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Original Research

Assessment of Various application times of diamine silver fluoride desensitizing solution on Dentin hydraulic conductance

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ABSTRACT:
Background and Aim: Dentin sensitivity can be reduced through the formation of intratubular crystals from minerals from saliva or dentinal fluid, peritubular dentin formation, reparative dentin formation, and invasion of the tubules by bacteria or plasma proteins. Silver diamine fluoride application is new alternative treatments for dentin hypersensitivity. Present study was done with an aimed to evaluate the influence of the time of application of diamine silver fluoride on the hydraulic conductance of dentinal tubules. **Material and Methods:** The present study was conducted with a single-blind and randomized controlled design. The sample of this prospective experimental study included 90 healthy human third molars with indications of extraction in malocclusion. Groups of 15 dentin disks were obtained and divided in the following way. GC (no treatment), G1 (were actively treated with diamine silver fluoride for 15 s, e- sdf, Kids -e- dental LLP, India), G2 (30 s), G3 (60 s). Then, was measured hydraulic conductance of dentin. The rate of flow of the fluid through the dentin disks was measured by recording the initial position of a bubble of air inside a capillary in 20 min. **Results:** There is a statistically significant difference in hydraulic conductance between the control group and the samples treated with desensitizing solution based on diamine silver fluoride. There was no statistically significant difference between the groups treated with different application times of the desensitizing solution. **Conclusion:** Dentin hypersensitivity can effectively be reduced by utilization of silver diamine fluoride as a desensitization agent. Silver diamine fluoride has potential as a management for dentin hypersensitivity after instant application.
Key Words: Dentin hypersensitivity, Desensitizing Solution, Dentinal Tubules, Silver Diamine Fluoride

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INTRODUCTION

Dentin hypersensitivity, also known as sensitive teeth, is a common complaint.Tooth sensitivity to various stimuli, including cold air, has been explained by hydrodynamic changes within the dentinal tubules that activate intra-dental nerves.[1]Pain is the normal pulp response to exposed dentin. Dentinal hypersensitivity may be caused by several conditions such as a result of periodontal pathologies, trauma, dental bleaching, professional oral hygiene, acid foods and beverages, bad oral hygiene habits or incorrect brushing techniques with consequent gingival recessions, etc.[2, 3]

Dentin hypersensitivity affects eating, drinking, and even breathing. However, despite the pain, patients often do not take preventive action. Some studies have found that dentin hypersensitivity occurs in 25% to 40% of individuals, most often in men.[4]The pain mechanism underlying sensitive teeth have not yet been fully explained, but the most accepted theory is the hydrodynamic theory. According to this theory, the ideal solution is to reduce the flow of fluid in the dentin tubules, block the pulp response, or both.[5] Desensitizing agents can ease teeth hypersensitivity. One of the common desensitizing agents is silver diamine fluoride, a fluoride topical solution containing fluor and silver ions. Previous studieshave shown that topical application of silver diamine fluoride effectively reduces teeth pain for 24 hours to 7 days after treatment.[6, 7]

Dentin sensitivity can be reduced through the formation of intratubular crystals from minerals from saliva or dentinal fluid, peritubular dentin formation, reparative dentin formation, and invasion of the tubules by bacteria or plasma proteins.[8] The reduction of permeability through tubular occlusion is a methodthat is used by many of the existing desensitizing agents today for the treatment of sensitivity. The treatment is aimed at preventing the flow of dentinal fluid and the reduction of pain. This tubular occlusion can be generated by the deposit of salts or ions within the dentinal tubule and by precipitation of proteins or dentin sealant.[9]

Silver diamine fluoride (SDF) was approved in February 2017 in Canada for the prevention and arrest of dental caries but it has been used for many decades in other countries like Japan. The US FDA has approved SDF for the treatment of tooth hypersensitivity. It is available as 38% silver diamine fluoride in Canada and is applied as a topical agent making it less invasive than traditional procedures for treating caries; therefore, it is more appealing to younger patients or those with particular needs.SDF is believed to have antimicrobial properties while promoting remineralization. The literature has considered it as the "silver bullet" with relatively minimal adverse events, such as tooth discoloration and some gingival irritation[9-11]

SDF is a 38 percent silver diamine fluoride which is equivalent to five percent fluoride in a colorless liquid, with a pH of 10. The exact mechanism of SDF is not understood. It is theorized that fluoride ions act mainly on the tooth structure, while silver ions, like other heavy metals, are antimicrobial. It also is theorized that SDF reacts with hydroxyapatite in an alkaline environment to form calcium fluoride (CaF2) and silver phosphate as major reaction products. CaF_2 provides sufficient fluoride to form fluorapatite which is less soluble than hydroxyapatite in an acidic environment.A side effect is the discoloration of demineralized or cavitated surfaces. Patients and parents should be advised regarding the black staining of the lesions associated with the application of SDF.[12-14]

The required application time for the product to be effective is not clear. This study uses an in-vitro model to compare the hydraulic transdentinal conductance of disks of human dentin treated with different application times of desensitizer based on diamine silver fluoride. This work aimed to evaluate the influence of the time of application of diamine silver fluoride on the hydraulic conductance of dentinal tubules.

MATERIAL AND METHODS

The present study was conducted with a single-blind and randomized controlled design. The sample of this prospective experimental study included 90 healthy human third molars with indications of extraction in malocclusion. These were extracted from patients between 17 and 32 years of age.Ethical approval was taken from the institutional ethical committee and written informed consent was taken from all the participants.

Candidates were excluded if they were using any type of tooth desensitizer, had received a fluoride varnish treatment within the preceding month, or were taking prescription medications, aspirin, or non-steroidal anti-inflammatory drugs; women who were pregnant were also excluded. Individuals using smokeless tobacco or chewing coca leaves are also excluded. Individuals with known sensitivity to silver or other heavy-metal ions were excluded.

The teeth were disinfected for 24 h in a solution of 0.1% Thymol. Then, they were manually cleaned to remove all traces of periodontal ligament using curettes. The teeth were then preserved in 0.9% saline at room temperature. The teeth were etched with 35% orthophosphoric acid over all the enamel for 30 s. Then, they were washed for 60 s and dried to proceed with the application of a layer of cyanoacrylate. We then made cylindrical silicone molds, where the teeth were suspended in blocks of epoxy resin. These were left to spend 48 h to complete polymerization.

Etching with enamel acid was carried out to enable micromechanical adhesion of the enamel to the cyanoacrylate and to enhance bonding with the epoxy resin. Disks of dentin that were 1 mm ± 0.2 mm thick were cut in a cutting machine at 750 rpm under the intermittent load of 500 g and refrigeration. The cut disks were numbered and randomized for distribution in the study groups. Subsequently, the occlusal face of each disk of dentin was regularized with abrasive paper under circulating water to standardize the thickness, regularize the surface, andstandardize the smear layer. Finally, the disks were washed with an air/water spray for the 30s. The human dentin disks were treated on their occlusal faces with desensitization based on diamine silver fluoride. The following instructions from the manufacturer were

followed for the application of the desensitizing solution.
Groups of 15 dentin disks were obtained and divided in the following way.

- Control group: 15 dentin disks were etched with 35% orthophosphoric acid for 15 s and washed later with abundant water.
- Group 1: 15 dentin disks previously etched with 35% orthophosphoric acid were actively treated with diamine silver fluoride e- SDF (Kids -e- dental LLP, India) for 15 s using a micro brush,. Finally, the disks were washed with plenty of water.
- Group 2: 15 dentin disks previously etched with 35% orthophosphoric acid were actively treated with diamine silver fluoride e- SDF (Kids -e- dental LLP, India) for 30 s. Finally, the disks were washed with plenty of water.
- Group 3: 15 dentin disks previously etched with 35% orthophosphoric acid were actively treated with diamine silver fluoride e- SDF (Kids -e- dental LLP, India) for 60 s with a micro brush. Finally, the disks were washed with plenty of water.

In addition, two control groups were added to verify the operation of the device before placing the samples in the diffusion chamber.

- Positive control: Measurement of diskless dentin
- Negative control: Disk of resin epoxy.

The experimental model used was developed by Pashley et al. and modified and validated by Hevia et al.[4] The model is simple, inexpensive, and easy to mount, and it allows for measuring the hydraulic conductance of dentin. The rate of flow of the fluid through the dentin disks was measured by recording the initial position of a bubble of air inside a capillary. After 20min, it enters its final position, and the rate is measured in µl/min by visual observation. The hydraulic conductance (CH) corresponds to a formula that determines the permeability of the disks of dentin. The variable F corresponds to the flow rate of each experimental group. The variable A corresponds to the area of dentin exposed to the fluid. The variable P corresponds to the intrapulpal pressure, whose value corresponds to the height of the columnof distilled water (20 cm). The variable T is the time in minutes. The results for the hydraulic conductance are calculated using the following formula. CH= F / A*P*t The measurements of the exposed dentin from the disk area were calculated using Image J software, which is widely used in medicine, using a previous photographic record obtained with a Nikon p90 camera at a distance of 30 cm.[15]

STATISTICAL ANALYSIS

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to the data editor page of SPSS version 15 (SPSS Inc., Chicago, Illinois, USA). For all tests, confidence level and level of significance were set at 95% and 5% respectively.

RESULTS

The present study was done to evaluate the influence of the time of application of diamine silver fluoride on the hydraulic conductance of dentinal tubules.A total of 60 dentinal disks were included in the study. Each of the disks was of size 1 mm ± 0.2 mm thick. The disks were divided into 4 groups; one control group and three study groups. Each group consists of 15 dentinal disks. Each of the disks was analyzed using the Image J license software. The area of the disk was tabulated in table 1. The area was expressed in cm^2. The average area was found to be almost similar in all the groups and the difference was found to be statistically non-significant. The numbering of disks from Groups 1-3 has a random distribution due to the previous randomization.
The results for the hydraulic conductance are calculated using the following formula. CH= F A*P*t. The conductance values were tabulated in Table 2 below. With the Wilcoxon signed-rank test [Table 3], it was established that there is a statistically significant difference in hydraulic conductance between the control group and the samples treated with desensitizing solution based on diamine silver fluoride/potassium iodide. There was no statistically significant difference between the groups treated with different application times of the desensitizing solution.

Table 1: Average area of dentin disk of each group

	Control	G1	G2	G3
MEAN	**0.48**	**0.57**	**0.55**	**0.52**
SD	**0.12**	**0.11**	**0.12**	**0.14**

Table 2: Hydraulic conductance (CH) group expressed in µl/min* cm2

	Control	G1	G2	G3
MEAN	**0.04**	**0.005**	**0.004**	**0.003**
SD	**0.013**	**0.001**	**0.002**	**0.001**

Table 3: Wilcoxon sign for hydraulic conductance

Groups	Z	Significant
Control 1	-2.207	0.001
Control 2	-3.490	0.001
Control 3	-3.490	0.001
1-2	-2.32	0.65
1-3	-1.123	0.33
2-3	-1.12	0.23

DISCUSSION

Regardless of investigations of diverse essences and materials, to a great extent is still unidentified about the hypersensitivity of dentin. In regards to this, dental professionals need to build up new tactics for the management of dental hypersensitivity to develop the quality of life of patients.[14]

In a population with teeth sensitive to air, this trial demonstrated that a topical solution of diammine silver fluoride was more effective than a placebo in reducing tooth pain.The results, however, are consistent with those from similar studies of other desensitizers, such as self-administered 0.717% fluoride solution or fluoride varnish.[14,15, 16] In the fluoride solution study, the authors concluded that two one-minute applications reduced sensitivity to cold. Participants in the varnish study experienced a pain reduction in response to ice, but not to air, at 2 wks.

The results in this study showed thatcompounds formed by the desensitizing solution managed to decrease the permeability of dentin independently of the time applied. However, there was a statistically significant difference between the control group with no desensitizing solution treatment and the experimental groups to which desensitizing solution was applied. Findings of the present study are in consistent with study done by Bersezio C et al (2015)[17] in which there was a statistically significant difference in hydraulic conductance between the control group and the samples treated with desensitizing solution based on diamine silver fluoride.

Between experimental groups, the application of 15, 30, and 60 s of treatment was not relevant to measuring the hydraulic conductance of disks measured immediately after application. This can be explained by the 15 s of the application generating saturation with salts of silver that precipitated on the dentin. This generated an occlusion of dentinal tubules. With these results, we conclude that an application for 15 s is effective for intratubular occlusion, which saves time. These results are consistent with the null hypothesis of the research that different application times would produce no statistically significant difference. However, it should be considered that the in-vitro results cannot be extrapolated to the possible outcomes in-vivo, since conditions in the oral environment are different from those in this experimental model.[18]The utilization of silver diamine fluoride for the prevention of dentin hypersensitivity is supported by research by Castillo et al. which demonstrated the clinical efficacy of silver diamine fluoride as a desensitization agent. The effect lasts for 24 hours to 7 days after application to the surface of the teeth. However, clinical tests over a longer period and comparison with other techniques are still needed to measure the effectiveness of silver diamine fluoride.A clinical study by Castillo et al[7]used VAS to evaluate a population with teeth sensitive to cold air. Two 1-min applications of diamine silver fluoride were performed. As a result, there was a significant reduction of pain in response to cold air in comparison to a placebo. This was measured at 24 h and 7 days after application. It can be concluded that the diamine silver fluoride/potassium iodide has potential as a treatment for dentin hypersensitivity after immediate application. However, other studies are necessary to measure the maintenance of the effect over a longer period and for comparison with other occlusive desensitizing agents.The model with dentin disks has been widely used to assess intra-tubular occlusion and the effects on fluid flow through the dentin by desensitizing agents.[17]

CONCLUSION

There was no difference in hydraulic conductance between disks with different application times of desensitizing solutions of diamine silver fluoride/potassium iodide. Dentin hypersensitivity can effectively be reduced by utilization of silver diamine fluoride as a desensitization agent. Silver diamine fluoride has potential as a management for dentin hypersensitivity after instant application. Though, future studies are essential to determine the continuation of the effect over a longer time period and for assessment with various occlusive desensitizing agents.

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