Effectiveness of the use of silver diamine fluoride for the prevention of dental caries

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ABSTRACT
Silver diamine fluoride SDF is a non-invasive agent with antimicrobial, remineralizing and bactericidal properties used for the prevention and control of carious lesions. The objective of the research was to know the properties and ideal concentration of silver diamine fluoride to achieve its effectiveness in the prevention, arrest, and control of carious lesions. To carry out the work, the standards of the Cochrane protocol used in systematic research were followed. Furthermore, the search criteria involved the utilization of the PRISMA review method, which is the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols. The analysis incorporated a total of 168 articles, 134 studies were excluded based on the title, 15 based on the information found in the abstract and 11 after reading the full text articles. In this way, the information included in this work consists of 8 specific articles that deal with the topic. It was concluded that SDF at 38% is effective in preventing and controlling enamel caries lesions in first molars of the permanent dentition and dental caries in anterior teeth of the deciduous dentition, remineralizing dental structures and does not present significant adverse effects after treatment. of your application.
Keywords: silver diamine fluoride, dental caries.

1. Introduction

The WHO defines caries as amultifactorial disease, given by the interaction of the teeth, the biofilm and microorganism present in the mouth, alterando the process of demineralization and remineralization of the teeth. (1), is presented worldwide, becoming a challenge for public health, since it is one of the most prevalent chronic diseases worldwide, in turn restorations in children become challenging due to their young age and lack of cooperation before these oral procedures, in addition to this dental care is often limited by lack of resources or Simply parents or guardians choose not to treat these types of injuries. (2). This oral pathology isdirectly related to oral health and the quality of life that the population leads from its type of food, habits, customs and economic resources where the inequity of these resources causes unfavorable oral health affecting both the adult population and children.

In recent years, the use of SDF has aroused interest in oral health professionals due to its high degree of control and arrest of caries. There are different preventive methods for the detection of caries such as silver diamine fluoride which is considered as a non-invasive treatment. Silver diamine fluoride in its topical presentation is a transparent liquid that paints the dental surfaces indicating an active carious lesion, its mechanism of action is based on the tubular and peritubular resistance of dental tissues against decalcification, since it transforms hydroxyapatite into fluorhydroxyapatite (3), for its part the Silver ions inhibit the growth of all oral bacteria and denature enzymes that cause degradation of collagen dentin. Calcium fluoride neutralizes the imbalance in the process of demineralization and remineralization, favoring the remineralization of the tooth. (4).

The application of the SDF consists of the placement of this fluoride as an anticariogenic in the enamel of the dental organs that seeks as a goal the detection and progression of caries. Silver diamine fluoride (SDF) is easy to handle and place where its use at the community level is efficient due to its active ingredient of caries detection and its low cost. By performing a preventive treatment with this type of fluoride or some other sealant material, oral health and quality of life can be clearly restored.

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This agent in addition to retreating caries offers several advantages in relation to its low cost, is non-invasive, does not require specialized equipment and is easy to handle, presents immediate relief to a generalized hypersensitivity of dentin and control of cariad a,remineralizes dentin. It is ideal for patients at high risk of caries such as salivary dysfunction, usually secondary to cancer treatment, Sjogren's syndrome, xerostomia caused by medications, aging or methamphetamine abuse, patients who cannot tolerate standard dental treatment, in carious lesions with difficult access to perform treatment and in patients without access to dental care . (5). The bibliographic review of this topic allows to expose key points that provide an easy and safe alternative to the prevention of caries. Therefore, the existence of previous research is confirmed, which through clinical studies proves the effectiveness in the application of SDF and first treatment option to stop carious lesions and remineralize the dental organs.

PFS should be limited when pulp irritation, necrosis, carious lesions in intimate contact with the pulp chamber, irritation of the oral mucosa, disposition by the patient or responsible guardian are observed. (6).

To address this topic of study it is necessary to know the mechanism of action, concentration and ideal dose, those possible adverse effects and success rates in the arrest and control of caries. The discussion starts from the approach of the problem What is the effectiveness of the use of silver diamine fluoride for the prevention of dental caries?

Once the aspect of interest in this context has been identified, the investigation starts from the effectiveness and ideal percentage of the SDF for the prevention of carious lesions in deciduous and permanent dentintion, its adverse effects, comparison with NaF and its impact on the general health of the patient. The objective of this review was toknow the properties and ideal concentration of fluoride diaino de plata to achieve its effectiveness in the prevention, arrest and control of carious lesions.

2. Methods

Protocol

The protocol was designed in accordance with Cochrane standards for systematic reviews. The search criteria met the Preferred Reporting Items for Systematic reviews and Meta-Analysis Protocols (PRISMA) guidelines. (7)

Inclusion and exclusion criteria

The inclusion criteria were: studies published in the last 5 years, studies conducted on adults or children with permanent or deciduous teeth, studies conducted in Spanishor English, studies addressing thepresence of dental caries through the use of silver diamine fluoride, itsideal centering and indicated for application, the effectiveness in terms of caries arrest, adverseeffects of treatment, the relationship of its use and the quality of life provided and the success of the restoration of carious lesions.

The exclusion criteria were: studies older than 5 years, conducted on animals, studies without statistical analysis, studies in a language other than Spanishl or English, analytical studies that did not associate carious lesions and silver diamine fluoride, studies conducted among people with intellectual disabilities, studies in hypomineralized molars.

Search strategy

We searched the following database from 2018 to April 2022: 1) MEDLINE via PubMed. The search strategy used was: ("silver diamine fluoride" [Supplementary Concept]) AND "Dental Caries"[Mesh].

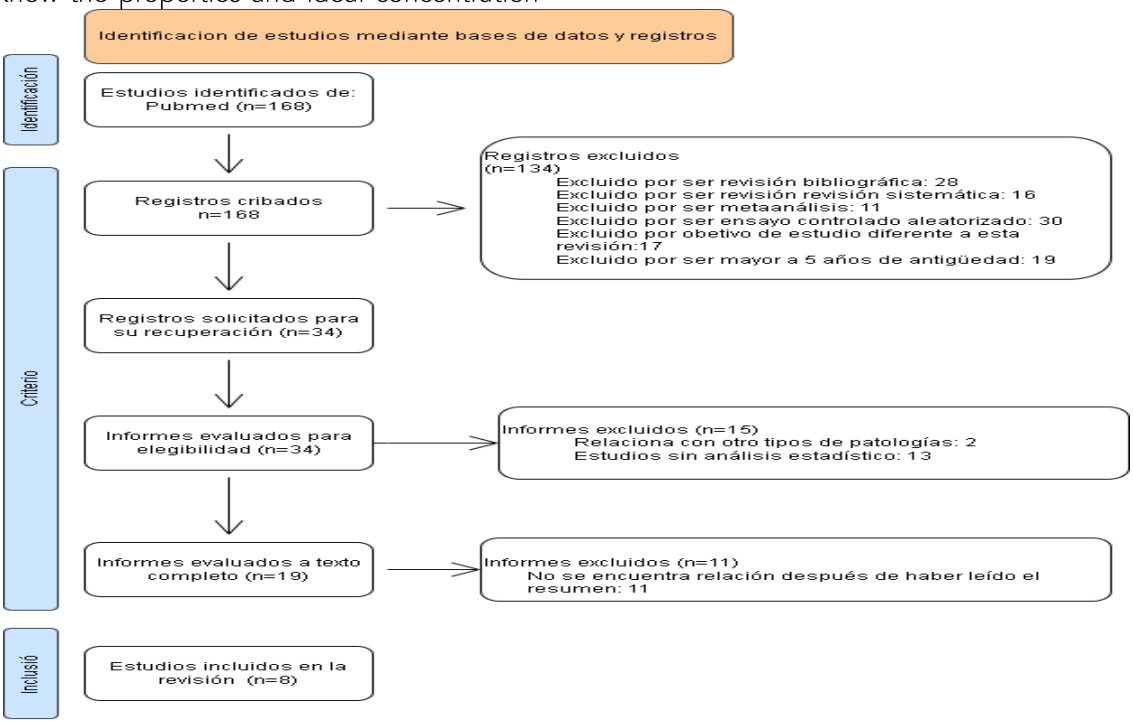

Figure 1 Flowchart of this review. Adapted from Page et al.

Study eligibility and data extraction

We screened the full texts of potentially relevant studies to answer the research question. A matrix was generated for data extraction from selected studies. The matrix had the following fields: authors, year of publication, types of study, population and theme. Table 1

Analyzed result.

Studies investigating the association between carious injury prevention and silver diamine fluoride. Selected studies must be randomised clinical trials. Its ideal concentration and indicated for application, The main results of this review can be found in Table 1.

3. Results

A total of 168 articles were reviewed, 134 studies were excluded based on the title, 15 based on the information found in the abstract and 11 after reading the articles in full text. Finally, 8 studies were included in the review. You can see the diagram flow in Figure 1.

Tableto1 Matrix for data extraction of selected studies.

Nª	Authors	Year Of Publication	Type Of Study	Age Of The Population	Findings Found
1	Milgrom P, Horst JA, Ludwig S, Rothen M, Chaffee BW, Lyalina S, Pollard KS, DeRisi JL, Mancl L.	2017	Randomised controlled trial	2 to 6 years	Arrest of caries 14 to 21 days after the intervention.
2	Fung MHT, Duangthip D, Wong MCM, Lo ECM, Chu CH.	2017	Randomized clinical trial	3 to 4 years	Effectiveness of 2 concentrations (12% or 38%) silver diamine fluoride
3	Mabangkhru S, Duangthip D, Chu CH, Phonghanyudh A, Jirarattanasopha V.	2020	Randomized clinical trial	1 to 3 years	Efficacy of 38% Silver Diamine Fluoride (SDF) Solution and Comparison with 5% Sodium Fluoride (NaF) Varnish for Dentin Caries Arrest
4	Abdellatif HM, Ali AM, Baghdady SI, ElKateb MA.	2021	Randomized clinical trial	3 to 8 years	Effect of a biannual application of 38% silver diamine fluoride (SDF) with an alternative restoration technique
5	Duangthip D, Fung MHT, Wong MCM, Chu CH, Lo ECM.	2017	Randomized clinical trial		To compare adverse effects after silver diamine fluoride (FDS)
6	Ruff RR, Barry Godín TJ, Small TM, Niederman R.	2022	Randomized trial	5 to 13 years	SDF on oral health-related quality of life
7	Cleary J, Al-Hadidi R, Scully A, Yahn W, Zaid Z, Boynton JR, Eckert GJ, Yanca E, Fontana M.	2022	Randomized clinical trial	2 to 10 years	Effectiveness of 38% silver diamine fluoride (FDS) application versus restorative therapy
8	Jiang M, Wong MCM, Chu CH, Dai L, Lo ECM.	2020	Randomized controlled trial	2 to 5 years	To compare the success rates of restoring untreated and treated dentin caries lesions treated with SDF

The bactericidal and bacteriostatic effects of SDF at different concentrations on cariogenic streptococci in an in vitro evaluation of Pérez et al. compared concentrations of 12% and 38% (3), in turn, Milgrom et al. d demonstrated through their randomized double-blind clinical study the clinical effectiveness of 100% of silver diamine fluoride in concentration to 38% in the arrest of low short-term carious lesions injury inactivity criteria, Nyvad inactivity criteria. Oral pathologies such as gingival or soft tissue stomatitis or ulcerative lesions were also identified. (2)

Table2 Proportion of caries lesions stopped at 14 to 21 days by treatment condition in the Stopping Cavities trial with silver diamine fluoride (FDS). Where 95% CI: is the 95% confidence interval for the average proportion of caries stopped and the difference in the average proportion of caries arrested. (SD) standard deviations.

Condition	Group	Media (DE)	95% IC	Median (RIC)
SDF	29	0,72 (0,38)	0,55 a 0,84	1,00 (0,50, 1,00)
Control	35	0,05 (0,18)	0,00 a 0,16	0,00 (0,00, 0,00)
Difference between groups		0,67	0,49 a 0,80	

Fung MHT and colleagues addressed the ideal concentration of SDF for use and application in caries arrest, which is identical to 38% more effectively (8)

the concentration of 38% being a higher concentration should be considered that its highest recommended dose is 1 mg / kg (4), where carious lesions receiving 38% SDF have a higher probability of black staining in the enamel and the surrounding tissue of the dental organ, thus it should be considered that the clinical success of the application of SDF for the detection of active caries lesions may be positively related to the presence of the apparent protective layer that forms as a black spot on the carious lesion and it can be verified whether the SDF inactive the carious lesion, at the same time it is evident that there are no statistically significant differences with the degree of SDF concentration between 12% and 38%. (9)

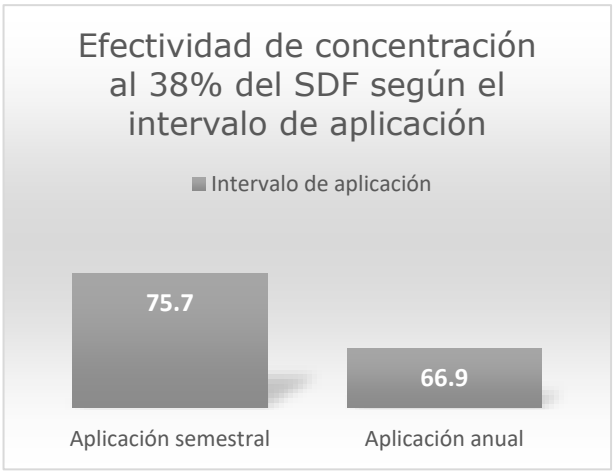

Figure 2 Comparison of SDF application where 66.9% corresponds to an annual application and 75.7% for semi-annual application.

The application of silver diamine fluoride (SDF) causes questions about its possible adverse effects that is, if it presents systemic toxicity, causes irritation or pain after its application, based on scientific evidence it is proven that there are no adverse effects or systemic diseases related to the use of SDF where gingival irritation is ruled out, oral pain, swelling and whitening. (3). The results of the different studies confirm the safety of treatment with SDF and it can be applied safely especially in children. It is important to know that the application of SDF does not cause symptoms that includes nausea, vomiting and general malaise after treatment in this way it is evident that it does not cause systemic toxicity and there are no adverse effects. (10)

Within conservative dentistry, there is currently an approach to treat caries through non-invasive procedures such as the application of topical fluoride-based agents directly on tissues with carious processes in order to stop the carious lesion and turn the active lesion into an inactive lesion(11). It has been shown that the application of the Silver Diamine Fluoride (SDF) solution is efficient to stop the progression of carious lesions especially in preschool ages, it should also be considered that the application of SDF stops the progress of caries but the cavity is visible and has no restorative material, so it compromises functional abilities such as chewing. (11)

When comparing the success rates of an untreated dentin caries lesion treated with SDF, it is established that the type of cavity was significantly related to the success rate of restorations, where lesions treated with SDF stop in greater proportion.

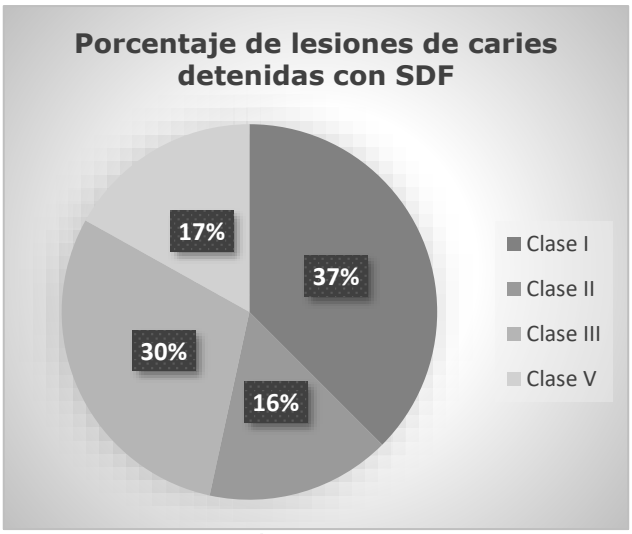

Figure 3 Percentage of caries lesions stopped with SDF. Class I with 37.5% and Class III with 29.7% presented a higher percentage of caries arrest after the application of the SDF.

More caries lesions are stopped with application of SDF, where more than a third of the restored lesions are Class I, followed by Class III, Class V and Class II, taking into account the relatively small cavity size. Most lesions treated with SDF are stopped and difficult to probe before the application of restorations with ART (atraumatic restorative treatment), in this way the amount of dental tissue to be removed is small. (12)

Table 3 Results of multilevel logistic regression analysis with the arrest and efficacy to stop carious lesions. Group 1: 38% SDF (Topamine) was applied and Group 2: 5% sodium varnish was applied fluoride.

	Group 1 SDF 38 % (Topamine)	Group 2 NaF varnish 5 % (Duraphat)
Rate of caries arrest	35,7%	20,9%
Efficacy in stopping carious dentin lesions	>1	<1

Mabangkhru et al. through their clinical trial demonstrated the rate of arrest of SDF higher than NaF, as well as greater efficacy of SDF for caries arrest, taking into account plaque accumulation, tooth type, surface, diet and socioeconomic factor influence caries activity(13). Table3 (13)

Generally, a non-surgical preventive treatment seeks the detection of caries especially in the stage of childhood and adolescence because they are ideal

stages to apply fluoride in addition to teaching and strengthening oral hygiene measures considered as preventive and non-invasive procedures, it should be noted that silver diamine fluoride after its application is visible a permanent black stain in dental caries and a superficial staining of the mucosa Which is a disadvantage in relation to oral aesthetics, but within the clinical and economic field it is beneficial. In children aged 5 to 9 years, the worldwide prevalence rate of caries in temporary teeth is greater than 40%, where caries develop more frequently on the occlusal surfaces of the premolar and molar dental organs, being one of the considerations for the application of silver diamine fluoride where oral and facial aesthetics are not affected.

However, within the ages of 12 to 15 years this black spot is already a concern because adolescents are already affected by their aesthetic appearance and especially the facial, therefore, the application of silver diamine fluoride would already be a little limited option within these ages especially in the anterior sector of the arcades. In the case of the application in the posterior sector is more accepted for its low visibility and benefits for the control of caries, it is also important to recognize that the application of SDF in the case of deciduous teeth especially in the anterior sector does not cause a disadvantage because they are teeth close to exfoliation. Silver diamine fluoride is applied in a short time so its use is indicated in a large population, it becomes a viable and accessible option for the health professional looking for new options for preventive non-surgical treatment is compared to traditional processes.

4. Discussion

The SDF is currently applied for its potential to stop the progression of carious lesions as it is an antimicrobial, its easy application protocol and its low cost makes it an efficient alternative for a population with low resources where the high risk of dental caries and poor oral hygiene is evident. Silver diamine fluoride is an anticariogenic agent, has bactericidal or bacteriostastic properties depending on its concentration, has been used since 1960 (14).

Milgrom and other collaborators document the effectiveness of SDF at 38% to stop and prevent caries directly The effectiveness was demonstrated on untreated surfaces and on high-risk non-cavitated surfaces, such as grooves of surfaces in permanent molars, and its safe application, being able to prevent morbidity rates associated with untreated early childhood carious lesions, This will reduce the need for treatment. (2). However, a certain optimal time for treatment has not been established, but authors suggest that greater efficiency is achieved every 6 months. Likewise, Fung et al agree with Milgrom & colabs that SDF is more effective in stopping dentin caries at a concentration of 38% than 12% and when applied every 6 months than every 12 months. Literature authored by Fung MHT / colab, and Gao, Zhang, et al. share the same criteria on the recommendation of the use of high concentration SDF at 38%, the latter adds that increasing the frequency of application from one to two times a year would increase the success of early arrest of carious lesions in children with poor oral hygiene. (8).

The arrest of caries by silver diamine fluoride uses a microbial mechanism that indiscriminately eliminates or inhibits all bacteria in a caries lesion, and only has a selection against a particular cariogenic bacterium, thus ensuring detention. (6) Gao et al. They mentioned that this agent slows down the demineralization of the tooth structure and stops cariogenic bascterias from growing. (15)

According to the results of the clinical study by Mabangkhru et al., 38% SDF is more effective than 5% NaF in stopping dentin carious lesions in children aged 1 to 3 years, with a biannual application for greater effectiveness, taking into account demographic background of the samples, oral hygiene habits such as parental satisfaction during the study, Although it had no negative impact, however, there is a need for studies to support the aforementioned study. (13)

The black stain of the arrested carious lesions while it is true is visible, nevertheless the benefits of SDF outweigh its disadvantages. Lesions treated semiannually are more likely to turn black than those treated annually because their application is not constant, it is also important to know that staining is not an adverse effect and does not cause major concern in parents and school-age children. (10)

A recent report from the American Dental Association (ADA) on the non-restorative management of caries prioritizes the use of SDF over other products to treat cavitated caries lesions (14). The previous application of SDF is evident that it does not affect the success rate of ART restorations in deciduous teeth, from this mammary it is easier to apply ART restorations in caries lesions that have been previously treated with SDF. (9) ART restorations placed in children who do not use toothpaste are more likely to fail teeth, it is evident that poor oral hygiene is associated with the failure of ART restorations, however, brushing with fluoride-based toothpaste cannot guarantee the success of ART restorations, the maintenance of good oral hygiene and the use of fluoride prevents tooth decay and should be beneficial for the conservation of restorations. (16)

Carious cavities should be restored after the application of SDF based on a restorative approach with ART, within a period of 10 weeks, because it is important to allow a prudent time for active caries to stop after the application of SDF, however active caries can be stopped after six months of application. For this it is important to combine with an ART restoration to reduce the time of active caries, where caries lesions treated with SDF are stopped at the same time as the placement of the restorations with ART, this technique consists of filling the cavity of the caries lesion where it is

covering the margin of the surface and the black spot of the cavity due to the application of SDF, the restorative material of ART allows to obscure this stain and the black halo around the restoration is not appreciated. (17)

It is evident that the SDF does not indicate any negative impact on the quality of life related to oral health since it implies the satisfaction of both functional and emotional well-being of children, youth and adults, in addition the clinical support approves the continued use of silver diamine fluoride especially in age from 5 to 13 years. (18)

Some articles demonstrate the diverse applications of neutrosophic theory in various fields. One such field is sustainable development, as discussed in the article by Jesus Estupiñán Ricardo et al. Their analysis of sustainable development indicators through neutrosophic correlation coefficients shows the potential of neutrosophic theory in quantifying and evaluating complex, multidimensional concepts such as sustainability.In addition, the article by Alex Javier Peñafiel Palacios et al. highlights the use of phenomenological hermeneutical method and neutrosophic cognitive maps in the causal analysis of transgressions against the homeless. This approach provides a new perspective in the understanding and prevention of social injustices, especially towards vulnerable populations.Another interesting application of neutrosophic theory is in the field of dental health, as demonstrated by Paola Andrea Mena Silva et al. in their study on the prevalence of dental fluorosis. Their use of neutrosophic statistics shows the potential for a more nuanced and accurate understanding of the factors contributing to dental health issues(19,20,21).

Finally, in light of these studies, it is worth discussing the effectiveness of using silver diamine fluoride for the prevention of dental caries. While not directly addressed in the articles, this topic is relevant to the discussion of dental health and the potential applications of neutrosophic theory in this field. Studies have shown that silver diamine fluoride is effective in preventing and arresting dental caries, particularly in children and those with limited access to dental care. However, further research is needed to fully understand the potential benefits and drawbacks of this approach, and to ensure its safe and ethical implementation. Overall, these studies highlight the potential of neutrosophic theory in a range of fields and provide a basis for further exploration and application.

5. Conclusions

Clinical studies demonstrated the efficacy of SDF in reducing enamel caries lesions in the first molars of the permanent dentition and tooth decay in anterior teeth of the deciduous dentition. The application of SDF is a good alternative to stop tooth decay especially in temporary dentition when children are in their preschool stage and following this procedure can be used restorations with ART when children are at an age of ability to cooperate with the operator and lesions treated with SDF can be restored with ART to improve aesthetics, morphology and the main function of the teeth which is chewing. The interval of application of the SDF will depend on oral hygiene, if the patient has ulcerative lesions or stomatitis we must refrain from its use. When applying care should be taken not to touch the oral mucosa, it could irritate it.

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