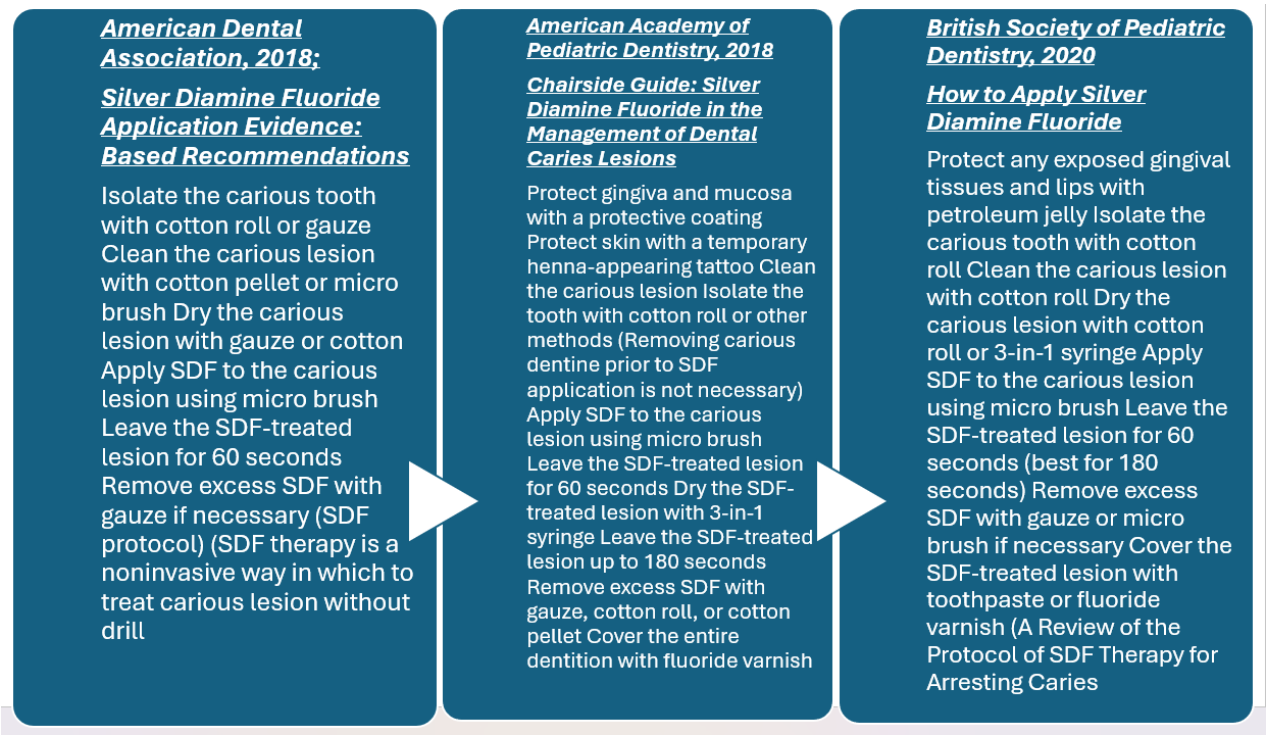
Figure 3: Frontal view of arrested caries after consecutive application of SDF for 3 weeks

Figure 4: Use of 38% SDF for halting coronal caries in the primary teeth of a young child

Caries management using silver diamine fluoride for dependent older adults.

Many publications and studies have shown that there are public health challenges in managing the oral wellbeing of older person.[24] Currently lack facilities for this population group demands, appropriate strategies to avoid and control dental diseases. There is evidence supporting the effectiveness of SDF, in arresting and preventing dental caries among the elderly population as a minimum invasive approach[25]. Individuals who could potentially benefit from SDF include those at high risk of decay, those undergoing behavioral or medical treatment, having cavities in multiple teeth, or facing limited access to dental care.[26]

Recommendations by national dental organizations for silver diamine fluoride (SDF) use to arrest caries.[27]



Parental acceptance of the utilization of silver diamine fluoride

Parents show willingness to accept staining related to SDF application primary dentition as compared to permanent dentition. A study revealed that parents of uncooperative children were open to the use of SDF despite its potential for staining. This could be attributed to parent's awareness about eventual shedding of primary teeth.[28]

Indications of SDF [29]

The SDF is indicated in the following situations.

- Those with a high caries risk cavities.
- Treatment for those patients with behavioral or medical challenges, who have cavitated dental caries, such as young children who are not cooperative.
- Managing patients with multiple cavitated lesions, requiring multiple visits.
- Providing treatment for individuals and communities with limited access to dental care.
- Addressing the active cavitated dental caries lesions without any well-known signs of pulp involvement.
- Incorporating SDF into the silver modified atraumatic restorative technique (SMART).
- Managing dentinal hypersensitivity.
- Treating molar incisor hypomineralization (MIH).
- Addressing recurrent caries (secondary caries) at the restoration margins
- Treating the incipient interproximal lesion.
- For disinfection of the root canal.
- For Indirect pulp capping treatment.
- For halting the caries to preserve the teeth nearing exfoliation.
- Alternative to sealants in children who cannot bear sealant application procedure.

The SDF is contraindicated in the following situations.[30]

- Those with identified silver allergy
- Those present with oral soft tissue ulcerations particularly which occur during application of SDF
- Active cavitated caries lesions with pulp association

• If parents/custodians do not provide consent for using SDF, due to concerns of color change.

Disadvantages

The biggest drawback of using silver as silver nitrate and silver diamine fluoride in dentistry is that carious lesions become eternally black. This color change results from the oxidation of ionic silver to metallic silver, this phenomenon limits the use of silver compounds in patients with high aesthetic demands.[31]

Traditionally, silver ions are thought to be cytotoxic. Silver toxicity can manifest in various forms, including argyria (a condition characterized by blue-gray discoloration of the skin and mucous membranes), nephrotoxicity, and neurotoxicity. Additionally, the application of SDF is usually localized to the affected tooth surface, minimizing systemic exposure and potential cytotoxic effects on other tissues[32]. Recent studies have provided valuable understandings about the toxicity of SDF. A study by Mei et al. (2016) explored the systemic absorption of silver resulting SDF application and found that even though there was detectable silver in saliva and urine, the levels were within the acceptable range. However, concerns regarding the long-term effects of silver exposure, particularly in young children, persist[33].

CONCLUSION

The evidence presented in this literature review emphasizes the significant efficacy of Silver Diamine Fluoride (SDF) in preventing and arresting the caries, particularly in pediatric and high-risk populations. The application of SDF provides numerous advantages, comprising its non-invasive nature, cost-effectiveness, and capability to arrest the carious lesions. Furthermore, the dual mechanism of action, uniting the antimicrobial properties of silver with the remineralizing effects of fluoride, makes it a valuable addition in the prevention and control of dental caries.

SDF has shown favorable outcomes in arresting carious lesions, in short term studies. Future research should incorporate patient-reported outcomes and qualitative assessments to better understand the widespread impact of SDF treatment on individuals' oral health and overall quality of life.

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