Original research

Assessment 0f Fluoride Ion Release from a Commercially Available Varnish

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Abstract: The remineralizing property of fluoride in a varnish depends on its sustained release, thus increasing the availability of fluoride ions around the tooth for a prolonged period. **Aim:** The purpose of this in vitro study was to assess the quantum of fluoride ions released from Clinpro^{TM}XT varnish over a period of three weeks. **Materials and Methods:** Freshly extracted thirty premolar teeth indicated for orthodontic extraction were collected from healthy children aged 13-15 years. The teeth were painted with an acid resistant varnish exposing a window of 5x5 mm that was covered with adhesive tape. The tape was later removed, and the window was etched with 15% phosphoric acid for 15 seconds and coated with one layer of the Clinpro^{TM}XT varnish (3M ESPE) using a disposable brush. The varnish was light cured for 20 seconds. Each tooth sample was stored in a bottle containing 20 ml of deionized water and incubated at 37^{0}C. Fluoride concentration was measured using a microanalytical technique with an inverted fluoride ion selective coupled to a benchtop analyzer. The data obtained was subjected to statistical analysis using paired t test. **Results:** Fluoride release at the end of three weeks was 0.27±0.04 ppm which was significantly higher than that of 0.16±0.03 ppm observed at the end of first week (P value<0.001). **Conclusion**: There was a significant release of fluoride ions from the tested varnish over a period of three weeks.

Keywords: Fluoride; Ions; Varnish; Remineralization; Deionized; Ionomer.

INTRODUCTION

Fluoride varnishes are a convenient form of topical fluoride that has a benefit of prolonged contact of fluoride with tooth enamel. It is used to prevent demineralization and aid in remineralizing the tooth. Fluoride varnish has been used in public health settings as a much-needed concentrated-treatment of fluoride for children with high-caries rates.

Fluoride varnish works by increasing the concentration of fluoride in the outer surface of teeth, thereby enhancing fluoride uptake during early stages of demineralization. The varnish hardens on the tooth as soon as it contacts saliva, allowing the high concentration of fluoride to be in contact with tooth enamel for an extended period of time (about 1 to 7 days).

The remineralizing property of fluoride in a varnish depends on its sustained release, thus increasing the availability of fluoride ions around the tooth for a prolonged period. Conventional varnish with water-soluble sodium fluoride is designed to release much of its fluoride within an initial brief period, typically up to one day, before the bulk coating is worn away by brushing or food abrasion. This reduces the availability of fluoride at the site of demineralization at the right time and in the right concentration.

A combination of glass ionomer cement and fluoride in the form of a varnish can have an added benefit. Clinpro^{TM}XT varnish is a recently introduced varnish that is a resin modified glass ionomer cement based fluoride varnish. Clinpro^{TM}XT varnish is moisture-tolerant and suitable for application on wet surfaces such as newly erupted teeth. It can also be used as a site specific protective coating on tooth surfaces that are at caries risk.

Clinpro^{TM}XT varnish has been shown to be highly durable and remains on the tooth for six months or longer. It is used as a remineralizing agent for precavitated lesions, erosive enamel lesions and around bands and brackets. The purpose of this in vitro study was to assess the quantum of fluoride ions released from Clinpro^{TM}XT varnish over a period of three weeks.

MATERIALS AND METHODS

Freshly extracted thirty premolar teeth indicated for orthodontic extraction were collected from healthy children aged 13-15 years. Prior informed consent was obtained from the patients and parents to allow the use of these teeth for research purpose. Teeth with intact enamel surfaces, not affected by fluorosis or signs of decalcification and without white spot lesions were included for the study. The exclusion criteria were teeth with caries, fracture or developmental defects.

Each tooth was cleaned with pumice slurry and polishing brush at slow speed and washed thoroughly under tap water. The teeth were painted with an acid resistant varnish exposing a window of 5x5 mm that was covered with adhesive tape. The tape was later removed, and the window was etched with 15% phosphoric acid for 15 seconds. (Prime&Bond® NT,Dentsply) and coated with one layer of the Clinpro™XT varnish (3M ESPE) using a disposable brush. The varnish was light cured (LEDition, Ivoclar Vivadent) for 20 seconds as per manufacturer's instructions. Each tooth sample was stored in a bottle containing 20 ml of deionized water and incubated at 37ºC.

At the end of 1 week each sample was removed from the bottle, washed with 1 ml of deionized water, dried with absorbent paper and immediately placed in a bottle containing new solution of 20 ml of fresh deionized water. 20 ml of the previous solution and 1 ml used for washing was mixed with 20 ml of the prepared total ionic strength adjustment buffer solution (TISAB II).[1]

Standardization of fluoride ion electrode

Standard solutions for fluoride uniformity were prepared from a 100 ppm fluoride solution and deionized water. These 20 ml standard solutions containing 0.1, 1.0, 10.0ppm of fluoride were prepared and buffered similar to the sample solutions. This was used to calibrate the ion selective electrode.

Measurement

The sample containing 21ml of deionized water with 20 ml of buffering solution was transferred to a glass beaker into which a magnetic stirrer was placed. The electrode was dipped into the solution and fluoride concentration was recorded in parts per million. Fluoride concentration was measured using a microanalytical technique with an inverted fluoride ion selective electrode (Orion 9609 BNWP, Ionplus Sure-Flow Fluoride Electrode, Thermo Scientific, USA) coupled to a benchtop analyzer (Orion Star ISE Benchtop Meter, Thermo Scientific, Beverly, MA, USA). Detection limit was ±0.001ppm, and all data were recorded in ppm. All measurements were performed at a constant room temperature of 23°C. [1] The same procedure was followed for each of the thirty samples.

The fluoride ion release was assessed for a second time at the end of three weeks using the same method as described above. The data obtained was subjected to statistical analysis using paired t test.

RESULTS

Fluoride release at the end of three weeks was 0.27±0.04ppm which was significantly higher than that of 0.16±0.03ppm observed at the end of first week (P value<0.001).

DISCUSSION

Fluoride varnishes have been the standard of practice for the professional application of topical fluoride. They do not adhere permanently to a tooth, but remain in close contact with enamel for a long duration of time. The current concept of the caries-preventive mechanism of fluoride varnish is based on the formation of globular calcium fluoride on the enamel surface, which serves as a reservoir and releases fluoride ions in response to pH changes in the mouth.

Since pure calcium fluoride crystal is cubical rather than spherical, these globular deposits have been described as calcium fluoride. The reason for prolonged retention of calcium fluoride on the enamel surface is the protective coating of pellicle proteins and secondary phosphate. At lower pH levels, such as during a caries attack, the pellicle coating is lost and an increased dissolution rate of calcium fluoride occurs. The fluoride ions released in this way may adsorb onto the enamel surface and inhibit dissolution of hydroxyapatite or increase the rate of remineralization.[2]

Studies on topical fluoride gels have shown that the number and size of calcium fluoride globules deposited on enamel surfaces depend on pH, concentration of the fluoride solutions and exposure time. However, a dose-response relationship seems to be absent in the caries preventive mechanism of fluoride varnishes.[3]

Featherstone and Zero[4] commented that increasing fluoride indiscriminately would not necessarily produce better clinical results in regard to preventing caries. It appears that, in most cases, the amount of fluoride incorporated into the varnishes might have exceeded the threshold needed to develop sufficient calcium fluoride on the enamel surface. However, the lack of fluoride uniformity and the high quantity of fluoride released into the mouth might reduce the retention of calcium fluoride to levels below that threshold. Ultimately, it is the quality of loosely bound calcium fluoride and the quantity of this fluoride in terms of its dissolution rate that prevent caries.[3]

Various materials are available that exclusively deliver remineralizing agents. Incorporating fluoride, a remineralizing agent in a restorative material, definitely reduces the occurrence of secondary caries. Fluoride releasing dental restorative materials like glass ionomer cements have been developed with the same consideration.

Glass ionomer cements also have the ability to replenish the fluoride content in the cement. This ability of glass ionomer materials to take up fluoride and then release it has been labeled “recharge” and is a valuable attribute of these materials. The fluoride thus released has been shown to have an effective zone of about 1 mm from the margin of glass ionomer restorations.[5] Release of fluoride from restorative materials also maintains the fluoride level in oral fluids. A study showed that following placement of glass ionomer restorations, the immediate salivary fluoride concentration is approximately 0.3ppm and remains up to 0.04ppm after 1 year.[6] Clinpro™XT varnish, which is a resin modified glass ionomer based varnish also, has the similar property of being recharged by other fluoride exposures.

Clinpro™XT varnish is a site-specific, protective coating for enamel and dentin tooth surfaces that remains on the tooth for 6 months or longer. The glass ionomer component of the varnish provides a sustained release of fluoride ions and also improved adhesion to the tooth. Its sealing ability arises from the adhesive potential of glass ionomer component as well as its resin component that infiltrates into the demineralized lesion and prevents further demineralization. Its remineralizing potential arises from sustained release of fluoride, calcium and phosphate ions. Fluoride is present in fluoroaluminosilicate glass particles and reaction at the surface provides its immediate release, while the bulk of the material provides a reservoir of fluoride for sustained release. [7]

Resin-modified GIC materials like Clinpro™XT varnish have the potential for more controlled and sustained release of remineralizing agents.[8] In an earlier study sustained fluoride release was seen for a period of 5 weeks from Clinpro™XT varnish as compared to other varnishes that released fluoride for a lesser duration. The slower rate of fluoride release was attributed to the chemical bond between glass ionomer component and tooth structure.[9] This is in accordance with our study, where a significant continuous release of fluoride was seen over a three week period.

Two mechanisms have been proposed by which fluoride may be released from glass ionomer into an aqueous environment. One mechanism is a short-term reaction, which involves rapid dissolution from outer surface into the solution (wash out), whereas the second is more gradual and resulted in the sustained long-term diffusion of ions through its bulk.[10]

The manufacturers of Clinpro™XT varnish claim that the tested varnish also contains calcium glycerophosphate, which can provide a continual release of calcium and phosphate and act as a cariostatic agent.[2] The importance of calcium and phosphate along with fluoride for remineralization of carious lesions has been well established.

The ability of fluoride to affect the demineralization-remineralization process depends on whether fluoride is available in the oral cavity at the right time and proper concentration.[11] Leverett et al demonstrated that prolonged, slightly elevated fluoride levels in saliva resulted in caries prevention.[12] The salivary fluorides have been seen to be influenced by the initial fluoride concentration applied, time since exposure, delivery method, fluoride retention and fluoride clearance from oral cavity.[13] The manufacturers of the varnish claim that the varnish releases more fluoride in the first hour than Duraphat and releases fluoride for over 6 months. Hence the property of long term retention of Clinpro™XT varnish maintains the elevated fluoride levels in the mouth for caries prevention.

CONCLUSION: There was a significant release of fluoride ions from the tested varnish over a period of three weeks.

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