

Fluoride in Caries Treatment and Prevention in Children – A Review

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INTRODUCTION

DENTAL caries is an infectious disease affecting most person in industrialized and developed countries⁽¹⁾. It is a multifactorial disease of the teeth in which there is demineralization of the inorganic constituents of the tooth. Studies have shown dental caries and its sequelae to be a common cause of premature loss of teeth among children if left unchecked as bacteria can penetrate dissolved tooth surface, attack underlying dentine and reach the pulp tissue^(2,3). An initial step in the formation of a carious lesion takes place when cariogenic bacteria in dental plaque metabolize a substrate from the diet (e.g. sugars and other fermentable carbohydrates) and the acid produced as a metabolic by – product demineralizes the adjacent enamel crystal surface. Demineralization involves the loss of calcium phosphate and carbonate. Dental plaque is a sticky organic matrix of bacteria, food debris, dead mucosal cells and salivary components that adheres to tooth enamel.

Recent studies have shown a decline in the prevalence and severity of dental caries in the United States and other economically developed countries due to the exposure of residents to some degree and wide spread use of fluoride in its many forms which has provided a buffer against caries, despite the continued high sugar consumption^(1,4). Use of fluorides for the prevention and control of caries is documented to be both safe and highly effective^(5,6,7).

Fluoride is the ionic form of the element fluorine. It is negatively charged and readily combines with positive ions such as calcium and sodium to form stable compounds. In humans, fluoride is mainly associated with calcified tissues (i.e. bones and teeth) because of its high affinity for calcium⁽⁷⁾. The first use of adjusted fluoride in water for caries control began in 1945 and 1946

in the United State and Canada when the fluoride concentration was adjusted in the drinking water supplying four communities⁽⁸⁻¹¹⁾. Much of the research on the efficiency and effectiveness of individual fluoride modalities in preventing and controlling dental caries was conducted before 1980 when dental caries was more common and more severe. Excess intake of fluoride causes dental fluorosis. This effect depends on the duration and the concentration of intake.

The success of water fluoridation in the control of caries led to the development of other fluoride containing products such as toothpastes, mouth rinses, dietary supplements and professionally applied or prescribed gel, foam or varnish. Naturally occurring sources of fluoride include leafy vegetables, tea and fish.

This article reviews the various uses of fluoride in the treatment and prevention of dental caries with emphasis on the efficacy and effectiveness of each fluoride modality.

Cariostatic Mechanisms of Fluoride

The current concept considers caries as a dynamic and reversible process. Caries activity is the result of the interplay of a number of aetiological factors. Some of these factors cause demineralization, others promote remineralisation of the tooth. Usually demineralization is limited and quickly reversed by the effect of fluoride and the buffering and repair action of saliva.

Fluoride when present in the mouth is retained and concentrated in plaque and saliva. The effects of fluoride are usually classified as either systemic (pre-eruptive) or topical (post-eruptive)⁽¹²⁾. Systemic effects can be obtained through the ingestion of foods that contain natural levels of fluoride, water that contain natural levels of fluoride or to which fluoride have been added and dietary fluoride supplements. Topical benefits are available from the previously mentioned sources as a result of their contact with

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the teeth as well as from fluoride tooth pastes or other more concentrated forms that are self administered or professionally applied⁽¹²⁾.

Evidence supports earlier hypothesis by investigators that fluoride affects enamel and inhibits dental caries only when incorporated into developing dental enamel⁽¹³⁾. Although laboratory and epidemiological researches indicate that fluorides predominant effect is post eruptive and topical and that the effect depends on fluoride being in the right amount in the right place at the right time⁽¹⁴⁾

Recent Australian studies⁽¹⁵⁾ have confirmed earlier findings that children with optimal exposure to fluoridated water both pre and post eruptively had the lowest caries on all surface types.

Fluoride works to control and prevent early dental caries in several ways. Fluoride concentrated in plaque and saliva inhibits the demineralization of sound enamel and enhances the remineralization of demineralized enamel⁽¹⁶⁾. As cariogenic bacteria metabolize carbohydrates and produce acid, fluoride is released from dental plaque in response to lowered pH at the tooth-plaque interface⁽¹⁷⁾. The released fluoride and the fluoride present in saliva are then taken up along with calcium and phosphate by demineralized enamel to establish an improved enamel crystal structure known as fluoroapatite, which is more acid resistant and contains more fluoride and less carbonate giving a reduced solubility^(16,17). Fluoride is more readily taken up by demineralized enamel than by sound enamel. Concentrated fluoride in plaque also inhibits the process by which cariogenic bacteria metabolize carbohydrates to produce acid and affects bacterial production of polysaccharides⁽²⁰⁾. In vitro laboratory studies have shown that when low concentration of fluoride is present, *streptococcus mutans*, a type of cariogenic bacteria

produced less acid⁽²¹⁾. Confirmation of this effect on human is yet to be proven⁽²²⁾.

Topical application of high concentration of fluoride to teeth leaves a temporary layer of calcium fluoride – like material on the enamel surface. The fluoride in this material is released when the pH drops in the mouth in response to acid production and it is available to remineralize enamel⁽²³⁾.

Other preventive mechanism of actions of fluoride include the following⁽²⁴⁾

- Fluoride intake during development of teeth modifies the size and shape of teeth i.e. shallow fissures and grooves which are less favorable for food lodgment.

- Fluoride also inhibits catalytic action upon enamel crystallization

- Fluoride alters the ecology of dental plaque by removing competitive advantage possessed by *streptococcus mutans*.

Uses of Fluoride

The indications for administering the various forms of fluoride primarily depend on the age of the child, caries experience of the child and perceived susceptibility to develop caries in the future and access to fluoridated drinking water. Different fluoride compounds, different vehicles and vastly different concentrations of fluoride have been used with different frequencies and duration of applications with a resultant varying effectiveness of the different forms⁽⁷⁾. These variables influence the clinical outcome with respect to caries prevention and management. The use of fluoride can be by systemic administration, which has a pre-emptive effect or by topical administration, which has a post-eruptive effect.

Before promoting fluoride modality or combination of modalities the dental health care provider must consider a persons' or groups' risk for dental caries, current use of other fluoride

Table 1:

Dietary Fluoride Supplementation Schedule

Age	Fluoride < 0.3ppmF	Concentration 0.3-0.6ppmF	PPM >0.6ppmF
Birth—6months	0	0	0
6months—3yrs	0.25mg	0	0
3yrs—6yrs	0.50mg	0.25mg	0
6yrs—16yrs	1mg	0.50mg	0

sources and potential for enamel fluorosis. A risk category can change overtime, therefore the type and frequency of preventive interventions should be adjusted accordingly⁽⁷⁾.

SYSTEMIC FLUORIDATION

· Community water fluoridation

This is the use of optimally adjusted concentration of fluoride in community drinking water to maximize caries prevention and limit enamel fluorosis. The recommended concentration ranges from 0.7ppm (Parts Per Million) to 1.2ppm depending on the average maximum daily air temperature of the area⁽²⁵⁾. Earlier studies of community water fluoridation demonstrated that reduction in childhood dental caries attributable to fluoridation were approximately 50% - 60%⁽²⁶⁻²⁷⁾. More recent estimates were lower 18%-40%⁽²⁸⁾. The decrease has been attributed to increasing use of fluoride from other sources especially with the wide spread use of toothpastes. Water fluoridation has been found to be the most effective and efficient strategy to reduce dental caries⁽²⁹⁾. It is also the most cost effective, most convenient and reliable method of providing the benefits of fluoride to the population because it does not depend on individual compliance.

· School water fluoridation

This involves fluoridation of school water supply system when the school has its own source of water and was not connected to community water supply system. It has been tested in certain isolated rural schools in the United States of America that have independent water supplies⁽³⁰⁾. Since children are at school only part of each week a fluoride concentration of 4.5 times the optimal concentration for a community in the same geographic area was recommended to compensate for the more limited consumption of fluoridated water⁽³⁰⁾.

Studies of the effects of school water fluoridation in the United States reported a caries reduction in school children by 40%^(30,31). This effect might no longer be as indicated in a more recent study⁽³²⁾ and school water fluoridation has been phased out in several states.

This method of fluoridation has the advantage that daily involvement of teachers is not necessary but operating and maintaining small fluoridation system created practical and logistical difficulties⁽²⁵⁾. Its other disadvantage is that in schools that enroll pre-schoolers in day care programs, children age <6years might receive more than adequate fluoride

· Bottled water

This had been the source of drinking water for many people lately. Investigations has shown that some bottled waters marketed in the US contain an optimal concentration of fluoride approximately 1.0ppm although most contain < than 0.3ppm fluoride⁽³³⁾.

· Dietary Fluoride supplements

These are known to provide an alternative source of dietary fluoride for children who do not have access to optimally fluoridated water. Fluoride supplements have both topical and systemic effects. Topical effect is achieved by allowing the supplement that may be in liquid or tablet form to contact the teeth prior to being swallowed. The tablets may be sucked for 1-2minutes. The supplements may also be in the form of Lozenges (including fluoride vitamin preparations). The active ingredient is sodium fluoride and the fluoride concentration is between 0.25mg, 0.5mg or 1mg fluoride⁽⁷⁾.

Fluoride supplements are prescribed by a dentist or physician and the dosage schedule requires knowledge of the fluoride content of the child's primary water supply and consideration to other sources of water and other source of fluoride which may complicate the prescribing decision.

Table I shows the dietary fluoride supplements schedule recommended by the American Academy of Pediatric Dentistry (AAPD) for all children drinking fluoride deficient (<0.6ppm) water⁽⁷⁾.

Use of fluoride supplement by pregnant mothers has been known not to benefit the baby⁽³⁴⁾. Studies have reported mixed evidence for using fluoride supplements against dental caries. While some studies reported that fluoride supplements taken by infants and children before teeth eruption reduce the prevalence and severity of caries^(28,35), others have not^(36,37). Use of supplements if not will assessed, will cause dental fluorosis⁽³⁸⁻⁴⁰⁾. Therefore it is important to maximize benefit and minimize harm when prescribing.

Parental compliance plays a key role in determining the effectiveness of these supplements.

· Topical Fluoridation

The efficiency of topical fluoride in caries prevention depends on:

- q The concentration of fluoride used
- q The frequency and the duration of

application and

q The specific fluoride compound used⁽⁴¹⁾.

The more concentrated the fluoride and the more the frequency of application, the greater the caries reduction.

Use of topical fluoridation plays an increasing role in the 3-6 year old group⁽¹²⁾. It can be professionally applied fluoride treatment or self/parentally applied fluoride (toothpastes & mouth rinses)⁽⁵⁾.

· Tooth pastes and gels

Due to lack of fluoridated water in many countries, use of fluoridated toothpastes might be the most important source of fluoride globally⁽¹⁾. More frequent use has been known to offer additional protection against dental caries⁽⁴²⁾. Studies of 2-3 years duration have reported caries reduction among children by 15%-30%⁽⁴³⁾. Currently approved fluoride tooth pastes contain sodium fluoride or sodium monofluoro phosphate as active ingredients and the fluoride concentration in the United States ranges between 1000 – 1300ppm⁽²⁴⁾

Synergetic effect has been reported when fluoridated toothpaste is used with fluoridated water⁽⁴⁴⁾. When used topically as toothpastes or gel, fluoride is taken up by plaque and the concentration in saliva is also increased⁽⁴⁵⁾. The concentration in saliva returns to base line level in 1-2 hours and may be maintained by regular use of fluoridated toothpaste.

Fluoridated tooth pastes and gels predisposes very young children to fluorosis due to the swallowing reflex of children <6years⁽⁴²⁾. This effect can be prevented by supervising children and using a "pea size" amount of tooth paste or using "child strength" tooth paste with lower fluoride concentration of about 500-550ppm⁽⁴⁶⁾. Studies have reported that vigor of rinsing after tooth brushing affects fluoride concentration in the mouth and reportedly affects caries experience⁽⁴²⁾. Children ³6years can retain more fluoride in the mouth by either rinsing briefly with a small amount of water or not at all.

· Fluoride mouth rinse

Rinses are indicated for persons deemed to be at high risk for caries. Included in this group are those who lack manual dexterity necessary for effective oral hygiene procedures, Patients who wear orthodontic appliances or prostheses and those with medical conditions that place them at increased risk.

Fluoride mouth rinse is a concentrated solution intended for daily or weekly use⁽¹²⁾. Usual

concentration are 0.05% sodium fluoride (230ppm fluoride) for daily rinsing and 0.20% sodium fluoride (920ppm fluoride) for supervised school based weekly rinsing program both with greater effects on older children >6years. An average caries reduction in non-fluoridated communities attributable to fluoride mouth rinse was 31%⁽⁴⁵⁾.

· Professionally applied compounds

This is the application of high concentration fluoride compounds directly to patients' teeth. It involves semiannual applications of the concentrated fluoride in a gel or foam forms in the dental office. A pumice prophylaxis is not an essential pre-requisite to this prophylaxis⁽⁴⁶⁾ as the fluoride compound forms a calcium fluoride like material on the enamel surface that releases fluoride for remineralization when the pH in the mouth drops.

Fluoride gels and foams include 1.23% acidulated phosphate fluoride (APF- 12,300 ppm fluoride), 2% sodium fluoride (9200ppm fluoride) and 8% stannous fluoride (19,500ppm fluoride). An average caries reduction of 26% has been recorded⁽⁴⁷⁾ and an application time of 4minutes has been found to be efficacious although 67% caries reduction has been found with the use of APF.

Fluoride vanishes involves the direct painting of the vanish on the teeth. Clinical studies have demonstrated caries reduction rate of 25% to 75% from its use^(48,49). Fluoride vanish are easy to apply especially in young pre-cooperative children when topical fluoride treatments are indicated. Duraphat and duraflor commonly available fluoride vanishes contain 22,600ppm fluoride.

In conclusion, over the years fluoride has been found to be safe and effective in prevention and management of dental caries in persons living in developed countries. Its use through out life to protect teeth against tooth decay can not be over emphasised. Early but controlled and supervised exposure of children to its use becomes necessary especially in developing countries where the cost of restoration of carious teeth may be out of the reach of the general populat. Also it is important to prevent the occurrence of enamel fluorosis which is a consequent of ingesting high amount of fluoride especially during the developmental periods of the teeth.

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