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Topical fluoride as a panacea for dental caries: A Review

Dr. Nesa Aurlene*
Post Graduate Student (Masters in Dental Surgery), Department of Public Health Dentistry, SRM Dental College and Hospital, Ramapuram, Chennai, India
Dr. Sunayana Manipal
Masters in Dental Surgery, Reader, Department of Public Health Dentistry, SRM Dental College and Hospital, Ramapuram, Chennai, India
Dr. Rajmohan
Masters in Dental Surgery, Senior Lecturer, Department of Public Health Dentistry, SRM Dental College and Hospital, Ramapuram, Chennai, India
Dr. D. Prabu
Masters in Dental Surgery, Head of the Department and Professor, Department of Public Health Dentistry, SRM Dental College and Hospital, Ramapuram, Chennai, India
Dr. R. Sindhu
Post Graduate Student (Masters in Dental Surgery), Department of Public Health Dentistry, SRM Dental College and Hospital, Ramapuram, Chennai, India

Abstract:

The use of fluorides for the prevention of caries has been in practice for more than seven decades worldwide. Fluoride's administered systemically through community water fluoridation or topically through various topical fluoride delivery systems have been shown to be effective in preventing dental decay and thereby reducing the dental caries burden in communities. This review was conducted to examine the benefits to two most commonly administered topical fluoride delivery systems namely, fluoride mouthrinse and fluoride varnish. This review discusses the commercially available fluoride mouthrinses and fluoride varnishes, their method of usage, the indications for usage, the safety and side effects of both topical fluoride delivery systems and why these methods are important in context of India for the prevention of dental caries in the community.

Key words: Topical fluoride, fluoride mouthrinse, fluoride varnish, dental caries

INTRODUCTION:

Dental caries is found to be a ubiquitous and the most prevalent disease of the oral cavity that affects the oral health of individuals and communities at large. It is an irreversible microbial disease of the calcified tissues of the teeth, characterized by demineralization of the inorganic portion and destruction of the organic substance of the tooth, which often leads to cavitation.[1] The discovery of fluorosis in the 1900's, by Fredrick McKay brought forth the knowledge that, at a certain optimum concentration of 0.7 to 1.2 parts per million (ppm), fluoride has the ability to impart caries resistance to susceptible enamel surfaces. Ever since the discovery, fluoride has been widely used as a preventive measure against dental caries.[2,3,4]

Fluoride is the simplest, monoatomic anion of fluorine with the chemical formula F^-. It has a wide range of industrial applications in addition to being used as a preventative measure against caries. Fluoride imparts resistance to acid producing caries bacterium by a number of mechanisms. When fluoride reacts with hydroxyapatite of the normal enamel, it forms fluorapatite which is less soluble and therefore more resistant to acid attack. Fluoride also increases the post eruptive maturation of hypomineralized enamel surfaces in the newly erupted permanent teeth.[5]

In the 1940's, systemic administration of fluoride through community water fluoridation was widely accepted and practiced as a strategy to reduce dental caries. Grand Rapids, Michigan was the first place in the world where community water fluoridation was initiated in the year 1945. Even though studies exist to prove the reduction in dental caries that was observed in areas where water fluoridation was practiced, recent studies have provided ample evidence that fluorides delivered as topical delivery systems are much more effective in the prevention of dental caries.[6]

Topical fluoride delivery systems are recommended for usage among school children, because it is generally recognized that children are at a higher risk for development of dental caries owing to a number of factors. These factors are, just erupted permanent teeth have comparatively less ability to resist acid attack by bacteria in the oral cavity as enamel maturation process is still incomplete, children may not be particularly concerned about oral health maintenance unless such practices are enforced by parents or care givers, children have more propensity to prefer a caries inducing diet including confectionary and sugar sweetened beverages.

This review was conducted with an aim to explore the benefits of two topical fluoride delivery systems that are widely used in school-based programmes, namely fluoride varnishes and fluoride mouthrinses.

FLUORIDE MOUTHRINSES

Fluoride mouth rinses are used for their preventive action on dental caries. The purpose of fluoride mouth rinsing is to provide frequent, relatively low concentrations of fluoride to intra-oral sites with a predilection for caries

occurrence. The effectiveness of fluoride mouth rinses in reducing caries was first demonstrated in a study conducted by Bibby et al (1946), where he concluded that there was a 43% reduction in new caries occurrence when topical fluoride rinses were used.[7] The agents that are used as fluoride mouthrinses include sodium fluoride solutions, acidulated phosphate fluoride solutions (APF), and stannous fluoride solutions. Out of these, sodium fluoride solutions are most commonly used. Figure 1 shows the commercially available fluoride mouthrinse NeturaFluor marketed by Colgate.

Figure 1: Commercially available fluoride mouthrinse

Figure 2: Commercially available Fluor Protector varnish with applicator brush

METHOD OF USAGE:

Sodium fluoride rinses are usually dispensed in quantities of 10 ml or 5 ml and swished around in the mouth for a period of 1 – 2 minutes after which they are expectorated. Fluoride rinses with a fluoride concentration ranging from 200-250 ppm are indicated for daily usage.

Fluoride mouth rinses are also available at higher concentrations of fluoride ranging from 900-1000ppm fluoride. Such mouth rinses are indicated for weekly use and a 10 ml rinse containing 1000ppm fluoride will contain 10 mg of fluoride. The reports from many fluoride mouth rinse trials indicate that both daily and weekly rinsing is equally effective in preventing dental caries.[8]

Some of the commercially available fluoride mouthrinses are as follows,

1) Sensodyne Pronamel – It is a fluoride rinse that has a fluoride concentration of 448ppm
2) Paradontax – Manufactured by Glaxo Smith Kline group of companies, Herrenberg, Germany. This fluoride mouth rinse has a fluoride concentration of 250ppm
3) Depurdent – Manufactured by Dr. Wild company, Muttenz, Switzerland. Fluoride concentration of 250 ppm
4) Colgate Multiprotection – Fluoride concentration of 250 ppm
5) Aquafresh (Extreme Clean) – Fluoride concentration of 250 ppm
6) Listerine Fluoride Defense – Manufactured by Johnson and Johnson company with a fluoride concentration of around 225 ppm

SIDE EFFECTS:

One of the important side effects of additive fluoride programmes is that fluoride at a higher concentration than the optimal range can lead to dental fluorosis, which is an aesthetically impairing condition characterised by enamel hypoplasia in the form of scattered white spots or flecks on the surface of the teeth. In its severe form, dental fluorosis is more pronounced with brown stains on the teeth and pitting which may be discrete or confluent.

The most susceptible age group to develop dental fluorosis are children who are below six years of age. Studies have been done to determine the amount of rinse swallowed by children of different ages by Ericsson and Forsman (1969). This study concluded that children below 3 years of age had inadequate swallowing reflexes and hence mouth rinse was not recommended for children below 3 years of age. The amount of rinse swallowed by 4 to 6-year olds was found to be 20-25 percent of the rinse solution and hence it was recommended that for 4 – 6-year-old children fluoride rinse with a concentration of 110 ppm F was appropriate. Fluoride at this concentration would not lead to dental fluorosis in children even taking into account the amount of rinse that may be swallowed.[9]

For children above six years of age a fluoride rinse of 7ml or 10 ml with a fluoride concentration of 225-250 ppm F is recommended, as most of the solution can be expectorated completely in this age group.

Table 1: Results of clinical trials with sodium fluoride mouthrinses

Authors	Fluoride Concentration	Frequency of rinsing	Age of study subjects in years	Duration of study	Caries reduction%
Bibby 1946	1000 ppm	3/week	18-21	1 year	43%
Torell, Ericsson 1965	225 ppm	1/day	10	2 years	49%
Torell, Ericsson 1965	900 ppm	2/week	10	2 years	22%
Koch 1967	225 ppm	2/day	8-10	2 years	16%
Horowitz 1971	900 ppm	1/week	11	20 months	44%
Rugg Gunn 1973	225 ppm	1/day	11-12	3 years	36%
Ripa 1978	900 ppm	1/week	7-12	2 years	32%
Heifetz 1982	225 ppm	1/day	10-12	34 months	34%
Brodeur 1988	900 ppm	1/week	9-11	20 months	47%

Table 2: Recommended frequency for application of fluoride varnish based on caries risk

Age	Low caries risk	Moderate caries risk	High caries risk
1 -4 years	1 time per year	2 times per year	3 times per year
5 -7 years	2 times per year	3 times per year	4 times per year
8 -11 years	1 time per year	2 times per year	3 times per year
15 -19 years	1 time per year	2 times per year	3 times per year
20-69 years	Nil	2 -3 times per year	4 times per year
70 year and above	2 times per year	3-4 times per year	6 times per year

Table 3: Results of clinical trials with fluoride varnishes

Authors	Country	Study Sample	Age of study subjects	No. of applications per year	Duration of study	Caries reduction%
Heuser & Schmidt 1968	Germany	224	13-14yrs	1	15months	30%
Hochstein 1975	Germany	94	3-4yrs	1	2 yrs	34%
Winter 1975	Germany	165	6 yrs	1	2 yrs	37%
Murray 1977	England	302	5-6yrs	2	2 yrs	7.4%
Maiwald 1978	Cuba	350	6-12yrs	2	4 1/2yrs	39%
Seppa 1982	Finland	62	11-13yrs	2	3 yrs	30%
Grodzka 1982	Poland	322	3 yrs	2	2 yrs	9%
Holm 1984	Sweden	109	5yrs	2	2 yrs	56%
Clarke 1985	Canada	703	6-7yrs	3	20 months	7%

CONTRAINDICATIONS FOR USAGE OF FLUORIDE MOUTHRINSE:

1) Fluoride mouth rinses are not recommended for children below 3 years of age.
2) Fluoride mouth rinses have to be prescribed with caution in the age of 4 – 6 years because an increased exposure to fluoride may result in dental fluorosis.
3) The use of fluoride rinses requires good perioral muscle function without which the fluoride rinse may be inadvertently swallowed or aspirated. This precludes the use of fluoride rinses in conditions where there is lack of muscle co-ordination like Down's syndrome, unilateral or bilateral facial palsy, cerebral palsy, microstomia, macroglossia and facial dysmorphism.

Ever since its inception by Bibby et al in the 1940's, fluoride mouthrinsing has been adopted as a school based preventive intervention for caries by many countries

including Sweden, Denmark, USA, Cuba and Norway. The community trials conducted with fluoride mouthrinses generally express their outcomes in terms of percentage reduction in dental caries. The studies conducted since the 1940's have been summarized in Table 1 along with their observed percentage reduction in dental caries.

In addition to the evidence provided by these studies, a Cochrane database review on "Fluoride mouthrinses for preventing dental caries in children and adolescents" examined evidence from 37 clinical trials with sodium fluoride mouth rinse. All trials included children who received sodium fluoride mouth rinse on a daily or weekly basis with a fluoride concentration of 230 ppm or 900 ppm respectively. The pooled DMFS reduction percentage from all these trials was found to be 27%. The authors have thus concluded that supervised use of fluoride mouth rinses for preventing dental caries in children and adolescents is a practical and effective method of preventing dental caries.[10]

FLUORIDE VARNISH:

Fluoride varnishes are professionally applied adherent material which consists of high concentration of fluoride as a salt or silane preparation in fast drying, alcohol-based solutions in natural resin. Fluoride varnishes were first developed and marketed in the 1960's as sodium fluoride varnish Duraphat by Colgate, New York and then later in the 1970's as silane fluoride, which was called Fluor Protector and was marketed by Ivoclar Vivadent and Lichtenstein, Germany.[11] This newer method of topical delivery of fluoride was envisioned as a method which could provide close contact between the fluoride ions and tooth surface for a prolonged period of time in comparison to other topical fluoride delivery systems. Figure 2 shows the commercially available Fluor Protector varnish with applicator brush.

Duraphat was first used by Heuser and Schmidt (1968) and contained fluoride in the form of a suspension of sodium fluoride in an alcoholic solution of natural varnish substances. It has a fluoride concentration of 2.26% which is 22, 600 ppm fluoride.[12]

Fluorprotector was developed in 1975 by Arends and Schuthof and contains 1% difluorosilane in a polyurethane base. It has lower pH than Duraphat and is less viscous. It is supplied in a box containing twenty vials and each vial has 0.4ml of varnish.[13]

Duraflor is another fluoride varnish marketed by Medicom, Montreal, Canada and is similar to Duraphat except that it contains 5% sodium fluoride and has xylitol added to it to improve taste and patient acceptability. It is usually supplied as a 10 ml tube and is less viscous than Duraphat. Cavity Shield is a fluoride varnish produced and marketed by Omnii products, West Palm Beach, Florida. It contains 5% sodium fluoride varnish in a resin base. It is packaged as either 0.25ml containing 12.5 mg NaF or 0.40 ml containing 20 mg fluoride based on the number of teeth to be treated.

Bifluorid is a fluoride varnish that has a fluoride concentration of 56, 300 ppm F. It is produced and marketed by Voco, Cuxhafen, Germany. Carex is a fluoride varnish that has lower fluoride concentration than Duraphat, 1.8% fluoride but has been found to be equally effective in inhibiting caries in studies done by Marya and Dahiya (2006).[14]

METHOD OF USAGE:

Fluoride varnishes have a very high concentration of fluoride and hence a small amount of varnish is adequate for application. For primary dentition the recommended amount is 0.25 ml varnish, for mixed dentition upto 0.4 ml varnish can be used and for the permanent dentition upto 0.75 ml of varnish can be used.

Duraphat contains 5 wt% NaF and is a viscous, resinous varnish that should be applied with pointed bristles or syringes to the dried tooth surfaces. When it comes into contact with saliva, Duraphat hardens into a yellowish-brown coating. Duraphat usually remains on the tooth surface for about 24 hours and is supplied in tubes (10 ml or 5 ×30 ml) for application with pointed bristles or in glass ampoules (5 ×1.6 ml) for application with a syringe.

Fluor Protector is a polyurethane-based varnish containing 0.9 wt% silane fluoride (0.1% F). The standard package consists of 50 glass ampoules of Fluor Protector with 1 ml varnish in each ampoule. After drying the tooth surface Fluor Protector is applied with a disposable brush or minipipette. Fluor Protector in acidic and hardens in air to a colorless, transparent film within 2 to 3 minutes. It is retained on the teeth as a slow release fluoride agent for one to two weeks. Compared to Duraphat and Bifluorid 12, the exposure time is markedly prolonged.

Bifluorid 12 is a clear varnish containing 6% NaF and 6% CaF_2 which corresponds to 60 mg of each fluoride compound per 1 gram of the preparation. Only 1 g of the preparation contains 56.3 mg of fluoride. Bifluorid 12 is supplied in a bottle containing 4 or 10 g fluoride varnish, solvent bottle and special foam pellets for application. The varnish is applied with the foam pellet to tooth surfaces and due to its low viscosity only about 0.02 ml is used per tooth. The varnish is retained on the tooth surfaces for several days.[15]

After drying and isolating the teeth, one or two pea sized drops of fluoride varnish is expressed on to an applicator and then painted onto the teeth. An oral prophylaxis before application is indicated only in children with a moderate or heavy plaque build-up but otherwise the fluoride varnish can be applied without performing prior oral prophylaxis. Only a thin film of the material is painted onto the teeth, a yellowish hue may be retained owing to the application of varnish. Children must be instructed not to eat or drink for 20-30 minutes after application of fluoride varnish.

Varnishes contain anywhere between 1000 to 56,300 ppm fluoride and have to be applied twice or four times a year depending on whether the children being treated come under a high caries risk category. The recommendations for frequency of application of fluoride varnish based on age and caries risk are summarized in Table 2.

SIDE EFFECTS:

Fluoride varnishes are adherent and remain in contact with the tooth surface for a prolonged period of time. They are

safe to use because of their fast setting and slow fluoride releasing property. Bioavailability of fluoride from fluoride varnishes is less when compared to other forms of topical fluoride delivery systems like APF gels and mouthrinse solutions which have nearly 100% bioavailability of fluoride. Contact dermatitis or stomatitis in dentists and children respectively has been recorded to occur because of use of fluoride varnish.[16]

CONTRAINDICATIONS FOR USAGE OF FLUORIDE VARNISH:

1. Must not be used in children who have ulcerative gingivitis or stomatitis.
2. Must not be used in children who have a history of allergies to colophony or rosin.
3. Must not be used in children suffering from bronchial asthma.

In-vivo studies on the efficacy of fluoride varnish were first conducted by Stamm in 1974, where he tested 35 subjects. Study subjects' right or left maxillary arches were used for treatment with fluoride varnish with the other side acting as the untreated control. After five weeks of treatment with fluoride varnish enamel biopsies were taken from the fluoride treated and untreated sides and fluoride measurements were obtained. Stamm found that there was a mean increase of 591 ppm fluoride on the treated side compared with the control side after five weeks of topical fluoride varnish application.[17]

Studies on the effect of fluoride varnish on children' teeth and its caries inhibitive action was studied by several scholars in different countries and all these studies unanimously found a decrease in the occurrence of caries after fluoride varnish treatment. These studies and their results have been summarized in Table 3.

A Cochrane database review (2013) on the efficacy of fluoride varnishes in preventing caries included 22 trials with a total of 12, 455 participants found that the pooled prevented fraction estimate for dental caries in permanent teeth comparing fluoride varnish with placebo or no treatment was 43% and the pooled dental caries preventive fraction for primary teeth was 37%. The review concluded that fluoride varnishes have a substantial caries reducing potential and that they are a worthful public health intervention that can improve the oral health and the oral health related quality of life of children when instituted as a school based programme.[18]

COST- EFFECTIVENESS: Fluoride varnish or mouthrinse?

For any public health intervention to be beneficial, it has to be evaluated for its economic effectiveness, when being implemented as a large-scale intervention, to prevent the burden of some disease in the community. Economic evaluation may be defined as the comparative analysis of alternative course of action in terms of their costs and consequences.

Keeping school-based fluoride programmes in mind, this would mean, that the cost effectiveness of various methods of topical fluoride delivery, must be compared to find which alternative gives the maximum benefits at the least costs incurred. Möberg Skold U (2008) did a cost analysis study of two school-based fluoride programmes conducted for 3 years in Sweden, one study with fluoride varnish and the other with fluoride mouthrinse. Fluoride varnish was applied twice a year, every 6 months, totalling 6 applications in 3 years' time. Fluoride mouth rinse was administered every first and last 3 school days of each semester, totalling 36 times in 3 years' time. The study compared the efficacy of fluoride varnish and fluoride mouth rinse in reducing dental caries in enamel and dentin and caries progression.

The study found that fluoride varnish was more effective in preventing dental caries in comparison to fluoride mouth rinse. Fluoride varnishes benefit also came at a lower cost when compared to fluoride mouth rinse. The estimated cost of fluoride varnish treatment per child per school year was about 35.80 SEK (Swedish Krona), whereas the cost of fluoride mouth rinse per child per school year came to about 63 SEK. One Swedish Krona is equal to Rs. 7.89 Indian Rupee. A cost benefits analysis comparing fluoride mouth rinses and fluoride varnishes also yielded a cost benefit ratio of 1.8:1 for fluoride varnish, and a cost benefit ratio of 0.9:1 for fluoride mouth rinses.[19]

In terms of its caries preventive effect, fluoride varnishes have proven to be mildly more effective in their caries preventive action than fluoride mouth rinses. This is because of the relatively high concentration of fluoride in fluoride varnishes, that remains in close approximation to the tooth surface, when compared to fluoride mouth rinses which have very low concentrations of fluoride and are not adherent to the tooth surface like varnishes. Moreover, because fluoride varnishes are effective with biannual application, they require less in terms of manpower to be implemented as a school-based programme unlike fluoride mouthrinses which require supervision on a daily or weekly basis over a long period of time.

CONCLUSION:

Fluoride has been used widely as a preventive intervention to reduce dental decay in communities all over the world. Because of the capacity of fluoridation to bring about a drastic decline in dental decay from the 1950's to 1980's, Dr. Luther Terry, U.S. Surgeon General (1961-1965) described water fluoridation as one of the four great advances in public health and termed water fluoridation as one of the "four horsemen" of public health, the others being chlorination, pasteurization and immunization. In parallel with many communities of the world adopting water fluoridation which is a systemic fluoride delivery method, there were also topical fluoride delivery systems that were advocated for prevention of dental decay. The earliest among these topical fluoride delivery systems was the fluoride mouthrinse, clinical trials with fluoride mouthrinse began as early as 1946 and were proven to be effective in reducing dental decay. In the 1960's, a newer system of topical fluoride delivery called fluoride varnishes, that furnished a high concentration of fluoride and were adherent to the tooth surfaces came into the market. As evidence mounted on the effectiveness of both

community water fluoridation and topical fluoride delivery systems in preventing dental decay there existed a dilemma as to which method to choose and adopt as a public health intervention.

This dilemma was solved when several Scandinavian studies in the 1980's demonstrated in in-vitro studies of human and shark enamel that topical fluorides were comparatively more effective in preventing dental caries than systemic intake of fluoride. Notable among these studies is a study done by Ogaard (1988) comparing human enamel, shark enamel and human enamel treated with sodium fluoride for net mineral loss which revealed that structurally incorporated fluoride in shark enamel showed a higher percentage of mineral loss when compared to human enamel treated with sodium fluoride mouth rinse. Shark enamel was chosen for comparison because it is naturally composed of fluorapatite with fluoride concentrations as high as 30,000ppm. Nevertheless, shark enamel with more structurally bound fluoride exhibited more mineral loss when compared to human enamel treated with sodium fluoride mouth rinse.[20]

In lieu of this, two topical fluoride systems namely fluoride mouthrinse and fluoride varnish were explored in this review as both can be instituted as a public health programme in schools to prevent dental decay. The National Oral Health Survey, India (2002) has found a caries prevalence in 5, 12 and 15-year-old children ranging anywhere between 30% to nearly 95%.[21] Even with such a high prevalence of dental caries among school children, school-based fluoride programmes are not in practice in India. This review provides recommendations on two topical fluoride delivery methods that can be safely and effectively implemented in schools to prevent decay in children.

RECOMMENDATIONS:

1. Despite a higher material cost, fluoride varnishes have been found to be more effective and more cost-effective in school-based settings.
2. Where possible fluoride varnishes must be used instead of fluoride mouthrinses as they require application only at six-month intervals to effectively prevent caries in children.
3. Fluoride mouthrinses can be used in children who have been determined to be at lower risk for caries occurrence through caries susceptibility tests. A high-caries risk necessitates the use of fluoride varnish as high concentration of fluoride in fluoride varnish and adherence of the material to tooth surface imparts better caries resistance than fluoride mouthrinse.
4. Fluoride mouthrinses must not be used in children who are below 3 years of age as swallowing reflexes are inadequate. Fluoride rinses must be used cautiously in 4-6-year olds as there is a risk of developing dental fluorosis in the permanent teeth in this age group. Fluoride rinses with a lower concentration of 110 ppm fluoride are recommended for children in the ages of 4-6 years.

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