

Silver Diamine Fluoride – An Alternative Strategy for the Treatment of Caries in Individuals with Special Needs

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Abstract

Aim

To investigate the effectiveness of Silver Diamine Fluoride (SDF) in arresting dental and root caries in people with special needs (PSN); to evaluate whether SDF could be an alternative strategy in arresting/managing caries compared to the conventional restorative techniques involving fillings.

Results

A systematic literature search was conducted using electronic databases, manual reference list, and grey literature searches. Applying inclusion criteria 18 studies were used for data extraction; 15 studies were randomized/controlled clinical trials (RCT) examining caries arrest in primary and permanent dentition and 3 RCT on root caries in the elderly. No RCT investigated the effectiveness of SDF on dentine caries arrest or compared the effectiveness of SDF with conventional restorative treatments in normal individuals older than 10 years old, in PSN or elderly. The majority of studies revealed high dentine and root caries arrest/prevention during bi-annual application of 38% SDF compared to other interventions.

Conclusion

Application of SDF could be a potential alternative strategy in arresting/managing caries in PSN. However, a well-designed trial is needed to assess the effectiveness of SDF on PSN and compare the outcomes to conventional restorative treatments due to the current gap in literature research.

Keywords: SDF, Silver Diamine Fluoride, People with special needs, Special Needs, Dental Caries, Root caries, Caries, Dental Decay, Special Care Dentistry, Disability

Introduction

Studies have shown that dental caries is the most prevalent disease among people with special needs (PSN) worldwide¹ causing pain and discomfort. These individuals receive less restorative care and are more likely to have decayed teeth extracted² than receive fillings, crowns, and bridges.^{1,3} Furthermore, the need for proper dental care for PSN is crucial due to the close link among oral health and balance of stomatognathic functions such as mastication, phonation, and swallowing⁴, as well as reducing the risk of chronic diseases such as diabetes and coronary heart disease.⁵

Poor oral hygiene can be explained by their struggle in understanding the importance of oral health, manual dexterity and difficulties related to physical limitation. Moreover, PSN present unique challenges for dental professionals⁶ as they do not cooperate well during long appointments, fear of loud noise and find invasive treatments uncomfortable.⁷ As a result, poor oral health may result in severe infections and caries leading to decay and tooth loss.^{6,8}

Silver diamine fluoride (SDF) may be an effective treatment option for PSN due to the material's unique ability to non-invasively arrest and prevent new caries lesions.⁹ Due to the complexity of conventional restorative treatments (fillings) that require local anesthetics, drilling of the tooth structure and keeping still with mouth open for long periods, many PSN may find difficulties to cope with these invasive treatments.¹⁰ In contrast, SDF is a topical solution that is very simple and easy to use by only cleaning tooth and applying it onto the cavity.¹¹

Even though the clinical effectiveness of SDF has been studied across different age groups, populations and types of dentitions, there are no published records involving PSN.¹² Hence, this literature review aims to assess the effectiveness of SDF in arresting dental caries lesions in PSN by reviewing the available quantitative studies done to date and explaining how SDF could be a potential choice of treatment for caries in PSN. This can be clinically important as it may provide a quicker, cheaper and non-surgical treatment which leads to improvement of oral health and promotes a more designated way of preventing caries in affected individuals.

Methods

Electronic Data Bases

The systematic review was conducted following guidelines delineated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Searches were conducted in Medline Ovid, Embase Ovid, Cochrane Oral Health's Trials Register, Web of Science and Scopus databases. Any on-going trials were checked in the U.S National Institutes of Health Trials

Registry. Additional articles were also identified by reviewing the reference lists and bibliographies of the articles.

Inclusion and Exclusion Criteria

The search strategy and research question were developed using PICOS (population, intervention, comparators, outcome, study design) framework. Search terms and keywords used to identify relevant articles from electronic databases are provided in Table 1.

Component	Inclusion Criteria	Exclusion Criteria
Population	Any individuals who have dentine and root caries. Individuals with and without learning disabilities, PSN. Participants with age groups ranging from children to adults (2-85+ years old).	Individuals who may be undergoing cancer treatment, smoke, are obese, have type 1 and 2 diabetes or are suffering from malnutrition.
Intervention	Silver Diamine Fluoride	
Comparators	Conventional restorative treatments, fillings, other fluoride varnishes, atraumatic restorative treatments.	Other non-restorative treatments or preventive methods; such as tooth brushing, flossing or diet control, water fluoride content.
Outcomes	Arresting dental and root caries and being more manageable approach in arresting caries than restorative treatments.	
Study design	Randomized controlled trials (RCT), Controlled clinical trials (CCT), Quasi-randomised trials, Qualitative studies.	Systematic Reviews, Commentary, Letters to the editor, Umbrella reviews, In-vitro studies
Date	Studies published until 16th January 2020.	Studies published after 16th January.
Language	No language restriction	

Table 1: PICOS criteria for inclusion and exclusion studies.

Due to the lack of available data and studies done on PSN, studies involving children and the elderly were included. The advantage of comparing the low age groups with PSN is because children normally exhibit similar behaviour management difficulties, lack of cooperativity during dental treatments, dependence on tooth brushing by their family member as well as poor awareness of diet. Conventional restorative techniques were considered as methods for caries removal using rotary instruments or restorations with any restorative material.

Elderly and adolescent participants were included as dentine and root caries has similar/same progression rate and process in these groups of individuals compared to PSN. In addition, the elderly population may also be reliant on carers of family members, present impaired dexterity leading to poor brushing hence and consequently have similar outcomes in their oral hygiene and caries prevalence as the PSN. Common conditions which are present in elderly such as impaired salivary flow and xerostomia can be useful to investigate the effectiveness of SDF in the arrest of root caries.¹³

Lesion Cavity and Follow-Up Assessments

Studies included in this study followed the same generic diagnostic criteria for caries which involved clinical investigation only and follow-up assessment procedures. Studies using other methods such as taking radiographs or using different dentists during follow up assessments were excluded.

Search Strategy

Detailed search strategies were developed using relevant keywords in the databases mentioned above. The initial search strategy (Table 2) revealed 0 studies that met the following inclusion criteria. As a result, a more extensive and broader search strategy (Table 3) was conducted to maximize searches and find the most suitable studies that could be used to answer the question and aims. The second search strategy was applied to all the databases (Table 3).

1	SDF* OR Silver Diamine Fluoride OR Silver Diamine Fluoride
2	Special Needs*
3	Intellectual* OR Learning* OR development* OR incapacity* OR impair* OR difficult* OR problem* OR Condition* OR disabled* OR Disturb*

4	Cooperativity* OR Cooperation* OR Coping* OR Cope*
5	Phobia* OR Anxious* OR Fear* OR Anxiety* OR Scare*
6	Dental Decay* OR Tooth Decay* OR Decay* OR Dental Caries* OR Caries* OR Oral care* OR Teeth* OR Dent* OR Dentition* OR Dentin decay OR cavity*
7	#2 or #3 or #3 or #4 or #5
8	#1 and #6 and #7
9	Comparison* OR Comparative* OR Compare* OR Instead*
10	Dental Fillings* OR Dental restorative treatment* OR Drilling* OR Sealants* OR Amalgam* OR Composite* OR Drill&Fill* OR Fillings
11	#8 and #9 and #10

Table 2: Search strategy for studies relating to the effectiveness of SDF as treatment of dental caries in individuals with special needs compared to convention restorative methods.

1	SDF* OR Silver Diamine Fluoride OR Silver Diamine Fluoride
2	Dental Decay* OR Tooth Decay* OR Decay* OR Dental Caries* OR Caries* OR Oral care* OR Teeth* OR Dent* OR Dentition* OR Dentin decay or cavity*
3	Effectiveness* OR Effect* OR Successful*
4	Prevent* OR Prevention OR Arrest* OR Stop OR Treat OR Treatment
5	#3 or #4
6	#1 and #2 and #5

Table 3: Search strategy for studies relating to the effectiveness of SDF as a treatment of dental caries in all individuals.

Selection of Clinical Studies

Studies that were potentially eligible for the study were screened by reviewing titles and abstracts independently by two reviewers. Duplicated publications were removed. Literature reviews, case reports, laboratory studies, clinical trials in other aspects (such as not investigating caries arrest with SDF) clinical treatment guidelines, protocols and other irrelevant studies were excluded. Full texts of the articles which addressed the inclusion criteria were retrieved and read. All full texts were also independently evaluated following the inclusion criteria and the risk of bias by two reviewers. Disagreements were solved by argumentation and discussion. Manual search was performed on the bibliographies of these publications to identify relevant papers, which were included for assessment. Finally, all the studies that met the inclusion criteria were selected in this systematic review.

Results

Figure 1 represents the flow results at each review stage. A total of 18 studies were included in this systematic review. Out of which, 15 studies were RCT examining the effectiveness of carries arrest in primary and permanent dentition¹⁴⁻²⁸ and finally 3 RCT²⁹⁻³¹ on root caries in the elderly. Summary of RCT on dentine and root caries results are presented in tables 4 and 5, respectively.

Effectiveness of Sdf in Arresting Dentine Caries in Primary Dentition

Summary of the results of dentine caries arrest using SDF on permanent and primary dentition is presented in Table 4 Among the 15 studies investigating caries arresting effect of SDF presented only with 4 studies in permanent dentition (permanent first molars).^{22,25-27} Unfortunately, no clinical trials were found investigating the effectiveness of SDF on dentine caries arrest in participants older than 10 years or in PSN, elderly and a very low number of studies presented on the permanent dentition. In addition, there were absolutely no records of studies comparing the effectiveness of SDF with the conventional restorative treatments mainly drill and fill in adults/children with special needs as well as normal individuals.

The majority of studies and their results (Table 4) agreed that SDF is a more effective method in arresting dentine caries and preventing new caries lesions in primary dentition compared to other interventions such fluoride varnishes and GIC or/and resin sealant applications. It was noticed that the bi-annual application is more effective than the annual application of SDF. The concentration of SDF ranging between 12%, 30% and 38% also played a significant role, with 38% concentration having a higher caries arrest rate.

Furthermore, no significant differences between with and without prior removal of decayed tissue using hand instruments before the application of SDF was reported in neither study^{15,17,19} with caries arrest rates 99.7% and 97.7% respectively.

Study Author and location	Dentition and participants age (years)	Number of participants, length and study design	Methods	Results and conclusion
Fung et al., 2016, China	Primary, 3-4	831 (dropout rate 6%), 16 months RCT (double-blinded)	G1: Topical application of 12% SDF every 12 month G2: Topical application of 12% SDF every 6 month G3: Topical application of 38% SDF every 12 month G4: Topical application of 38% SDF every 6 month	Caries arrest; G1:50% G2:55% G3:64% G4:74% Based on the 18-mo results, 38% SDF is more effective in arresting dentin caries in the primary teeth 12% SDF and when applied bi-annually rather than annually.
Zhi, Lo and Lin, 2012, China	Primary, 3-4	181 (dropout rate 15%), 24 months RCT (using parallel group design)	Before providing the treatment soft decayed tissues of the selected decayed primary teeth were removed by hand instruments. G1: Topical application of 38% SDF every 12 months G2: Topical application of 38% SDF every 6 month G3: Glass ionomer application every 12 months	Caries Arrest; G1: 79% G2:91% G3:82%
Dos Santos et al., 2012, Brazil	Primary, 5-6	91 (dropout rate 0%), 12 months RCT	G1: Annual Application of 30% SDF G2: GIC application every 12 months	Caries arrest after 6 months; G1:85% G2: 43.4% of GI lost Caries arrest After 12 Months: G1: 66.9% G2: 38.6% After a 12-month follow-up, SDF proved to be 1.73 times more effective than application of GI
Lo, Chu and Lin, 2001, China	Primary, 2-4	375 (dropout rate 9%), 18 months CCT	G1: Caries lesion removed with hand instruments. Application of 38% SDF annually. G2: Application of 38% SDF w/o caries removal G3: Removal of caries lesion with hand instruments. Application of 5% NaF every 3 months G4: Application of 5% NaF every 3 months w/o caries removal G5: Control group, application with distilled water	Caries Arrest; G1: 99.7% G2: 97.7% G3: 21.2% G4: 47.3% G5: 32.3% An annual application of a 38% SDF is more effective in arresting dentin caries than the application of a 5% NaF varnish at three-month intervals or a placebo. Removal of carious tissue did not seem to affect the agent's ability to arrest dentin caries.
Duangthip et al., 2018, China	Primary, 3-4	309 (dropout rate 17%), 30 months, RCT	G1: Annual application of 30% SDF G2: Three applications of 30% SDF at weekly intervals G3: Three applications of 5% NaF varnish at weekly intervals.	Caries Arrest; G1: 48% G2: 33% G3: 34% Over a 30-month period, annual applications of SDF solution is more effective than three weekly applications of NaF varnish or SDF solution.
Chu, Lo and Lin, 2002, China	Primary, 3-5	308 (dropout rate 8%), 30 m,	G1: Hand instrument removal of caries in dentin tissue	Arrested caries surfaces: G1: 2.49

		CCT	<p>followed by annual application 38% SDF.</p> <p>G2: Annual application 38% SDF application w/o prior removal of caries</p> <p>G3: Hand instrument removal of caries in dentin tissue followed by 5% NaF application every 3 months</p> <p>G4: 5%NaF application every 3-month w/o prior removal of caries</p> <p>G5: Control group, application of distilled water</p>	<p>G2: 2.82</p> <p>G3:1.45</p> <p>G4:1.54</p> <p>G5:1.27</p> <p>New caries surfaces:</p> <p>G1: 0.26</p> <p>G2: 0.47</p> <p>G3:0.89</p> <p>G4: 0.70</p> <p>G5: 1.58</p> <p>Excavating the carious tissues before the SDF application had no significant beneficial effect.</p> <p>An annual application of SDF is effective in arresting dentin and hardening dentin caries compared to the application of a 5% NaF varnish at three-month intervals or a placebo.</p>
Duangthip, Chu and Lo, 2016, China	Primary, 3-5	275 (dropout rate 9%), 18 months RCT, using parallel group design)	<p>G1: Annual application of 30% SDF solution</p> <p>G2: Three applications of 30% SDF at the weekly interval at baseline</p> <p>G3: 3 applications of 5% NaF varnish at weekly interval</p>	<p>Caries Arrest;</p> <p>G1: 40%</p> <p>G2: 35%</p> <p>G3:27%</p>
Yee et al., 2009, Nepal	Primary, 3-9	976, 24 months, RCT	<p>G1: One application of 38%</p> <p>G2: One application of 38% with a reducing agent (tannic acid)</p> <p>G3: One application of 12% SDF w/o tannic acid</p> <p>G4: Control group, no treatment,</p>	<p>Caries arrest:</p> <p>6, 12, and 24 months; the mean number of arrested carious surfaces was significantly higher in G1 and G2 than G3.</p> <p>No significant difference in the mean number of arrested carious surfaces between the 38% SDF and the 38% SDF + tannic acid groups.</p>
Llodra et al., 2005, Cuba	Primary and First permanent molars, 6	373 (dropout rate 12%), 36 months, CCT	<p>G1: Biannual application of SDF on primary teeth</p> <p>G2: Biannual application of SDF</p>	<p>Number of the mean of new decayed surfaces,</p> <p>In permanent: 0.37</p> <p>In primary: 0.29</p> <p>Carries Arrest;</p> <p>In permanent: 65%</p> <p>In primary: 79.7%</p> <p>The 38% SDF solution was found to be effective for caries reduction in primary teeth and first permanent molars but more effective in caries arrest primary teeth than in first permanent molars</p>
Fung et al., 2017, China	Primary, 3-8	799 (dropout rate 11%), 30 months, CCT	<p>G1: Annual application of 12% SDF</p> <p>G2: Biannual application of 12% SDF</p> <p>G3: Annual application of 38% SDF</p> <p>G4: Biannual application of 38% SDF</p>	<p>Caries Arrest:</p> <p>G1: 55.2%,</p> <p>G2:58.6%</p> <p>G3: 66.9%</p> <p>G4: 75.7%</p> <p>SDF at a concentration of 38% is more effective than that of 12% in arresting active caries in primary teeth. Biannual application of 38%</p>

				SDF increases carries arrest rate
Vollú et al., 2019 China	Primary, 2-5	68, 12 months RCT (using parallel group design)	G1: Annual treatment with 30% SDF G2: Annual treatment with an application of GI. Caries tissue was removed with hand instruments. Additional: The time required to perform the treatments was recorded and a facial image scale was applied to assess anxiety before and after treatment.	Mean Treatment time; SDF: 6.97 minutes ART: 13.88 minutes Facial Image assessment; No significant differences Caries arrest after 3 months G1: 100% G2: 96 Carries arrest after 12 months G1:89% G2:96%
Liu et al., 2012, China	Permanent first molars, 9-10	485, 24 months RCT (using parallel group design)	G1: Placement of resin sealant – with no replacement G2: Biannual application of a 5% NaF varnish G3: annual application of a 38% SDF solution G4: placebo control — annual application of water	Caries arrest: G1: 60% G2: 39% G3:41% At the 24-month examination, 54% of the sealants were lost. Placement of resin sealant, semi-annual application of NaF varnish, and annual application of SDF solution, are effective in preventing pit and fissure caries in permanent molars.
Shah et al., 2014, India	Primary and Permanent first molars, 6-9	123 18 months, RCT	G1: 38% SDF application primary canines and molars and 1st permanent molars G2: 6% NaF on primary canines and molars and 1st permanent molars G3: application of APF Gel 1.23% on primary canines and molars and 1st permanent molars	Fluoride Content after 6 months: G1: 5,663.08 ppm G2: 4903.81 ppm G3: 4698.31 ppm New caries lesions; G1: 2 G2: 10 G3:9 Enamel fluoride content was increased significantly after 6 months of application of SDF compared to Fluoride Varnish and APF Gel. Although not significant, SDF was more efficient in reducing the number of new carious surfaces when compared to fluoride varnish and APF Gel.
Monse et al., 2012, Philippines	Permanent first molars, 6-8	704 18 months RCT	G1- G3 involved the application of SDF and ART sealants along with daily school brushing program with fluoride toothpaste. G4-G6 underwent treatment w/o the brushing program G1 and G4: Annual application of 38% SDF on a sound permanent first molar G2 and G5: Application of GIC on sound occlusal surfaces G3 and G6: Control group	Caries arrest in the groups receiving ART sealant had significantly higher caries arrest than SDF groups. Caries arrest was higher in toothbrushing children than in non-toothbrushing children. GIC fillings missing after 18 months: 42%

Tirupathi, SVSG, Rajasekhar and Nuvvula, 2019, India	Primary Molars, 6-10	50 children 12 months RCT	G-1 Annual application of 38% SDF G-2 Annual application of 5% NSSF	Annual application of 38% SDF and 5% NSSF resulted in similar caries arrest rates. However, author suggests NSSF over SDF due to dark staining of dentinal tissue.
Study Author and location	Number of participants and mean age	Length (months) and Study design	Methods	Results and conclusion
Tan et al., 2010, China	203 (dropout rate 34%) 78.8	36 months, RCT	G1 (OHI) every 3 months G2: OHI and applications of chlorhexidine every 3 months G3: OHI and applications of 5% NaF varnish every 3 months G4: OHI and annual applications of 38% SDF solution.	Reduction of root caries; G2: 57% G3: 64% G4: 71% Application of SDF is most efficient in arresting root caries.
Li et al., 2016, China	67 (dropout rate 19%) 100 root caries lesions 79.5	30 months, RTC	G1: Control, annual application of soda water G2: Annual application of 38% SDF solution G3: Annual application of 38% SDF solution immediately followed by potassium iodide (KI) solution.	Arrest of root caries; G1:45%, G2:90%, G3: 93% Proportions of root caries being arrested in the SDF and SDF/KI groups were not significantly different (p > 0.05).
Zhang, McGrath, Lo and Li, 2013, China	227 (15% drop-out) 60-89	24 months RTC	G1: Annual OHI + placebo G2: Annual OHI + Annual application of 38%SDF G3: Annual OHI + Annual applications of 38%SDF + bi-annual OHE	The mean numbers of new root caries surfaces G1: 1.33 G2: 1.00 G:3 0.70 Arrested root caries surfaces G1 0.04 G2 0.28 G3: 0.33 Annual application of 38% with Annual OHI and bi-annual OHE resulted in lower numbers of new root caries surfaces compared to G1 and G2.

Table 4: Summary of clinical trials of efficacy of SDF in dentine caries arrest in permanent and primary teeth.

Abbreviations: APF Gel- Acidulated Phosphate Fluoride Gel, GIC- Glass Ionomer Cement, ART- Atraumatic Restorative Treatment, 5%NSSF – 5% Nano-Silver Incorporated Sodium Fluoride

Effectiveness of Sdf In Arresting Dentine Caries in Permanent Dentition

Data obtained in this systematic review showed that effectiveness of SDF in caries arrest in permanent dentition lead to varying results. One study concluded that application of 38% SDF resulted in increased fluoride content of primary and first permanent molars compared to application 6%NaF and APF Gel 1.23% and although not statistically significant, SDF being more efficient in reducing the number of new carious surfaces.²⁶ Contradictory, other studies reported that using ART which

involves using hand instruments followed by restorations of the cavity with GIC or resin sealants are more effective in caries arrest compared to the annual application of 38% SDF on occlusal surfaces of permanent first molars.²⁷ A similar conclusion however with no significant differences between permanent and primary dentition was reported by Llodra et al.²² Although, we cannot conclude that SDF is inefficient in arresting dentine caries in permanent teeth as we lack solid evidence from more studies.

However, results reported 43.4% and 54% of GIC and SDF being out just after 6-month follow up examination¹⁶ and with percentage loss being higher during 24-month examinations.^{15,25} It therefore seems that even though GI and resin sealants are slightly more effective in arresting dentin caries in permanent teeth than the application of 38% SDF, the disadvantage of placing them is the low retention rate and

longer treatment times which may be a problem for PSN. In addition, a study examining discomfort experienced in low age children during ART and SDF application showed that 11 children complained about pain and sensitivity during ART, compared to only 1 child complaining during the SDF application.²⁴

Table 5: Summary of clinical trials of the efficacy of SDF in root caries arrest in elderly.

Abbreviations: OHI= Oral Hygiene Instruction, OHE= Oral Health Education

Effectiveness of Sdf In Arresting Root Caries Lesions in Elderly

All three studies investigating the effectiveness of SDF in arresting root caries had similar results where 38% SDF was more effective in preventing new root caries lesions compared to the other interventions such as and 5% NaF or chlorhexidine. 29-31

Discussion

Present review was methodologically conducted as a systematic review however due to no studies conducted on PSN, this review attempted to provide evidence that application of SDF can be an alternative treatment for caries in PSN. Only three RCTs were identified that addressed the effectiveness of SDF on root caries in older adults, but none addressed coronal caries highlighting the scarcity of high-quality data available pertaining to SDF application in coronal caries in an adult population and in PSN. Furthermore, there are no comparative studies up to date with SDF to conventional restorative treatments using rotary instruments in any group of populations.

The evidence shows that PSN have worse oral health and present with more barriers in accessing dental services than the general population.³² This is mainly because these individuals present difficulties in dealing with complex and long treatments.³³ The key barriers experienced by PSN is the inability of accessing dental services and the high rate of anxiety and fear experienced during invasive treatments leading to the inability to cooperate. Since all the clinical trials were conducted outside dental setting (majority of which were conducted in schools and elderly homes), the physical barriers such as getting into the dental chair, transportation, and barriers associated with fear and anxiety proved that these can be avoided with the use of SDF. Although conventional restorative techniques can be provided in a home care setting by means of using dental portable devices, the majority of restorative work will be carried out in a dental surgery because of better equipment, positioning, and lightning.

It has been concluded that any invasive treatments involving rotary instruments, local anesthesia, or even treatments such as ART cause discomfort and fear in pediatric patients.^{24,34} It has been established that the sight, sound, and feeling of the drill is the most fear-producing stimuli next to the sight of the syringe and sensation of anesthetic injection.³⁵ Those with special needs can be even more sensitive to restorative treatments. This is because these individuals can experience abnormal responses

to sensory stimuli, over-reactivity to sound and under-reactivity to pain which can lead to behavioral difficulties in the dental office.³⁶ On contrary, SDF application did not cause any discomfort in children. Thus, application of SDF may be a more effective method in managing caries as it is minimally invasive and can be used at homes/care-homes by a carer/nurse who had been given instructions by a trained professional.³⁷

Data from the review showed that bi-annual application of 38% SDF was found to be more effective for dentine carious lesions prevention and arrest than any of the comparators such 5% NaF, placebo and placements of GIC and resin sealants. Furthermore, caries arrests between prior and without removal of carious tissue did not result in significant differences between caries arrests which can be a huge advantage for people with disabilities who cannot withstand even minimally invasive treatments.

Root caries arrest and prevention rates were also higher when SDF was used as a treatment option compared to applications of NaF varnish. Only one application per year of 38% SDF has been shown to achieve similar clinical results compared to four applications of NaF varnish.²⁹ This is a very important factor because disabled and infirm patients with limited capacity for independent oral self-care, and those with xerostomia can control the progression of root caries lesions with just annual application of SDF.

Disadvantage of SDF

One of the disadvantages of SDF is the formation of black staining on SDF-treated carious lesions due to the formation of silver phosphate.³⁸ Thus, more research is needed to evaluate aesthetic acceptability for older adults and ways to reduce staining in permanent dentition. SDF can temporarily stain gums, skin, and clothing, but with careful application, these can be easily avoided.³⁸

Limitations, Strengths and Knowledge Gap Analysis

This study recognized the importance of SDF as a therapeutic agent in caries arrest for people who cannot cooperate or/and experience anxiety and discomfort during conventional restorative treatments.

Thanks to SDF's non-invasive nature it can be a more suitable method of arresting caries lesions in PSN as studies reported children experiencing less anxiety and discomfort compared to invasive approaches such as ART and drilling. Regarding the potential risk associated with silver ingestion, preliminary data in adults show that occasional use of SDF is well below the concentrations associated with toxicity.^{39,40} In addition, no symptoms associated with acute toxicity or systemic illness, including nausea, vomiting, and generalized discomfort after treatment has been reported.⁴¹

However, a few weaknesses in this study must be acknowledged. The included studies in this systematic review were only written in English. Hence, it would have been interesting to have a full-text review of non-English articles however due to the language barrier and lack of resources to

translate, these had to be excluded. Moreover, all studies were conducted in only limited amount of countries.

All studies included in this systematic review experience a gap in the scientific literature research as none of them addressed a population of PSN. An extensive search conducted on 5 databases found zero results on the comparative studies of SDF and conventional restorative treatments on any type of individuals including those with special needs. Because none of the studies investigated the effectiveness of SDF on the adult population or PSN the results reported in this review are not reliable to the full extent. The assumption of SDF being effective in this group of individuals was based on the comparative approach of children in low age groups, since they may exhibit similar behaviour management difficulties and a similar level of cooperation. However, a well-organized clinical trial must be conducted on PSN to evaluate their behaviour and risks of SDF due to its possibility of staining surrounding tissues in the oral cavity.

Furthermore, we could not clarify whether SDF is as effective as conventional restorative techniques as there are currently no published studies in this field of interest. The only information we could obtain is that more children experienced anxiety during the ART or when rotary instruments were utilized and based on these factors SDF could potentially be a better approach for people who are sensitive or who cannot withstand long invasive treatments.

There is currently no established effectiveness of SDF on dentine caries on permanent teeth in individuals older than 10 years. In this systematic review, only four studies investigated the arrest of dentine caries on permanent dentition with contradictory results. Therefore, research is needed on the use of SDF to arrest root and dentine caries lesions in permanent dentition on adult patients and those with special needs. A well-designed RCT should be conducted to compare the outcomes of various concentrations and frequencies of SDF application and compare these outcomes to conventional restorative treatments.

Even though no clinical trials reported any adverse effects of SDF, the longest study included lasted only 36 months. Thus, a longer observation period is needed to investigate any long-term side effects and the full potential of SDF including its limitations. Additionally, further studies are needed to evaluate the minimal necessary concentration and frequency of application to arrest dentine caries/root caries on primary and permanent teeth and compare the outcomes to conventional restorative treatments.

Suggestions for Future Research

The results of this study open new avenues for future research and may serve as a study idea for further research on minimally invasive treatment options using SDF on PSN. This is important because SDF proved to be effective in caries arrest and prevention of new carious lesions in the few trials conducted so far. Thus, with more research, it can be potentially a great agent for managing dental caries not only in children and PSN but also those that suffer from dental anxiety leading to

improved oral health and reduce the burden of the disease. Furthermore, repeated caries removal has been reported to weaken teeth further, leading to teeth that are at high risk of fracture.⁴² Thus, PSN who are at high caries risk must include effective caries preventive measures that are less invasive and non-operative.⁴²

Even though substantial effort has been made in previous studies regarding the effect of carious arrest in children of a low age and primary dentition, this study implies that more research and trials could complement and enhance the effectiveness of SDF in other groups of individuals. Further quantitative research is necessary to investigate the potential effects of SDF in caries arrest of permanent dentition and the adverse effects. Thus, a larger comparative effectiveness study should be carried out lasting at least two to four years as this is the time necessary for significant numbers of lesions to develop at the cavitation level.⁴³

Additionally, a clinical trial should be conducted on PSN to evaluate their discomfort during SDF application and if needed a comparative approach between SDF and conventional restorative treatments. This is very important as it can improve the delivery of oral health services for arresting dental caries for those with special needs.³⁷

Conclusion

It can be concluded that results obtained from current studies have opened a new potential approach to treating decay in PSN with complex behaviours who cannot cope with long restorative treatments. This is due to the high percentage of studies reporting high root and dentine caries arrest during bi-annual application of 38% SDF in non-dental settings and its minimally invasive nature that does not cause anxiety and fear in PSN. Consequently, it has a potential to reduce the harmful impact of oral health problems in PSN who have limited access to conventional dental care.

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