Effect of silver diammine fluoride on hardness of root carious dentin in vivo

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Abstract

Objective: To investigate the effect of silver diammine fluoride on hardness of root caries in vivo.

Materials and methods: Ten patients with at least two teeth diagnosed for extraction participated in the present study. The two teeth with surface root caries (of similar size and depth) were selected on opposite sides of the patient's mouth. The clinical study was approved by the Board of Consideration and Research Control of the Metropolitan Bangkok Area (serial number 120/2012). The 38% silver diammine fluoride (SDF) was applied on the root caries following the manufacturer's recommendation. Simple randomization was used to select the teeth as control (without SDF application) and experimental groups. The control tooth was extracted leaving the other (with SDF application) in the patient's mouth for subsequent extraction. After one month, the SDF applied tooth was extracted, cleaned with water, soaked in 0.01% Thymol solution, and embedded in epoxy resin. A resin block with the extracted tooth was cut to expose the root caries lesion and hardness measurement of the carious dentin was performed using a micro-hardness tester using a Vickers indenter (50 gm force, 15 s dwell time). Statistical analysis was performed using the Pair t-test (alpha=95) to compare mean values of the teeth within the same mouth.

Results: The average root caries dentin hardness was higher when SDF was applied. However, there was no significant difference between the control and experimental groups ($p>0.05$).

Conclusion: There is no significant change in root caries hardness after being applied with SDF for one month in vivo.

Keywords: carious dentin, clinical study, hardness test, root caries, silver diammine fluoride, vickers indenter

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Introduction

Silver diammine fluoride has been used to stop caries progression for more than forty years starting in Japan during the time when the tooth decay epidemic was at its height amongst children. With many papers published during that period, they confirmed the effectiveness in preventing the spread of decay[1]. The chemical property of the silver diammine fluoride is $Ag(NH_3)_2F$. It possesses the property to fight with infection once decay has already begun and it stops any further spread. By applying the solution, the silver diammine fluoride will react with hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$, to form silver phosphate, $AgPO_4$, Calcium Fluoride, CaF_2 and fluorapatite. The silver phosphate will then react with protein of infected dentin and bacteria protein to become silver protein, which will stop tooth decay via two mechanisms. The first one is initiated when the fluoride from the calcium fluoride changes the hydroxyapatite into fluorapatite, with the calcium fluoride becoming a source of fluoride and is ready to be expunged by demineralization or the dissolving of hydroxyapatite. This process involves in the remineralization process which is a key to stop and prevent tooth decay [2,3].

The second process comes from the silver phosphate which does not dissolve in water and precipitates on the tooth surface. Due to this property, the silver will then proceed with the task eliminating the bacteria cell. The precipitated silver phosphate on the infected dentin will excrete silver for a long period, and during this period silver amino acid and silver nucleic acid will coagulate on the surface and attack the bacteria[4,5].

The silver diammine fluoride when applied can penetrate dentin up to 20 microns while fluoride can penetrate tooth tissue by more than 50 – 100 microns. The silver ions from silver diammine fluoride can penetrate deep down to dentin next to pulp[2] and effectively eliminate any existing bacteria. As was stated before, it is clear that the silver diammine fluoride can kill the bacteria in the infected dentin and enhance the remineralization process thus stopping the caries progression from existing infected carious lesion.

Root caries is one of major dental health problems in Thailand. From the seventh national survey conducted in Thailand[6], it was found that population between 60 – 74 years of age and 80 years of age have prevalence of root caries related to gingival recession up to 17.20%, while the prevalence for Bangkok alone was 30%. This is because in elderly citizen, it is more likely to have gingival recession and thus more area on root surface will be exposed to oral environment. Moreover, with less effectiveness of tooth cleaning of the elderly, there are more chances of demineralization process on the root surface and finally this situation promotes root caries. Since root caries progress rapidly, if not treated, there is a risk of losing the tooth. Thus dental practitioners must always attempt to manage root caries as well as promote the remineralization and prevention before root caries progress.

Due to the silver diammine fluoride quality to kill bacteria and promote remineralization of tooth tissue, the solution application could be used for the elderly suffering from root caries to stop the caries progression and to desensitize the root sensitivity. Recent research articles have shown effectiveness in prevention and treatment of root caries by silver diamnine fluoride however, there is very limited study on the root dentin hardness change due to the use of silver diammine fluoride. This research aimed to study the effect of silver diammine fluoride on the hardness of root caries dentin in vivo.

Materials and methods

This research was conducted on ten patients who had at least a minimum of two

teeth with root caries that were diagnosed for extraction. The patients selected for the clinical study are those who do not have any systemic diseases but with root caries on teeth diagnosed for extraction. Two teeth were selected with surface root caries (similar size and shallow) and they were on opposite side in the patient mouth. The selected tooth samples were chosen for one application of 38% silver diammine fluoride solution (Saforide, Bee Brand Medical, Japan) as experimental group and control group (without any application) via simple random sampling. The teeth were cleaned with pumice to remove dental plaque and blew dry before the silver diammine fluoride was applied. For the experimental group, the silver diammine fluoride was applied on root caries using micro application tip for one minute following the manufacturer's recommendation. A gauze was used to remove excessive amount of the silver diammine fluoride. Once the silver diammine fluoride was applied, the other tooth for control group was extracted for the hardness measurement. After the first extraction for a month, the patient was appointed to extract the silver diammine fluoride applied tooth. This study was approved by the Board of Consideration and Research Control of the Metropolitan Bangkok Area, serial number 120/2012.

For the hardness measurement, the two extracted teeth were cleaned with water and soaked in 0.01% of Thymol solution until they were embedded in epoxy resin. The extract tooth was embedded in epoxy resin (Suksapan, Thailand) within seven days after extraction. The embedded tooth block was horizontally cut to expose root carious lesion and to obtain two root carious areas for measurement, one next to crown side the other on the root side. The embedded tooth block was cut by carborundum disk with low speed cutting machine (IsoMet 1000, Buehler, USA) and the measured surface was polished by automatic polishing machine (DPS 3200; IMPTECH, South Africa), at rotating speed of 120 cycles per second. The polishing process started with silicon carbide paper (Leco, USA) No. 600, 1000 and 1200 respectively and finished with 0.2 micron of aluminum oxide powder (Struers, Denmark).

The root carious hardness was measured by micro-hardness tester (Fm -700e, FujiTech, Japan) by use of a Vickers indenter with an applied force of 50 grams and a dwell time of 15 seconds. Ten indentations were conducted on carious dentin 100 microns from carious dentin surface and 100 microns apart of each other for both crown side surface and root side surface.

Data analysis

Average hardness from both surfaces as representative of each tooth were compared between experimental and control groups using Student's t-test and significance set at $p < 0.05$.

Results

Average hardness of the experimental group (19.73±11.0) showed higher average hardness than the average hardness of the control group (16.67±4.4). However, there is no significant difference between the two groups studied ($p>0.05$). Another finding is carious lesion color turned to be black after the silver diammine fluoride application.

Discussions

The usage of silver diammine fluoride to prevent tooth decay among the elderly seems to be the most effective way of tackling the rising epidemic of root caries. Mei et al.[7,8] investigated the inhibitory effect of 38% silver diammine fluoride on demineralized dentin and found that it inhibited demineralization and preserved collagen from degradation in demineralized collagen in carious dentin thus positively promote dentin

remineralization and finally arrest dentin carious lesion. Yee et al.[9] confirmed the effectiveness in arresting dental carious lesion of a single spot application of 38% silver diammine fluoride. The high concentration of fluoride in the solution makes advantages than other fluoride base mixture. Moreover, simple application to the decay tooth will not only kill the bacteria but also crate calcium fluoride which becomes the repository for fluoride which is ready to be expunged by demineralization thus promote remineralization. The process is simple and user friendly and makes the treatment optimal for the elderly. Many articles have shown the success of the use of silver diammine fluoride in vitro as well as in epidemiology research.

For Zhi's experiment[10], frequency of silver diammine fluoride application for two times annually (91%) showed more effectiveness than the group with one time application annually (79%). Llodra et al.[11] evaluated the six monthly application with 38% silver diammine fluoride and found it to be effective to prevent and arrest caries in primary and permanent teeth. Therefore the frequency of application is also crucial and involve in the duration of silver diammine fluoride to stay in function in the oral cavity. In this study, the application of 38% silver diammine fluoride for one minute on root caries was decided to stay in oral cavity for a period of one month. Since the patients need two visits for their two teeth to be removed so a period of one month is possible for the experimental tooth to stay and having silver diammine fluoride in action.

Hardness is one of the parameters often used in the evaluation of demineralization and remineralization due to its ease of measurement and less time consuming. Hardness has been used to reflect lost and gain of mineral.

Table 1 Average Vickers hardness number of both halves of experimental and control groups.

Patient	Group	Tooth	Crown half	Root half	Average
1	Experiment	13	26.53	30.39	28.46±5.09
	Control	34	14.35	14.07	14.21±3.75
2	Experiment	24	23.38	25.07	24.23±5.81
	Control	31	22.54	25.05	23.80±4.59
3	Experiment	44	20.96	20.02	20.49±2.47
	Control	31	24.84	23.15	24.00±4.51
4	Experiment	35	16.05	13.62	14.84±4.85
	Control	47	14.29	13.92	14.11±4.07
5	Experiment	23	17.05	22.04	19.55±5.15
	Control	13	10.90	12.24	11.57±3.06
6	Experiment	44	52.73	37.78	45.26±8.47
	Control	34	21.10	18.08	19.59±2.99
7	Experiment	14	11.94	11.21	11.58±3.15
	Control	37	15.98	15.91	15.75±3.92
8	Experiment	33	12.34	14.45	13.40±2.22
	Control	44	9.02	22.22	15.82±7.63
9	Experiment	13	5.13	10.74	7.94±3.47
	Control	33	12.90	11.45	12.18±2.72
10	Experiment	43	10.97	12.19	11.58±3.00
	Control	21	13.63	17.77	15.70±2.96

Micro-hardness of primary teeth was shown to be increased after multi application of silver diammine fluoride every three months[12]. The lesions showed arrested area of caries and the hardness increased compared to caries lesion. In the present study, micro-hardness measurement was done in a short period compared to the work done by Gluzman *et al.* in order to see the difference of mineral change and found that there was no significant difference between experiment and control groups. However, the silver diammine fluoride applied area turned to black and showed arrested dentin (Figure 1).

With the short period in action for single application of silver diammine fluoride, change of hardness could not be seen from the experimental sample. The longer period of application is suggested for the future research however, the evaluation procedure is expected to be changed to other testing method such as quantitative light-induced fluorescence since the mineral content change of root caries in the mouth can be followed without any extraction required.

In conclusion, within one month follow up, hardness change according to single application of silver diammine fluoride could not be seen.

Figure 1 The tooth section for experimental group with carious dentin became black.

Figure 2 The tooth section for control group without silver diammine fluoride application.

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