

Silver Diamine Fluoride in Pediatric Dentistry

Çocuk Diş Hekimliğinde Gümüş Diamin Florür

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ABSTRACT

Although a decrease in the prevalence of dental caries, which is a chronic disease, has been reported in many developed countries, early childhood caries (ECC) as an early childhood disease is common, especially in developing countries. ‘Silver diamine fluoride’ (SDF) stops dental caries, prevents the formation of dental caries and reduces tooth sensitivity. The biggest feature that distinguishes SDF from other fluoride agents that prevent caries formation is that it effectively stops the caries process. This effect is provided by the synergistic effect of silver ions and fluoride. As a result of clinical studies, the use of SDF at the rate of 38% is recommended for the most effective result. SDF is becoming more popular as a practical and affordable treatment option to stop caries. SDF, especially during the pandemic period when minimal aerosol production is important; can be routinely experienced in a pediatric dental office in a variety of clinical scenarios for both primary and permanent teeth. It can be used effectively and efficiently in different behavior patterns of children and in different age groups. In this review, the effect mechanism, usage areas, clinical uses and results of SDF will be evaluated in the light of current literatures.

Keywords: silver diamine fluoride, caries, remineralization, dentistry, pediatric

ÖZ

Gelişmiş ülkelerin birçoğunda kronik bir hastalık olan diş çürüğü prevalansında azalma rapor edilmesine rağmen, özellikle gelişmekte olan ülkelerde bir erken çocukluk dönemi hastalığı olarak erken çocukluk çağı çürükleri (EÇÇ) yaygın olarak görülmektedir. Gümüş diamin florür (GDF) diş çürüklerini durdurma, diş çürüklerinin oluşmasını önleme ve diş hassasiyetinin azalmasını sağlama gibi özellikleri nedeni ile son yıllarda oldukça ilgi görmektedir. Çürük oluşumunu önleme etkisi olan diğer florür

ajanlarından GDF’yi ayıran en büyük özellik çürük sürecini etkin bir şekilde durdurmasıdır. Bu etki içeriğindeki gümüş iyonlarıyla flor iyonlarının sinerjistik etkisiyle sağlanmaktadır. Klinik çalışmalar sonucu en etkin sonuç için %38 oranındaki GDF kullanımı önerilmektedir. Çürük lezyonlarını durdurmak için pratik ve uygun fiyatlı bir tedavi seçeneğidir. GDF, özellikle minimum aerosol üretiminin önemli olduğu pandemi döneminde; hem süt hem de sürekli dişler için çeşitli rutin kullanıma girmiş olup farklı yaş gruplarında etkili ve verimli bir şekilde kullanılabilir. Bu derlemede, GDF’nin etki mekanizması, kullanım alanları, klinik uygulama ve sonuçları mevcut literatürler ışığında değerlendirilecektir.

Anahtar Kelimeler: gümüş diamin florür, diş çürükleri, diş remineralizasyonu, diş hekimliği, çocuk

INTRODUCTION

‘Early childhood caries’ (ECC) is recognized as one of the most common chronic diseases in early childhood. Many studies show that ECC is neglected and often untreated (Seow, 2018). Untreated caries; can cause pain, sepsis and spread of infection, difficulty in eating and malnutrition, and deterioration of general health (Seow, 2018). Dental caries management in pediatric population, especially in children under 3 years of age, requires pharmacological approaches, often consisting of sedation and/or general anesthesia. These methods are costly and bring potential danger (Andropoulos & Greene, 2017).

Although a decrease in the prevalence of dental caries in children has been reported in many developed countries in recent years; today, dental caries continues to amount to a considerable public problem, particularly in developing countries. It has been stated that dental caries is a preventable chronic disease, therefore, many preventive and therapeutic methods are being developed today (Featherstone, 2000).

The use of silver diamine fluoride (SDF) to avoid or delay invasive treatment after 3 years of age makes it

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an attractive adjunctive therapy that can control caries in the pediatric population. (Gao et al., 2016). Scientifically, patients can derive maximum benefit from non-invasive SDF application, which is less complex than restorative treatment (Clemens et al., 2018). In comparison to conventional restorative treatment, dental caries arrest with fluoride agents is easy to use, noninvasive and advantageous cost (Yilmaz et al., 2020).

SDF has been recognized as a therapeutic agent since the 1970s. It is also supported by the Brazilian Assistance Program for children up to 3 years of age with moderate and high caries activity (Peng et al., 2012). However, in 2014 it was accepted by 'Food and Drug Administration' (FDA) in United States and became available for sale in 2015 (Horst et al. 2018).

SDF, that has become progressively popular, is a practicable and low-cost treatment for stopping caries (Clemens et al., 2018). SDF is a semitransparent solution and most frequently used concentration is 38% SDF and has in it 44,800ppm fluoride and 255,000ppm silver ions (Gao et al., 2016).

1. EFFECT MECHANISM

Recent studies have reported three main mechanisms of SDF solutions in preventing and treating dental caries. These three effects are as follows; (Zhao et al., 2018)

1. Bactericidal effect on *S.mutans* and other cariogenic bacteria,
2. Remineralization, inhibition of enamel and dentin demineralization,
3. Reduction of dentin collagen matrix degradation through collagenase inhibition.

In addition, some of the efficacy of SDF is due to the fluoride activity released during application (Chibinski et al., 2017). When apply SDF to tooth, it respond with hydroxyapatite to create silver phosphate and calcium fluoride. Affairs as a reservoir for fluoride and phosphate ions to provide remineralization. And under microbial acid attack, fluoride interacts with hydroxyapatite crystals over tooth surface to prevent demineralization (Lou et al., 2011). Between SDF and hydroxyapatite reaction additionally causes the formation of silver nanoparticles dependent hydroxyapatite crystals (Tjäderhane et al., 2013).

It is uncertain whether any activity is the result of SDF's silver or fluoride component. Since the clinical efficacy of SDF is greater than only topical fluoride, thought that the antimicrobial effect of silver ion is contribute significantly to anti-cariogenic activity of SDF (Lansdown, 2006).

Fluoride and silver act synergistically to form fluorapatite. The first stage is the formation of calcium fluoride and silver phosphate. The next stage is the decomposition of calcium and fluoride. The final stage is the formation of fluorapatite. In vitro studies have shown that silver diamine fluoride penetrates the enamel up to 25 µm; it has almost 2-3 times further fluoride retention than sodium fluoride-phosphate, sodium fluoride, and stannous fluoride. Based on this, it was stated that SDF would be more effective than sodium fluoride and stannous fluoride (Rosenblatt et al., 2009).

SDF;

- Occludes dentin tubules,
- Enhancement mineral concentration and rigidity,
- Creates fluorohydroxyapatite, silver phosphate, silver-protein conjugates,
- Antimicrobial effect: Prevents biofilm adhesion, inhibits DNA replication with break down cell walls, denatures proteins,
- • Penetrates the tooth construction (Enamel: ~ 25 microns, Dentin: 200-300 micron) (Cohen et al., 2020).

Most of the clinical studies in the literature used 38% SDF solution and it is the recommended SDF strength to obtain better results (Cohen et al., 2020). The clinical efficacy of a 38% SDF solution in stopping caries and preventing dental caries of primary teeth in stopping root caries in adults has been consistently supported by all systematic reviews (MacLean, 2018). A 38% SDF solution has in it 44,800ppm fluoride and 255,000ppm silver ions (Cohen et al., 2020).

- 25% Silver – antimicrobial
- 8% Ammonia. – solvent
- 5% Fluoride. – remineralization

1.1. Main Effects

1. Stop cavities
2. Prevent tooth decay
3. Reducing tooth sensitivity

SDF helps reduce emergency visits for children with ECC while on treatment waiting lists. That confirming the effect for stopping caries in primary teeth of SDF (Thomas et al., 2020). SDF has been reported to be a practical and efficient treatment for caries in primary molars in children of indigenous communities (Roberts-Thomson et al., 2019).

It has been reported that using SDF solution is 89% further effective in managing/stopping dental caries according as other treatments either placebos. The status of evidence was rated as high (Chibinski et al., 2017).

2. SDFs USED AROUND THE WORLD

- Fagamin %38
- e-SDF %38
- Cariestop %12, %30
- Saforide %38
- Advantage Arrest %38
- Topamine %38
- Riva Star (SDF+KI)

3. SDF CLINICAL USE

Cases requiring clinical use of SDF:

- Patient before cooperation
- Avoiding or delaying deep sedation either general anesthesia (GA)
- Initial caries, which includes interproximal areas
- Saving time
- Root decays
- Furcations
- Molar incisor hypomineralization (MIH)
- Indirect pulp treatment, an application under the crown
- Recurrent caries

- Crown and restoration margins
- Particular needs
- Without access to treatment (Trieu et al., 2019)

SDF with accurate diagnosis and suitable treatment planning be able to an unavoidable tool for each ‘minimally invasive pediatric dentistry’ (MIPD) and ‘aerosol free dentistry’ (AFD), particularly during pandemic (Soni et al., 2021). The current COVID-19 pandemic calls for a shift from traditional dentistry to a minimal invasive and aerosol free but at the same time maximally effectual clinical practice. SDF be able to used effectually and efficiently in several behavioral types and age categories of kids in different clinical scenarios for both primary and permanent teeth, which is common practice in a pediatric dental office, particularly in the time of this pandemic period (Soni et al., 2021).

3.1. Case Selection

1. Patients in the high risk group for dental caries
2. Patients who can not allow common treatment for mental or medical causes: Pre-cooperative kids, mentally or physically disabled patients, dental phobias, immunocompromised patients
3. Patients who have more dental caries that can't be treated in a single call: Multiple quadrants
4. Lesions that are hard to treat like root cavities
5. Patients with no attainment to dental treatment (Seifo et al., 2020).

3.2. Materials that should be included in the SDF application kit:

- Silver Diamine Fluoride
- Disposable godets
- Micro brushes
- Vaseline
- Cotton swabs
- Cotton cylinder
- Dry Angles
- Gauze (2x2)
- Dental floss
- Patient gown/ tray cover

- Safety glasses
- Fluoride varnish
- Bite block (Jeremy & Horst, 2016)

3.3. Clinical Practice Procedure

1. Patient/Clinical conservation; safety glasses, patient gown, table cover
2. Applying vaseline to the perioral region
3. Brushing the teeth
4. Ensuring the isolation of the tooth
5. Drying
6. Application of SDF by a micro brush for 1 to 3 minutes
 - A disposable godet should be used
 - Care should be taken to apply just to the wanted tooth(s)
 - The lesion surface is saturated and allowed to be absorbed through capillary act
7. Coating with fluoride varnish (optional) (Jeremy & Horst, 2016)

FV is not required for the proven efficacy of SDF alone. No clinical studies (yet) have compared SDF with or without FV. FV masks the bad taste and improves the patient experience. It keeps the SDF where we applied it, helping to prevent unwanted stains on other surfaces (Jeremy & Horst, 2016).

3.4. Frequency of Application

Clinical evidence; until the tooth is restored or falls out, and perhaps indefinitely; supports the ongoing SDF application 1-2 times a year (Horst et al., 2016).

- It should not be applied more than once a week.
- Twice-yearly application is most effective for unrestored caries lesions.
- It can be applied as needed for hypersensitivity.
- It is reassessed and reapplied attached to the magnitude and place of the caries and the patient's level of risk. (2-4 weeks for cavitated dental caries, 6 months for initial caries 1)

- Once the restoration is made, once the lesion is bright, firm, hard and also asymptomatic, continue applying SDF is not necessity (Pradeepika Liyana Arachchige et al., 2021).

4. PARENTAL ACCEPTANCE OF SDF

The most frequently reported barrier to SDF use was parental acceptance (91.8%) (Nelson et al., 2016).

It is thought that parents will refuse it because of weak aesthetics, but many parents prefer the SDF applications (Horst, 2018). Although parents found SDF staining on the anterior teeth to be aesthetically unacceptable, 70-76% reported that they preferred this treatment option to advanced behavioral techniques (Crystal et al., 2017). Parents' acceptance of treatment varies according to their socioeconomic status (Crystal et al., 2017).

5. POSSIBLE PROBLEMS

- Silver allergy
- Mouth sores – soft tissue should be covered with Vaseline and contact should be avoided.
- Patient/parent should be informed about the possibility of accidental staining of soft tissue. It should be informed that the disappearance of a henna-like stain may take between 2 days and 2 weeks.
- Provided that SDF comes into touch with gingivitis, inflamed tissue or tongue, can cause feeling like burning because of ammonia.
- Metallic taste – can disappear quickly with help fluoride varnish or xylitol lollipops.
- It will permanently stain active caries. Healthy tooth structure does not change color. Discolored tooth can be restored with dental fillings or crowns.
- Restorations may also discolored when SDF is contact to them. Normally this discoloration is nonpermanent and be able to polished (Lavanya et al., 2020).

6. TOXICITY

SDF has a large margin of safety when the appropriate dosage of 1 drop per 10 kg per visit is followed (Featherstone, 2000). Attached to the size and position of the caries, 1 drop SDF solution can treat 6 teeth. 1 drop solution per 10kg weight of body, at maximum weekly intervals, is considered a safe dose. Possible Toxic Dose for fluoride = 5 mg/kg (Crystal & Niederman, 2016).

In one visit, SDF and fluoride varnish be able to applied safely (Crystal & Niederman, 2016).

- 1 drop solution of SDF has only 2.24 mg fluoride content (11.3 mg in 5% fluoride varnish)
- 1 drop of SDF + 5% varnish = 13.54 mg fluoride

7. EXTENDED CLINICAL USE OF SDF

7.1. SDF + Deep Caries

The use of SDF in deep lesions is not contraindicated. Irreversible pulpitis is a contraindication (Griffith, 2021).

In the study of Griffith, in which 227 permanent deep caries teeth were treated with SDF, silver fluoride showed the pulp protection capacity in this series of 277 teeth with very deep caries, only 13 teeth required endodontic treatment. It has been successful in managing peri pulp caries with minimal admission to endodontics and asymptomatic clinical outcomes. SDF conferred both a primary preventative and secondary protection in controlling decay that was already underway (Griffith, 2021).

7.2. SDF + MIH

'Molar incisor hypomineralization' (MIH) is a clinically challenging case that occurs in 20% to 40% of children's newly erupted first molars. Revolutionizing the clinical approach to efficiently and effectively treating MIH molars is SDF and high viscosity glass ionomer cement (HVGIC) (MacLean, 2018).

SDF application tips in MIH cases

- Being aware of hypersensitivity
- Being careful while cleaning and rinsing
- To isolate and dry with 2x2 gauze or cotton rolls instead of compressed air.

- Knowing that there may be sensitivity when applying SDF
- Knowing that a second application may be required to desensitize (MacLean, 2018)

Grossi et al., assessed the continuity rates of 'glass hybrid restorations' placed with 'atraumatic restorative treatment' (ART) method where MIH affected 1st permanent molars; The MIH affected teeth' restorations success rate was evaluated using glass hybrid cement and protocol of ART. 'Fuji EQUIA Forte' used for restoration of teeth by using 'GC cavity conditioner' and 'Fuji Coat'. The success of the restorations was found to be 98% after 12 month follow up (Grossi et al., 2018).

7.3. Potassium Iodide (KI)

Treatment of SDF+KI stops the evolution of secondary caries in Glass Ionomer Cement (GIC) restorations, however alone SDF treatment is more effective. In addition, treatment of SDF+KI causes a perceivable staining but less than SDF alone (Irene et al., 2017).

Teeth placed with KI are approximately twice as likely to be pulpally affected. The use of KI reduces spotting, but also reduces the chances of stopping caries (Turton et al., 2021).

8. BONDING OF RESTORATION IN SDF TREATED TEETH

- There is not any difference treated dentin with SDF both primary and permanent teeth in the the composite's bond strength (Quock et al., 2012; Wu et al., 2016).
- SDF does not negatively act between GIC and decayed primary teeth dentin's bond strength (Puwanawiroi et al., 2018; Ng et al., 2020). The strongest bond strength was found when GIC was placed on demineralized dentine treated with SDF 1 week ago and applied cavity preparation (Ng et al., 2020).
- Improvements in bonding properties were observed in fissure sealants applied after SDF application (Pérez-Hernández et al., 2018).

9. SMART = 'SILVER MODIFIED ATRAUMATIC RESTORATIVE TREATMENT'

Technique of SMART combines 2 materials. First, carious dentin treated with SDF. After that, restores with a GIC. SDF is used to stop and remineralize caries, GIC used for restoration and remineralization (Natarajan, 2022).

SDF can remineralize progressive dentin caries lesions which restored GIC after treated 1-2 applications of SDF solution, in synthetic saliva. This procedure is a potentially effective treatment on lesions that traditional restorations requires removal of significant dental tissue with traumatic procedures (Panahpour Eslami, 2021).

9.1. Benefits of SMART

- SDF as initial therapy in a non-cooperative or anxious patient; being fast, simple, painless, starting treatment in the examination, creating comfort and confidence in dental environments, saving time, eliminating the need for local anesthetics and/or hand tools, delaying or preventing the need for sedation, reducing sensitivity in teeth with MIH, indirect pulp treatment, comforting the tooth and the patient

- Creating an atraumatic, positive dental experience and appearance
- Reducing stress for patient, parent and dentist
- Prolonged fluoride release to help reduce recurrent caries
- Restoring SDF-arrested lesions in fissures and cavitations improves biofilm clearance and eliminates the need to keep reapplying SDF
- Patient-centered care (Alvear et al., 2016).

CONCLUSION

- SDF is protected and effective.
- SDF solution is more efficient than varnish containing fluoride.
- SDF is more efficient than 'Interim Therapeutic Restoration' (ITR).
- The most effective treatment is apply SDF two times in a year.
- SDF treatment stops 80% of the caries.
- Escalates accessibility, improves health, lowers cost.

Public awareness, popularity, and demand for minimally invasive treatment options such as SDF are increasing. Although blackish discoloration of treated lesions is an aesthetic concern, it is accepted by many compared to the advantages and ease of use of SDF.

Unlike other fluoride products, which are mainly effective on preventing the structure of new dental caries, 38% SDF has the ability to effectively stopping the caries. The reason is the synergistic effect of silver ions and fluorine ions. Multiple randomized controlled studies and systematic reviews confirm the effectiveness of SDF when used at a concentration of 38%.

The versatility of SDF, the minimal equipment required for the dentist, its ease of application and the fact that it is an aerosol-free, painless treatment option for the child make it an important tool for pediatric dentists, especially during the COVID-19 pandemic. It is observed that the global research interest in SDF has increased rapidly in the last five years.

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