

**Title:**

Influence of silver diamine fluoride application on the restorative treatment for root caries

**Abstract:**

The number and percentage of older adults in most countries around the world are rapidly increasing. Hong Kong is facing the same challenge where the pace of population ageing is continuing and will be ramping up with the number of older adults (aged 65 or above) projected to nearly double in the coming 20 years. The increasing ageing population amplifies the society's needs for dental care. With longer life-expectancy and more remaining natural teeth, older adults are at high risk to suffer from dental problems. As reported by the Department of Health, about one-fourth of non-institutionalised older adults in Hong Kong had root surface decay, and most of the decay remained untreated. Decayed roots, if left untreated, can cause pain, infection, tooth fracture or loss, which in turn will affect chewing ability, diet, and oral health-related quality of life. Thus, it is needed to find effective ways to handle prevalent dental problems of older adults.

At present, conventional approach of 'drilling and filling' is the most commonly used method to treat decayed dental roots. However, recent studies show that the conventional restorative approach is not a satisfactory treatment method due to its high annual failure rate. Therefore, in this study, aiming to improve the outcomes of treating root decay, we propose a novel approach to treat decayed roots by conjunctive use of silver diamine fluoride (SDF) solution and conventional restorative treatment.

First of all, the proposed novel approach may potentially improve longevity of the fillings in decayed lesions. Further, with prior SDF application, the chance of secondary caries associated with the fillings may be reduced. As application of SDF can arrest and harden the decayed root lesions, it is expected that there will be less amount of soft carious tooth tissues to be removed for placement of fillings. Thus, this can preserve natural dental tissues from removing. Besides, the proposed method may have additional benefits for patients other than an improved clinical outcome (longevity of fillings). For instance, older adults who are medically compromised, require additional support and cannot tolerate invasive treatment (drilling and filling) at the moment, or have too many decayed roots to be treated at a single dental visit, can be applied with SDF first to control the progress of tooth decay. The fillings can be placed later when the situation allows. Besides, placement of fillings in SDF treated lesions can reshape and repair the decayed tooth to have improved appearance, which may improve patient-based subjective evaluations, e.g. satisfaction and oral health-related quality of life.

Therefore, this study will generate valuable clinical evidence regarding the proposed novel approach in treating decayed dental roots. The treatment outcomes will be assessed both objectively (clinical indicators) and subjectively (patient-based outcomes). With the jointly comprehensive evaluations, the findings of the study will guide dental clinicians to make smart decisions when treating root decay for older adults.

## **Introduction**

### An increasing ageing population with amplified dental treatment needs

According to the Census and Statistics Department's latest report, the pace of population ageing in Hong Kong is continuing and will be ramping up with the number of older adults (aged 65 or above) projected to nearly double in the coming 20 years. The population of older adults in 2019 was 1.3 million and it is projected to be 2.5 million (33% of the total population) in 2039, i.e. about one in every three people will be an older adult <sup>1</sup>. Living longer and retaining more natural teeth, older adults are at potentially higher risks to have more dental problems. As reported by the Department of Health, about one-fourth of non-institutionalised older adults in Hong Kong had decayed tooth root surfaces, and most of these decayed lesions remained untreated <sup>2</sup>. Decayed roots (root caries), if left untreated, can cause pain, infection, tooth fracture or loss, which in turn will affect chewing ability, diet, and oral health-related quality of life (OHRQoL). In fact, the increasing ageing population amplifies the need to carry out effective dental treatments for older adults, and this is considered a great challenge faced by the Hong Kong society as reported by the Secretary for Food and Health <sup>3</sup>.

### High effectiveness of silver diamine fluoride solution application in arresting root caries

Our previous studies demonstrate that application of silver diamine fluoride (SDF) solution is highly effective in stopping and arresting the progress of decay in dental roots of older adults <sup>4,5</sup>, and this finding is consistent with a study conducted overseas <sup>6</sup>. Systematic reviews confirm the effectiveness of SDF in arresting root caries for older adults <sup>7,8</sup>. The American Dental Association (ADA) has published a guideline based on the up-to-date evidence to support the use of SDF for managing tooth decay <sup>9</sup>. As a non-invasive procedure, application of SDF is simple, quick, painless and non-aerosol generated, the advantages of which makes it favoured, in particular, during the period of Covid-19 pandemic <sup>10</sup>. However, an obvious drawback of SDF application is the black stain on the arrested caries lesions <sup>4</sup>, which may raise aesthetic concern.

### Current restorative treatment for root caries remains controversial

Conventional approach of 'drilling and filling' is still the most commonly used method to treat root caries lesions. However, a recent systematic review found that irrespective of various restorative materials used, high annual failure rates of restorations in root caries lesions were reported in majority of the clinical studies <sup>11</sup>. Besides, insufficient data is available to clearly rule out if any difference with regard to restoration longevity between different restorative techniques, i.e. conventional restorative treatment vs. atraumatic restorative treatment <sup>12</sup>. Since there is insufficient evidence to recommend any specific material or technique for routine use in placement of restorations in root caries lesions, it is necessary to further research in this area to seek for a novel approach to improve outcomes of restoring root caries lesions.

### Combination of SDF application and restorative treatment for root caries

#### *Potential improvement regarding clinical outcomes*

We propose a novel restorative approach to treat root caries lesions by combining SDF application and conventional restorative treatment. First, the antimicrobial effect of SDF can prevent caries formation around cavity margins. Laboratory studies showed that prior SDF application could increase resistance of restorations to secondary caries <sup>13-15</sup>. The conjunctive

use of SDF may reduce the chance of new caries associated with restorations as well as the failure rate of restorations. Second, as the application of SDF can arrest and harden the caries lesions<sup>16</sup>, it is expected that there will be less amount of soft carious tooth tissues to be removed for placement of restorations. This embodies the concept of the “minimal invasive dentistry” to remove and replace as little tissue loss as possible to preserve natural dental tissues<sup>17</sup>. Third, as shown in laboratory studies, prior SDF application can increase the chemical bonding strength between glass ionomer cement (GIC) and dentine<sup>18, 19</sup>, which implies potential to increase the success rate of restorations. Laboratory-based results show promise in conjunctive use of SDF application prior to restorative treatment, yet no clinical trial has been conducted to evaluate this novel restorative approach.

#### *Additional benefits*

Other than potential improvements in clinical outcomes, the conjunctive use of SDF application and restorative treatment may have additional benefits for patients. Older adults who are medically compromised, require additional support and cannot tolerate invasive treatment at the moment, or have too many decayed roots to be restored at a single dental visit, can receive SDF treatment first to control the progress of tooth decay. Dental restorations can be placed later when the situation allows. Besides, placement of restorations in SDF treated lesions can cover the black stain caused by SDF, which may improve patient-based subjective evaluations, e.g. satisfaction and oral health-related quality of life.

Therefore, a well-designed randomized controlled trial (RCT) is needed to provide high-quality clinical evidence regarding the conjunctive use of SDF application and restorative approach in treating root caries of older adults.

### **Aims and Hypotheses**

Based on our previous studies, we hypothesize that SDF application prior to placement of dental restorations is a novel approach to improve the outcomes of treating root caries lesions.

The aim of the proposed study is to investigate the influence of prior SDF application on the restorative treatment for root caries.

The objectives of the study are to

- 1) Compare the success rate of restorations placed in root caries lesions that have prior SDF application or that of restorations placed without prior SDF application;
- 2) Compare patient-based subjective evaluations on the two different approaches mentioned-above in treating root caries lesions.

Hypotheses to be tested:

- 1) Prior SDF application increases the success rate of restorations placed in root caries;
- 2) Patient-based subjective evaluations of the treatment outcomes are better when SDF is applied to the root caries lesions prior to restoring the lesions.

## Material and Method

This study is designed as a two-arm randomized controlled clinical trial with 24-month follow-up. This clinical trial will be conducted in accordance with the ethical principles that have the origin in the Declaration of Helsinki, and that are consistent with Good Clinical Practice (GCP) and the applicable regulatory requirements of ICH-GCP.

### Recruitment of participant

Community-dwelling older adults attending community centres in different districts of Hong Kong will be invited to join the study. It is planned to recruit 184 older adults who have untreated decayed dental roots. An invitation letter with information on the purpose and procedures of the study will be sent to community-dwelling older adults through the community centre they are attending. Free dental examination will be offered, and older adults who have decay in their exposed dental roots will be invited to join the study. Written consent form will be obtained before any clinical procedures. Screening will be conducted in the community centre by an experienced dentist using a ball-ended CPI probe and a dental mirror attached to an intra-oral LED light source. Exposed dental root surfaces will be examined by the visual-tactile method. No radiograph will be taken during the dental screening.

### Inclusion criteria

Older adults (aged 60 or above) with at least one untreated decayed dental root will be included in the study.

### Exclusion criteria

Older adults who do not have self-care ability for basic daily activities, such as tooth brushing, will be excluded. Teeth with severe decay, for example those with signs of pulpal pathology, an abscess or discoloured, indicating for endodontic treatment will be excluded. Teeth that are indicated for extraction due to any reason, such as advanced periodontal disease, will also be excluded.

### Sample size calculation

Sample size calculation is based on the primary outcome measure of this study which is the success rate of restorations placed in root caries lesions. Success of a restoration is defined as the restoration staying in place and without major defects or dental caries associated with it. According to a recent systematic review, the anticipated two-year success rate of restorations placed in root caries is 65%<sup>12</sup>, and the success rate of the restoration placed in root caries with prior SDF treatment is expected to be 80%. With a statistical significance level set at 5%, a power of 80%, and an enrolment ratio of 1:1, the calculated minimal number of restorations required in each group is 138 (<https://clincalc.com/stats/samplesize.aspx>). Since more than one caries lesion may be found in a participant, the clustering effect on sample size is taken into consideration. It is anticipated that the number of decayed roots included per person is 2. A design effect of 1.15, assuming an intra-class correlation  $\rho$  of 0.1, is used in the sample size calculation<sup>20,21</sup>. Thus, the minimal sample size needs to be multiplied by 1.15 to become 159. Furthermore, to compensate for a possible drop-out rate of 15%, the initial sample size is increased to 183 restorations per group. Therefore, 92 participants in each group will be recruited at baseline and the total number of enrolled participants will be 184.

### Randomization

The included older adults with decayed dental roots will first be divided into two strata:

- 1) with a small amount of caries (high caries risk), which is defined as the presence of less than 4 untreated caries teeth; and
- 2) with a large amount of caries (extremely high caries risk), which means 4 or more untreated caries teeth.

The participants will then be allocated by a block randomization method (block size=6) into the following two study groups. An independent statistician who is not involved in the trial will generate a random-number table. The enrolled participants will be allocated into two study groups following the random-number table.

- Group 1 (SDF group), the participants will be applied with SDF solution about 1 month before receiving dental restoration;
- Group 2 (control group), the participants will be applied with a placebo (tonic water to mimic the bitter taste of SDF) about 1 month before receiving dental restoration.

### Intervention

#### *SDF and placebo application*

A micro-brush will be used to apply a 38% SDF solution (Saforide, Toyo Seiyaku Kasei Co., Osaka, Japan) on decayed root surfaces of participants in the SDF group after the dental screening in the community centre. The decayed root surfaces in control group participants will be applied with tonic water as placebo following the same procedures as in the SDF group. All participants will be instructed not to eat or drink for half an hour after the application.

#### *Dental restoration placement*

Around one month after the application of SDF/placebo, participants will have their decayed root lesions restored by dentists following the standard restorative procedures in the Prince Phillip Dental Hospital (PPDH). Soft carious tooth tissues, if any, will be removed by means of hand instruments and dental burs until the surface of the cavity is hard on probing. Local anaesthesia injection will be given on demand from the participant and recorded. After removal of carious dental tissues, the cavity will be cleaned with water from a 3-in-1 syringe and then dried. The prepared cavity will be restored with an adhesive dental material, light-cured glass ionomer cement (Fuji II LC, GC Corporation, Tokyo, Japan). The dentists who place the dental restorations will not be involved in the SDF/placebo application.

### Allocation concealment

Based on the group allocation, a dentist will apply either SDF or placebo onto root caries lesions of the study participants. A dental assistant will follow the random-number table to dip dental micro-applicators in either SDF or tonic water, and then pass the micro-applicators to the dentist, so as to achieve the allocation concealment. The participants and the dentists who are responsible to carry out interventions are blinded to the group allocation.

### Data collection

#### *Clinical outcome*

Eligible participants will receive a detail clinical examination before the application of SDF/placebo and also right before the placement of dental restorations. In the clinical examination, the International Caries Detection and Assessment System (ICDAS II) will be used to record the status of the root surfaces<sup>23</sup>. The diagnosis of root surface status will be mainly made through careful visual inspection and aided by the use of a CPI probe, if indicated. Besides, other clinical parameters including the participant's caries experience, dental hygiene, and prosthesis status will be examined. The decayed, missing and filled tooth (DMFT) score of the participant will be recorded according to the World Health Organization (WHO) criteria<sup>24</sup>. The presence of visible plaque on each of the exposed root surfaces, four surfaces per tooth, will be recorded without using any disclosing agent. The proportion of root surfaces with visible plaque will be calculated by dividing the number of exposed root surfaces with plaque by the total number of exposed root surfaces examined. Whether the participant wears a denture as well as the tooth surfaces in close proximity (within 3 mm) to a denture component will be recorded.

Follow-up examinations will be carried out at the 6-, 12-, 18- and 24-month follow-ups by calibrated examiners who are not involved in the placement of restorations. The presence and status of the restoration will be assessed according to the criteria that are commonly used in other studies<sup>22</sup>. The coding system is shown as following:

- 0 = restoration present, no caries, no marginal defects or wear
- 1 = restoration present, no active caries, slight defects or wear not greater than 0.5 mm
- 2 = restoration present, marginal defects greater than 0.5 mm
- 3 = restoration present, wear greater than 0.5 mm
- 4 = restoration present, active caries found associated with the filling
- 5 = restoration missing, no active caries, surface hard to gentle probing
- 6 = restoration missing, active caries found, surface soft to probing allowing penetration of the tip of a blunt probe
- 7 = restoration was replaced by a new restoration
- 8 = tooth with signs of pulpal pathology or extracted due to caries
- 9 = tooth missing due to any other reasons

The study restorations will be assessed as success or failure. Codes 0 and 1 are considered as success of the restoration, and no further treatment is necessary. On the contrary, the restoration is regarded as failure when it has major defects (code 2 or 3), is associated active caries (code 4), is missing (code 5 or 6), is replaced by a new restoration (code 7), and the tooth has signs of pulpal pathology or has been extracted due to caries (code 8).

Duplicate examinations on about 10% of the participants will be carried out to assess examiner agreement regarding the status of restorations.

#### *Patient-based subjective evaluation*

Interviews using a structured questionnaire will be conducted to assess the patient-based subjective outcomes. The questionnaire consists of multiple sections: (i) participant's sociodemographic background; (ii) satisfaction with their dental health conditions as well as the dental treatment process; and (iii) the OHRQoL. The Chinese version of General Oral

Health Assessment Index (GOHAI) will be adopted as a tool to assess the OHRQoL of the participants <sup>25</sup>. It contains 12 questions covering three domains: physical function, pain and discomfort, and psychosocial function. The total GOHAI score is generated by adding up the score of each response to the 12 questions, and the total score ranges from 12 to 60. A higher score indicates a better perceived OHRQoL.

The interviews will be conducted at baseline before and after the placement of restorations, the 6-month follow-up and the 24-month follow-up by a trained interviewer. Before the interview, the participants will not be informed of their dental conditions to avoid possible bias. With data collected in the follow-up interviews, influence of the proposed novel restorative approach on patient perceived subjective outcomes can be analysed.

#### Data processing and analysis

Clinical charting forms and questionnaires will first be checked for completeness and obvious errors. The collected data will be entered into computers. Double entry will be carried out to detect any errors of entered data and the corrected data will be used for statistical analysis.

Basic data analysis will be carried out by using the statistical software SPSS for Windows. Chi-square test and t-test will be performed to assess the comparability between the two study groups regarding the demographic background, baseline dental caries experience and OHRQoL.

Clinical outcomes of dental restorations at each follow-up examination will be classified as either success or failure according to the criteria mentioned above. A multi-level survival analysis for interval-censored data will be adopted. The first level is the restoration while the second level is the study participant. This analysis will account for the correlation (clustering) between observations of multiple restorations placed in the same participant. The analyses will be carried out using the statistical software SAS for Windows (SAS Institute Inc., Cary, N.C., USA). The level of statistical significance for all tests will be set at 0.05. McNemar's test and paired t-test will be adopted to assess the change in patient-based subjective outcomes including satisfaction with the treatment and OHRQoL.

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