Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2021; 21:e0230
https://doi.org/10.1590/pboci.2021.158
ISSN 1519-0501 / eISSN 1983-4632

ORIGINAL ARTICLE

Silver Diamine Fluoride *versus* Bioactive Giomer Light-Curing Varnish: An *In Vitro* Study on Caries Arrest

Maressa Borges dos Reis[1], Monique Gonçalves D´Alessandro[1], Kenia Aparecida Freitas Moraes[1], Suéllen Peixoto de Medeiros Urquiza[1], Bruna Lorena Pereira Moro[2], Tamara Kerber Tedesco[3], José Carlos Pettorossi Imparato[1]

[1]Graduate Program in Dentistry, São Leopoldo Mandic Faculty, Campinas, SP, Brazil.
[2]Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, São Paulo University, São Paulo, SP, Brazil.
[3]Graduate Program in Dentistry, Cruzeiro do Sul University, São Paulo, SP, Brazil.

Correspondence: Maressa Borges dos Reis, Instituto de Pesquisa São Leopoldo Mandic, Campinas, SP, Brazil. **E-mail:** maressaborgesodontologia@gmail.com

Academic Editor: Alidianne Fábia Cabral Cavalcanti

Received: 29 October 2020 / **Review:** 21 May 2021 / **Accepted:** 10 June 2021

How to cite: Reis MB, D´Alessandro MG, Moraes KAF, Urquiza SPM, Moro BLP, Tedesco TK, et al. Silver diamine fluoride *versus* bioactive giomer light-curing varnish: an *in vitro* study on caries arrest. Pesqui Bras Odontopediatria Clín Integr. 2021; 21:e0230. https://doi.org/10.1590/pboci.2021.158

ABSTRACT

Objective: To compare the capacity of silver diamine fluoride (30%) and the bioactive giomer light-curing varnish for arresting ICDAS score 5 non-retentive caries lesions. **Material and Methods:** An *in vitro* analytical study was conducted using 36 healthy primary teeth, in which a cavity was created, divided into 3 groups: control (distilled and deionized water), giomer-based light-curing varnish - Barrier Coat, and Silver Diamine Fluoride 30% – Cariestop (SDF). The samples were analyzed for mineral loss as measured by surface microhardness (SMH). The Knoop microhardness test was performed using the HVS-1000 microhardness tester. The data were compared by two-way analysis of variance – treatment and time (before and after treatment) followed by Tukey's post-test. The significance level adopted in all analyzes was 5%. **Results:** The specimens treated with giomer showed higher SMH compared to the untreated group but were similar to those of the SDF group. The SDF group, on the other hand, showed no statistically significant difference from the control group (p=0.010). **Conclusion:** The giomer varnish had a remineralizing effect on artificial dentinal caries.

Keywords: Dental Caries; Fluorides; Mechanical Tests; Hardness Tests; Dentin.

Introduction

Dental caries remains a global health problem and is considered one of the most common chronic diseases in the world [1,2]. The most affected population is young children, and their cooperation during restorative procedures is not always satisfactory. Therefore, alternative, easy-to-perform, and cost-effective treatments are indicated to treat dental caries in children [3,4]. Recently, there has been a greater interest in non-invasive treatments, and studies show their comparable efficacy with conventional restorative methods [5,6].

The 30% Silver Diamine Fluoride (SDF) is a medication used for caries arrest, whose mechanism of action is based on its ability to increase enamel surface microhardness (SMH) and reduce mineral loss [1]. More than 20 clinical studies conducted worldwide have demonstrated the effectiveness of SDF in arresting caries [3]. In a recent systematic review, 38% SDF was shown to be effective in arresting lesions in primary teeth, with an overall success rate of 81%, suggesting that this may be a promising strategy for treating caries in young children or in patients with special needs [2]. However, a disadvantage is that the arrested caries is discolored brown-black.

With advances in Pediatric Dentistry, new materials have been developed to prevent caries lesions. The giomer varnish has the advantage of being aesthetically pleasing. It consists of a light-curing varnish composed of a resin-based material incorporated with the surface pre-reacted glass-ionomer (S-PRG) technology. Its bioactive functions are due to the gradual release of multiple ions, including sodium (Na+), aluminum (Al3+), borate (Bo3-), silicate (SiO2-), fluorine (F-), and strontium (Sr2+). Therefore, this technology can be advantageous for dental materials that require the release of fluoride ions for demineralization inhibition [6-10].

No study has compared the capacity of SDF and giomer varnish for dentin caries control. Therefore, this study aimed to compare the caries arrest capacity of 30% SDF and giomer light-curing varnish.

Material and Methods

Ethical Aspects

This *in vitro* study was approved by the Research Ethics Committee (CEP) of São Leopoldo Mandic Faculty, report number 3,575,656. The teeth used had been collected and authorized by a biorepository letter from São Leopoldo Mandic Faculty. The research complied with the ethical guidelines of Resolution No. 466/12.

Sample

Healthy primary teeth (incisors, canines and molars) lost due to normal exfoliation or extracted due to orthodontic purposes or prolonged retention were selected, immersed in distilled water, and stored in a refrigerator until use. Teeth with caries, cracks, enamel developmental defects and extrinsic or intrinsic stains were excluded.

For sample size calculation, a mean hardness value of 158 was considered for 30% SDF-treated enamel after cariogenic challenge and a value of 121.8 for untreated enamel [11]. With an effect size of 1.11, a significance level of 0.05, and a power of 0.80, a sample size of 12 specimens for each group was obtained, resulting in 36 specimens in total.

Teeth were cleaned with pumice stone and a Robinson brush at low rotation. Next, the roots were cut out with diamond disks (Microdont, São Paulo, SP, Brazil) and the tooth was fixed in a 1-inch high PVC tube

with JET acrylic resin (*Artigos Odontológicos Clássico*, São Paulo, SP, Brazil). Then, the specimens were sanded with a 180 grit sandpaper until dentin exposure, and then the surface was polished with 600- and 1200-grit sandpapers.

Artificial Dental Caries Protocol

Specimens were subjected to cariogenic challenge by individual immersion in 10 mL of demineralizing solution (2.2 mM $CaCl_2$, 2.2 mM NaH_2PO_4, 0.05 M acetic acid adjusted to pH 4.8 with 1 M KOH) for 8 hours, followed by immersion in 10 mL of remineralizing solution (1.5 mM $CaCl_2$, 0.9 mM NaH_2PO_4 and 0.15 mM KCl adjusted to pH 7.0) for 16 hours; the cycle was repeated for 14 days. The solutions were changed after each cycle and at each interval, the teeth were washed with distilled water and dried with sterile absorbent paper [12].

Randomization

The teeth were randomly allocated to three experimental groups according to the sequence obtained by a statistical software (Sealed Envelope Ltd., London, UK). The sequence was stored in sealed envelopes, which were opened only at the time of specimen preparation.

Specimen Treatments

The control group was immersed in distilled and deionized water. For the SDF group, 30% SDF - Cariestop (*Biodinâmica*, Ibiporã, PR, Brazil) was applied with a cotton swab for 2 min. After application, the blocks were washed with deionized water for approximately 30 seconds and lightly dried with absorbent paper. For the giomer group, a thin layer of the giomer light-curing varnish - PRG-Barrier Coat (Shofu Inc., Kyoto, Japan) was applied following the manufacturer's recommendations. The layer was light-cured with a LED unit for 10s, with a wavelength of 440-490 nm and an intensity of at least 1000 mw/cm^2. Then, the non-cured residual layer was removed gently with a cotton ball soaked in water.

Surface Microhardness Analysis (SMH)

The Knoop microhardness test was performed using the HVS-1000 microhardness tester (Pantec, São Paulo, SP, Brazil). Five indentations 100-µm equidistant from each other were performed on the dentin surface with a load of 5 g for 5 seconds [13]. The values for each sample were averaged and their mean was used for data analysis. Each specimen underwent 3 standardized tests performed by the same operator immediately after pH cycles and after 30 days of product application.

Statistical Analysis

The Kolmogorov-Smirnov test was used to verify the normality of the data distribution, and the Levene test was used to verify the homogeneity of the variances. The data were compared by two-way analysis of variance – treatment and time (before and after treatment) followed by Tukey's post-test. The significance level adopted in all analyzes was 5%. Analyzes were performed using the SPSS v25 software (SPSS Inc., Chicago, IL, USA).

Results

Table 1 shows the means and standard deviations for Knoop microhardness (KHN) of experimental groups. A statistically significant difference was found only for the treatment factor (p=0.01). However, the

interaction of treatment and time variables (p=0.547) was not significant. The giomer varnish-treated specimens showed higher SMH values compared to the untreated group, similar to the SDF group. On the other hand, the SDF group showed no significant difference from the control group.

Table 1. Mean and standard deviation of Knoop hardness values (KHN) according to the experimental group.

Time-point	Treatment		
	Giomer-Based Varnish	30% Silver Diamine Fluoride	Control
Immediately After pH Cycles	39.30 ± 9.07^{a,A}	36.10 ± 9.95^{a,b,A}	34.0 ± 8.37^{b,A}
30 Days After Treatment	45.9 ± 11.12^{a,B}	39.3 ± 7.31^{a,b,B}	34.8 ± 8.18^{b,A}

Different superscript lowercase letters indicate a significant difference among treatments regardless of the time-point (columns). Different superscript capital letters indicate a significant difference between time-points for each treatment (lines).

Discussion

The giomer-based varnish and the 30% SDF increased the microhardness values compared to the control group in non-retentive ICDAS 5 caries, suggesting tissue remineralization, and showed to be effective for caries arrest. The microhardness of the SDF group was higher than the control group but not statistically different. The microhardness of the giomer group was significantly higher than the SDF, thus indicating a higher remineralizing effect.

Although SDF at 30% is known to be effective for early childhood caries control, used especially in less cooperative children [14], its clinical use is limited by adverse effects, such as caries discoloration, which may affect aesthetically demanding patients [15,16]. The giomer varnish was shown to be as equally effective as SDF in increasing the microhardness of the tissue without causing discoloration.

According to the manufacturer, the giomer varnish protects the dental tissue from external irritants for over 6 months, releases and recharges fluoride ions, has self-adhesive properties that allow the application of a thin layer to any surface with good esthetic results (15 μm), and has an acid-neutralizing and anti-plaque effect. One of its many indications is for enamel white spots. Although not yet officially indicated for caries arrest, this *in vitro* study proved that it might control dentin caries and remineralize the tissue. This is probably due to the fluoride release and acid buffering properties of the material. However, the mechanism of action of this material in arresting dentin caries remains unclear. It is known that the hardness of the varnish layer can influence and mask the dentin remineralization results, but the samples were immersed in artificial saliva for 30 days after product application without retention of the material in the second hardness measurement. Therefore, the authors believe that the substance did not affect the dentin hardness measurements.

On the other hand, 30% SDF prevents and controls caries in primary and permanent teeth [17,18] by inhibiting plaque formation and decreasing the acid production by bacteria. The silver ions in SDF alter hydrogen bonding, inhibiting respiratory processes, cell wall synthesis, and cell division. In addition, SDF increases enamel resistance by reacting with the mineral component of the tooth, forming fluorapatite and obliterates dentinal tubules blocking the diffusion of acids and bacteria [19-24]. The application of the product is non-invasive, cost-effective, and easy-to-perform. SDF has also been shown in laboratory studies to increase dentin resistance to demineralization [25]. The use of SDF can be an effective treatment option in public healthcare services, where often treatment options are limited [26].

Our results suggest that the giomer varnish may be a better anticaries agent for superficial, non-retentive lesions on anterior teeth because it resulted in higher dentine hardness than both the control group to the SDF group, and the color of remineralized tissue remains unchanged.

In vitro studies provide ideal control of the conditions and variables that could affect the results and high precision in measuring the relationships between variables [27]. However, their major limitation is the extrapolation of results to humans, as clinical conditions, such as oral microbiota, presence of saliva, and contact with food and microorganisms, cannot be reproduced. Although microhardness is not the gold standard for measuring remineralization, it is widely used because it reflects mineral gain or loss, which can be extrapolated to demineralization or remineralization of substrates. Another limitation of this study was the relatively short observation period. A longer follow-up could be more representative of a clinical situation.

The silver nanoparticles in SDF have strong antibacterial and anti-biofilm properties, providing effective and long-lasting protection against bacteria [28,29]. However, the mechanism of caries arrest by the giomer varnish is unclear, and further studies should be conducted to evaluate this mechanism of action and assess the acceptability and cost of this material compared to other treatments.

Conclusion

The giomer-based light-cured varnish had a remineralizing effect on experimental dentinal caries.

Authors' Contributions

MBR	https://orcid.org/0000-0003-2783-5625	Conceptualization, Methodology, Investigation and Writing - Original Draft.
MGD	https://orcid.org/0000-0001-7769-7836	Methodology, Investigation and Writing - Review and Editing.
KAFM	https://orcid.org/0000-0003-4279-6206	Methodology, Investigation and Writing - Review and Editing.
SPMU	https://orcid.org/0000-0003-2764-9654	Conceptualization, Methodology, Investigation and Writing - Review and Editing.
BLPM	https://orcid.org/0000-0003-1859-1702	Conceptualization, Formal Analysis and Writing - Review and Editing.
TKT	https://orcid.org/0000-0003-0794-1578	Conceptualization, Formal Analysis and Writing - Review and Editing.
JCPI	https://orcid.org/0000-0002-1990-2851	Conceptualization and Writing - Review and Editing.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Mohammadi N, Farahmand Far MH. Effect of fluoridated varnish and silver diamine fluoride on enamel demineralization resistance in primary dentition. J Indian Soc Pedod Prev Dent 2018; 36(3):257-61. https://doi.org/10.4103/JISPPD.JISPPD_4_18

[2] Gao SS, Zhao IS, Hiraishi N, Duangthip D, Mei ML, Lo ECM, et al. Clinical trials of silver diamine fluoride in arresting caries among children: a systematic review. JDR Clin Trans Res 2016; 1(3):201-10. https://doi.org/10.1177/2380084416661474

[3] Burgess JO, Vaghela PM. Silver diamine fluoride: a successful anticarious solution with limits. Adv Dent Res 2018; 29(1):131-4. https://doi.org/10.1177/0022034517740123

[4] Fung MHT, Duangthip D, Wong MCM, Lo ECM, Chu CH. Randomized clinical trial of 12% and 38% silver diamine fluoride treatment. J Dent Res 2018; 97(2):171-8. https://doi.org/10.1177/0022034517728496

[5] Hu S, Meyer B, Duggal M. A silver renaissance in dentistry. Eur Arch Paediatr Dent 2018; 19(4):221-7. https://doi.org/10.1007/s40368-018-0363-7

[6] Alsayed EZ, Hariri I, Nakashima S, Shimada Y, Bakhsh TA, Tagami J, et al. Effects of coating materials on nanoindentation hardness of enamel and adjacent areas. Dent Mater 2016; 32(6):807-16. https://doi.org/10.1016/j.dental.2016.03.023

[7] Rabiabasree R, Krishnakumar R, Prabhu AS, Naik NS, Shashibhushan KK, Janarthanan K. Inhibitory effect of a resin coat-containing prereacted glass fillers on the enamel demineralization of the primary teeth: An in vitro pilot study. J Indian Soc Pedod Prev Dent 2019; 37(2):146-50. https://doi.org/10.4103/JISPPD.JISPPD_309_18

[8] Arita S, Suzuki M, Kazama-Koide M, Shinkai K. Shear bond strengths of tooth coating materials including the experimental materials contained various amounts of multi-ion releasing fillers and their effects for preventing dentin demineralization. Odontology 2017; 105(4):426-36. https://doi.org/10.1007/s10266-016-0290-1

[9] Ma S, Imazato S, Chen JH, Mayanagi G, Takahashi N, Ishimoto T, et al. Effects of a coating resin containing S-PRG filler to prevent demineralization of root surfaces. Dent Mater J 2012; 31(6):909-15. https://doi.org/10.4012/dmj.2012-061

[10] Kotaku M, Murayama R, Shimamura Y, Takahashi F, Suzuki T, Kurokawa H, et al. Evaluation of the effects of fluoride-releasing varnish on dentin demineralization using optical coherence tomography. Dent Mater J 2014; 33(5):648-55. https://doi.org/10.4012/dmj.2014-072

[11] Delbem AC, Bergamaschi M, Sassaki KT, Cunha RF. Effect of fluoridated varnish and silver diamine fluoride solution on enamel demineralization: pH-cycling study. J Appl Oral Sci 2006; 14(2):88-92. https://doi.org/10.1590/s1678-77572006000200005

[12] Marquezan M, Corrêa FN, Sanabe ME, Rodrigues Filho LE, Hebling J, Guedes-Pinto AC, et al. Artificial methods of dentine caries induction: A hardness and morphological comparative study. Arch Oral Biol 2009; 54(12):1111-7. https://doi.org/10.1016/j.archoralbio.2009.09.007

[13] Vale GC, Tabchoury CP, Del Bel Cury AA, Tenuta LM, ten Cate JM, Cury JA. APF and dentifrice effect on root dentin demineralization and biofilm. J Dent Res 2011; 90(1):77-81. https://doi.org/10.1177/0022034510383428

[14] Chu CH, Lo EC. Promoting caries arrest in children with silver diamine fluoride: a review. Oral Health Prev Dent 2008; 6(4):315-21.

[15] Mei ML, Lo ECM, Chu CH. Arresting dentine caries with silver diamine fluoride: what's behind it? J Dent Res 2018; 97(7):751-8. https://doi.org/10.1177/0022034518774783

[16] Zhao IS, Yin IX, Mei ML, Lo ECM, Tang J, Li Q, et al. Remineralising dentine caries using sodium fluoride with silver nanoparticles: an in vitro study. Int J Nanomed 2020; 15:2829-39. https://doi.org/10.2147/IJN.S247550

[17] Zhao IS, Gao SS, Hiraishi N, Burrow MF, Duangthip D, Mei ML, et al. Mechanisms of silver diamine fluoride on arresting caries: a literature review. Int Dent J 2018; 68(2):67-76. https://doi.org/10.1111/idj.12320

[18] Gao SS, Chen KJ, Duangthip D, Wong MCM, Lo ECM, Chu CH. Preventing early childhood caries with silver diamine fluoride: study protocol for a randomised clinical trial. Trials 2020; 21(1):140. https://doi.org/10.1186/s13063-020-4088-7

[19] Ando T. Indicações do uso do diaminofluoreto de prata (Saforide) em odontopediatria. RGO 1981; 29(1):48-9. [In Portuguese].

[20] Nishino M, Massler M. Immunization of caries susceptible pits and fissures with a diamine silver fluoride solution. J Pedod 1977; 2(1):16-25.

[21] Lansdown AB. Silver. I: Its antibacterial properties and mechanism of action. J Wound Care 2002; 11(4):125-30. https://doi.org/10.12968/jowc.2002.11.4.26389

[22] Lansdown AB. Silver in health care: antimicrobial effects and safety in use. Curr Probl Dermatol 2006; 33:17-34. https://doi.org/10.1159/000093928

[23] Wu MY, Suryanarayanan K, van Ooij WJ, Oerther DB. Using microbial genomics to evaluate the effectiveness of silver to prevent biofilm formation. Water Sci Technol 2007; 55(8-9):413-9. https://doi.org/10.2166/wst.2007.285

[24] Knight GM, McIntyre JM, Craig GG, Mulyani. Ion uptake into demineralized dentine from glass ionomer cement following pretreatment with silver fluoride and potassium iodide. Aust Dent J 2006; 51(3):237-41. https://doi.org/10.1111/j.1834-7819.2006.tb00435.x

[25] Zhao IS, Mei ML, Burrow MF, Lo EC, Chu CH. Prevention of secondary caries using silver diamine fluoride treatment and casein phosphopeptide-amorphous calcium phosphate modified glass-ionomer cement. J Dent 2017; (57):38-44. https://doi.org/10.1016/j.jdent.2016.12.001

[26] Wambier DS, Bosco VL. The use of cariostatic agents in pediatric dentistry. Rev Odontopediatr 1995; 4(1):35-41.

[27] Köche JC. Fundamentos de Metodologia Científica: Teoria da Ciência e Prática da Pesquisa. 19. ed. Porto Alegre: Vozes; 2001. [In Portuguese].

[28] de Almeida LF, Cavalcanti YW, Valença A. In vitro antibacterial activity of silver diamine fluoride in different concentrations. Acta Odontol Latinoam 2011; 24(2):127-31.

[29] Igarashi S. Antibacterial Effect of Ag(NH3)2F solution on Streptococcus mutans in plaque. Jpn J Paediatr Dent 1978; (1):1-18.