Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.06.021

A comparison of the efficiency of silver diamine fluoride liquid and gel against organisms causing dental caries - An in vitro study

Ivan Obadiah[1], Ganesh Jeevanandan[2*], S Rajeshkumar[3]

[1]Saveetha Dental college and hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai 600077.

[2]Reader, Department of Pediatric and Preventive dentistry, Saveetha Dental college and hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai 600077.

[3]Associate Professor, Dept. of Pharmacology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai - 600077.

***Corresponding author:** Ganesh Jeevanandan, Reader, Department of Pediatric and Preventive dentistry, Saveetha Dental college and hospitals, Saveetha Institute of Medical and Technical sciences, Saveetha University, Chennai 600077, Email: helloganz@gmail.com

Submitted: 13 February 2023; Accepted: 25 March 2023; Published: 03 April 2023

ABSTRACT

Minimally invasive dentistry is gaining its momentum in recent years as it requires less patient cooperation and less operator efforts. Silver diamine fluoride application is one of the recently introduced approaches in controlling caries progression, especially in early childhood caries (ECC). The chief objective of this study is to correlate the antimicrobial activity of SDF liquid of two different commercial brands and also with SDF gel against the cariogenic microorganisms S. mutans, L. acidophilus and A. comitans. Three similar aliquots of 107 CFU/mL of every organism were incubated after mixing, in a brain-heart infusion broth anaerobically at 37°C f. For S. mutans and L. acidophilus the broths were incubated for 24 hours and A. naeslundii was incubated for 48 hours. The agar plates used for Streptococci, Lactobacilli and Actinomycetes identification were Mitis Salivarius, Rogosa and Actinomyces. The zone of inhibition of each plate were measured for different SDF preparations in millimeters.The anticariogenic activity of all the three SDF preparations were similar and not statistically significant. Overall performance of FAgamin SDF solution was better than the other two preparations.

Keywords: *efficiency, silver, organisms, dental*

INTRODUCTION

Dental caries is a multi-factorial infectious disease. The most common etiology for the occurrence of dental caries is the interaction between the dental plaque , the high sugar diet and the susceptibility of the host (1). The fluid from the dental plaque has also been found highly responsible for the incidence of dental caries (2).

It is of high importance to prevent or intervene the progression of dental caries at an early stage as the damage it can cause to the oral health and also to the quality of life of the individual is cumulative over time (3). There available several methods and preventive plans to avoid the incidence of dental caries and the most popular and successful method is the control of biofilm

along with proper diet and periodic application of fluorides(3). In the dentin, caries progression is characterized by the demineralization of the minerals and also degradation of the organic matrix of type 1 collagen fibre network(4). This is in contrast to that happening in enamel, where the bacterial acids cause dissolution by attacking the highly mineralised tissues(5).

Throughout years, there were lots of topical and systemic agents introduced and studied over dental caries prevention. For centuries, the antibacterial effect of silver in water storage and purification, milk storage is well known among the public(6). In general medicine, the antibacterial efficacy of silver and silver compounds have been used in various contexts such as in soft tissue wound care(7), reconstructive osseous surgeries(8) and in cardiac devices(9).The three suggested antibacterial mechanisms of silver are : 1. Cellular respiration prevention: Silver ions bind to bacterial cell surfaces nonspecifically, causing membrane transport functions to malfunction; this disruption then allows the penetration of microbes by silver ions.(10) 2. Cell division (reproduction) Inhibition: Silver ions react with deoxyribonucleic acid base pairs ,preventing replication (11).3. Cell metabolism Disruption : Silver ions are highly reactive and bind readily to thiol groups (SH). The organism's energy system is thereby disrupted, causing lack of maintenance of osmotic pressure, and this leads to death by vital substrate leakage,(12). Silver diamine fluoride application is one of the recently introduced approaches in controlling caries progression, especially in early childhood caries (ECC) (13). It was found that SDF forms calcium fluoride and silver phosphate reacting with the hydroxyapatite crystals of the tooth thereby responsible for caries arrest.(14). Both 12% and 38% SDF is found to exhibit similar antibacterial effects against cariogenic microorganisms in pediatric dental patients(3). Our team has extensive knowledge and research experience that has translate into high quality publications. (15-24) The aim of this study is to compare the antibacterial activity of SDF liquid of two different commercial brands and also with SDF gel against the cariogenic microorganisms S. mutans, L. acidophilus and A. comitans.

MATERIALS AND METHODS

This in vitro study was carried after getting attestation from the institutional review committee. The three different preparations of silver diamine fluoride were

FAgamin SDF solution(Tedequim, Argentina), Kidz-e SDF solution(Kidz-e dental, India) and Kedo SDF gel(Kedo dental, India). Streptococcus mutans ATCC (American Type Culture Collection) 35668, Lactobacillus acidophilus ATCC 9224, and Actinomyces naeslundii ATCC 12014 - three species of cariogenic bacteria that are common, were selected for the study. Three similar aliquots of 107 CFU/mL of every organism were incubated after mixing, in a brain-heart infusion broth anaerobically at 37°C f. For S. mutans and L. acidophilus the broths were incubated for 24 hours and A. naeslundii was incubated for 48 hours. The agar plates used for Streptococci, Lactobacilli and Actinomycetes identification were Mitis Salivarius, Rogosa and Actinomyces. Each bacterial media contained 25µl, 50µl and 100µl preparations respectively. The zone of inhibition of each plate were measured for different SDF preparations in millimeters. Data was tabulated and statistical analysis was done using SPSS (IBM version 23) software.

RESULTS

Against S. mutans, Kidz-e SDF solution performed well in 25 µl and 50 µl preparations and Fagamin SDF solution was better in 100 µl concentration (Table 1). Similar results were obtained against Lactobacili i.e, Kidz-e SDF solution performed well in 25 µl and 50 µl preparations and Fagamin SDF solution was better in 100 µl concentration (Graph 1) . Kedo SDF gel performed better than both the liquid preparations against Actinomyces naeslundii (Figure 1). All these performances by the different SDF preparations were clinically evident in the variations in the measurements of zone of inhibition, yet statistically in-significant ($p>0.005$)

DISCUSSION

Dental caries is one of the most challenging and rapidly spreading diseases especially in children (25). Sound knowledge about its etiology, particularly microbiological pathogenesis is much needed to approach the disease in an efficient way(26). Minimally invasive dentistry is gaining its momentum in recent years as it requires less patient cooperation and less operator efforts(27).

Reichi Yamaga, Misuho Nishino, and colleagues developed Silver diamine Fluoride(SDF) to prevent and treat dental caries. The Japanese FDA approved SDF in 1970. SDF is colorless liquid, and has a pH of 10, 5.0-5.9% fluoride which is 44,800 ppm, 24.4-28.8% which is 253, 870 ppm of silver and ammonia. The alkalinity of this solution is responsible for the formation of covalent bonds of phosphate groups to grown onto proteins and crystallites(14).Among the most common SDF concentrations used in caries management, 38% was the most common. However, concentrations of 30% and 12% were also used. In laboratory

studies, it was found that SDF at a concentration of 38% inhibited collagenase activity and prevented collagen degradation more effectively than SDF with a concentration of less than 38%(28). SDF treated dentin surfaces had significantly less growth of Streptococcus mutans when compared to the control group (29). After application of SDF, the numbers of colony-forming units (CFUs) of monospecies of S. mutans and Actinomyces naeslundii decreased, with very few living bacteria found after application.(30). As a result of the application of SDF, surfaces of demineralised teeth become black(31); sScientists have proposed using potassium iodide to reduce the staining effect of SDF by generating silver iodide after topical application(29). Compared with controls treated with deionised water, carious lesions treated with SDF showed significantly higher surface microhardness, with a depth of approximately 150 *m(32). The effect of SDF on demineralised enamel surfaces was clearly demonstrated using photo-microscopy of polarised light-treated enamel surfaces as compared to those without SDF In experimental animals, either species alone induces periodontal disease and dental caries treatment(33). Through inhibition of the proteolytic activities of MMP-2, MMP-8, and MMP-9, SDF inhibited matrix metalloproteinases (MMPs), which play a vital role in collagen degradation.(34). The relationship between lactobacilli and dental caries is well established; Lactobacilli are also found in the mouths of breastfed infants, while they are seldom found in bottle-fed infants

The gram-positive, facultatively anaerobic streptococcus mutans (round bacterium) is often found in the oral cavity of humans, and it significantly contributes to oral and systemic diseases(35). . Following weaning and prior to tooth emergence, infants have relatively few lactobacilli in their mouths . Once teeth develop, the occlusal fissures may be suitable receptive sites for lactobacilli colonization. Dental caries is caused by Actinomyces naeslundii and Actinomyces viscosus (36). In experimental animals, either species alone induces periodontal disease and dental caries (37). Specifically, these two bacteria have been implicated in root surface caries in humans (38). In this study three different brands of SDF were compared. Two SDF solutions (Fagamin, Kidz-e) and a gel preparation (Kedo). The zone of inhibition of each material against S. mutans, L. acidophilus, A. naeslundii were not statistically significant. Against S. mutans, Kidz-e SDF solution performed well in 25 µl and 50 µl preparations and Fagamin SDF solution was better in 100 µl concentration. Similar results were obtained against Lactobacili i.e, Kidz-e SDF solution performed well in 25 µl and 50 µl preparations and Fagamin SDF solution was better in 100 µl concentration. Kedo SDF gel performed better than both the liquid preparations against Actinomyces naeslundii. Furthermore, invivo clinical studies are required to elaborate the anticariogenic activity of SDF against various bacterial strains.

CONCLUSION

The anticariogenic activity of all the three SDF preparations were similar and not statistically significant. Overall performance of Fagamin SDF solution was better than the other two preparations.

J Popul Ther Clin Pharmacol Vol 30(6):e157–e162; 03 April 2023.

CONFLICT OF INTEREST

No conflict of interests were declared by the authors.

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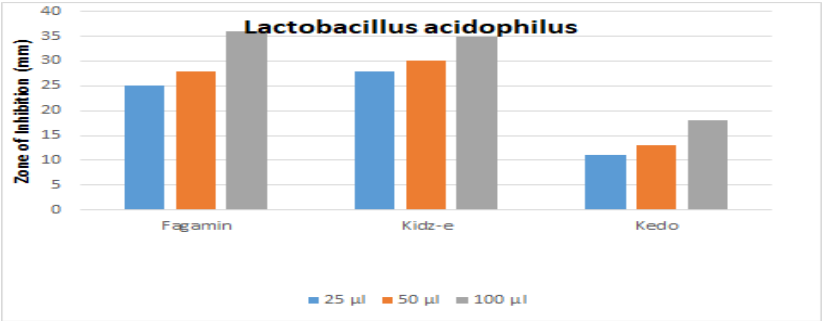
TABLE 1 : Sdf Preparations Against S.Mutans

S.mutans	Fagamin	Kidz-e	Kedo
25 microliters	25mm	35mm	12mm
50 microliters	32mm	36mm	14mm
100 microliters	40mm	38mm	28mm



GRAPH 1: SDF preparations against Lactobacillus acidophilus

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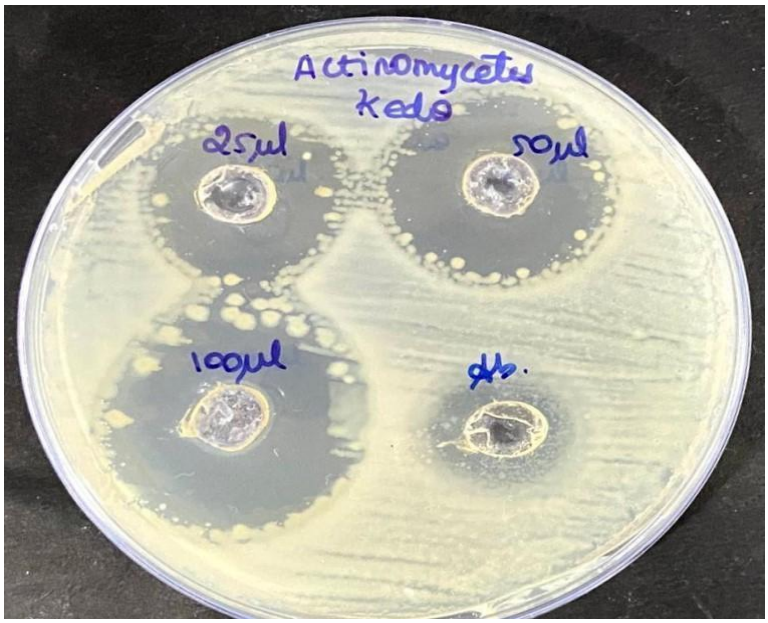

FIGURE 1: Kedo SDF gel against A.naeslundii