Topical Fluoride Therapy

The term topical fluoride therapy refers to the use of systems containing relatively large concentrations of fluoride that are applied locally, or topically, to erupted tooth surfaces to prevent the formation of dental caries. Thus this term encompasses the use of fluoride rinses, dentifrices, pastes, gels, and solutions that are applied in various manners.

At the time of tooth eruption, the enamel is not yet completely calcified and undergoes a post-eruptive period, approximately 2 years in length, during which enamel calcification continues. Throughout this period, called the period of enamel maturation, fluoride, as well as other elements, continues to accumulate in the more superficial portions of enamel.

The Unit cell of hydroxyapatite showing the central ion (the hydroxyl ion has been replaced with a fluoride ion) and possible location of other substituent ions notably carbonate and magnesium, Calcium ion, phosphate ion

The crystal chemistry of apatite

\[
\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + \text{Mg}^{++} = \text{magnesium whitlockite}
\]

\[
\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + \text{CO}_3^{-} = \text{carbonated apatite}
\]

\[
\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + 2\text{F}^{-} = \text{Ca}_{10}(\text{PO}_4)_6(\text{F})_2(\text{fluorapatite}) + 2(\text{OH}^{-})
\]

**Phosphate** The dry weight of phosphate in the enamel is 16–18% and 12% in the dentine. Phosphate deficiency is commonly not due to insufficient supply, but due to other causes, such as vitamin D-resistant rickets.

**calcium** The dry weight of calcium in the enamel is 34–40% and in the dentine 26–28%. To affect the teeth, the calcium deficiency must be extreme.
The combined action of parathormone, calcitonin and vitamin D maintains very stable calcium and phosphate blood levels, even when the mineral intake is suboptimal. When the bone shows signs of deficiency, the enamel will be normal, but the dentine seems more vulnerable.

**Magnesium:** (0.4% dry weight of the dentine and the enamel) appears essential in odontogenesis, but teeth with higher levels of magnesium are more vulnerable to caries.

**Trace elements:**

Insufficient iron causes enamel hypoplasia through enzyme damage. Other trace elements (which are not similarly distributed within the enamel and dentine) include: zinc, silica, and to a lesser degree copper, chromium, manganese, molybdenum and tin.

Very small quantities of selenium, vanadium and cobalt are also present. Their importance in odontogenesis is largely unknown. Strontium in the crystal lattice may cause diffuse opacities.

The dissolution can be avoided by increasing the concentrations of $\text{Ca}^{2+}$ and/or $\text{PO}_4^{-3}$ in the fluid.

Therefore, the lower the pH, the higher the concentrations of $\text{Ca}^{2+}$ and $\text{PO}_4^{-3}$ required to reach saturation in respect to hydroxyapatite.

**Mechanism Action of fluoride**
1- Inhibition of Demineralization

The continued deposition of fluoride into enamel during the later stages of enamel formation, and especially during the period of enamel maturation, results in a concentration gradient of fluoride in enamel. Invariably the highest concentration of fluoride occurs at the very outermost portion of the enamel surface, with the fluoride content decreasing as one progresses inward toward the dentin. This decrease in fluoride concentration is extremely rapid in the outermost 5 to 10 microns of enamel and is much less pronounced thereafter. This characteristic fluoride concentration gradient has been observed in unerupted teeth as well as in erupted teeth and in both the permanent and deciduous dentition, regardless of the amount of previous exposure to fluoride.

2- Enhance Remineralisation

The primary chemical reaction product with all three types of topical fluoride systems (i.e., NaF, SnF2, and APF) is the formation of calcium fluoride on the enamel surface. A relatively rapid loss of fluoride occurs within the first 24 hours, with some continued loss occurring during the next 15 days. The rate of loss varies between patients and is influenced by the nature of the fluoride treatment. Nevertheless, it is known that each individual professionally-applied fluoride treatment results in an increase in the permanently-bound fluoride content of the outermost layers of the enamel with a subsequent decrease in the susceptibility of the enamel for caries initiation and progression. It is known that the most desirable form of fluoride in enamel for caries prevention is fluorhydroxyapatite and that the most efficient means of forming this reaction product occurs with prolonged exposure of enamel to low concentrations of fluoride. It is also known that calcium fluoride may serve as a fluoride source for enamel remineralization and that calcium fluoride dissolves much more slowly in the oral environment than in an aqueous solution due to the presence of a phosphate or protein-rich coating of the globular deposits of calcium fluoride on the enamel surface. The deposits of calcium fluoride serve as an important fluoride reservoir and that these phosphate-coated globules are
dissolved in the presence of plaque acids providing an available source of both fluoride and phosphate to facilitate the remineralization of decalcified areas.

\[ \text{Ca}_{10} [\text{PO}_4\text{OH}]_2 + 20\text{F} = 10\text{CaF}_2 + 6[\text{HPO}_4]^{3-} \]

Hydraxyapatite Calcium fluoride

Effects of Fluoride on Plaque and Bacterial Metabolism

The cariostatic effects of fluoride are mediated through a chemical reaction between this ion and the outermost portion of the enamel surface. The preponderance of data supports this view. A growing body of information suggests, however, that the caries-preventive action of fluoride may also include an inhibitory effect on the oral flora involved in the initiation of caries. The ability of fluoride to inhibit glycolysis by interfering with the enzyme enolase has long been known; concentrations of fluoride as low as 50 ppm have been shown to interfere with bacterial metabolism. Moreover, fluoride may accumulate in dental plaque in concentrations above 100 ppm. Although the fluoride normally present in plaque is largely bound (and thus unavailable for antibacterial action), it dissociates to ionic fluoride when the pH of plaque decreases (i.e., when acids are formed). Thus, when the carious process starts and acids are formed, plaque fluoride in ionic form may serve to interfere with further acid production by plaque microorganisms. In addition, it may react with the underlying layer of dissolving enamel, promoting its remineralization as fluorhydroxyapatite. The end result of this process is a "physiologic" restoration of the initial lesion (by remineralization of enamel) and the formation of a more resistant enamel surface. The ability of fluoride to promote the reprecipitation of calcium phosphate solutions in apatitic forms has been repeatedly demonstrated.

In addition to these possible effects of fluoride, several investigators have reported that the presence of tin, especially as provided by stannous fluoride, is
associated with significant antibacterial activity, which has been reported to
decrease both the amount of dental plaque and gingivitis in both animals and
adult humans. Existing evidence suggests that these antibacterial effects of
fluoride and tin may also contribute to the observed cariostatic activity of
topically applied fluorides.

Dentin: De- and Remineralization

(1) Dentin is more susceptible to caries attack than enamel, with a critical pH
more than 1 pH unit higher than that for enamel.

(2) Dentin demineralizes faster and remineralizes slower than enamel under
the same experimental conditions.

(3) More concentrated fluoride is needed to inhibit demineralization and to
enhance remineralization of dentin when compared with enamel. Clinical trials
show a beneficial effect of 5,000 ppm fluoride over 1,100 ppm fluoride
dentifrices to arrest root carious lesions.

(4) Dentin seems to benefit from a higher daily frequency of exposure to
fluoride and also from the combination of methods of fluoride use which is not
necessarily the case for enamel.

(5) Dentin contact area with cariogenic acids is larger than that of enamel. For
this reason, dentin is apparently much more permeable to acids, with
demineralization taking place at a relatively large depth, while mineral
deposition is restricted to the outer layers.

Methods of fluoride application

Methods should be classified according to their mode of application, as
follows:

1– Community Methods: introduced on a population basis (water, milk and
salt fluoridation)

2- Self- Applied Methods: used at home (toothpastes, mouth rinses, tablets,
drops, lozenges and chewing gums)

Fluoride Compounds

1- Inorganic compounds: (e.g. Sodium fluoride (NaF))

readily soluble salts that provide free fluoride; the most commonly used fluoride compound (both selfapplication and professional use); when in solution, NaF salt readily releases fluoride into saliva, dental plaque, pellicle and enamel crystallites. Used in dentifrices, mouth rinses, chewing-gums, Solutions, gels, varnishes, prophylaxis pastes, slow- release devices

2-Ammonium fluoride (NH4F) although investigated intensively some decades ago, it is currently unused – mainly due to its unpleasant taste and lack of superiority in clinical performance over NaF. Formulations used in solutions, Titanium tetrafluoride (TiF4) able to significantly reduce enamel solubility (as solution), due to the formation of a glaze on enamel and dentine; currently being tested in solutions/varnishes as preventative for caries and erosion used: solutions, varnishes

3- organic fluorides: fluoride bound to organic compounds e.g. Amine fluoride which used in: dentifrices, gels, mouth rinses prophylaxis pastes. Associated with a reduction in plaque adhesiveness due to the greater affinity of hydrophilic counter-ions to the enamel.

Advantages and Disadvantages of Topical Fluorides

Advantages
1. Does not cause fluorosis.
2. Cariostatic for people of all ages.
3. Available only to people who desire it.
4. Easy to use.

Disadvantages
1. Person must remember to use.
2. Per capita cost is high compared to water fluoridation.
3. More concentrated professional use products can cause short-term side effects like nausea immediately after use. Not all fluoride agents and treatments are equal.
4. Different fluoride compounds, different vehicles, and vastly different concentrations of fluoride have been used with different frequency and duration of application. All of these variables influence the clinical outcome with respect to caries prevention.

The efficacy of topical fluoride depends on:
- a. The concentration of fluoride used
- b. The frequency with which it is applied and the duration application.
- c. The specific fluoride compound used.

Regarding the concentration of fluoride used, most fluoride dentifrice studies have shown a dose response effect which mean that the trends in clinical effectiveness of professionally applied topical fluoride agents are similar.

Classification: Fluorides Applied by Dentist/professionally Applied
A. Aqueous solutions
   • Sodium fluoride - 2 %
   • Stannous fluoride - 8%
B. Fluoride Gels
   Acidulated phosphate fluoride - 1.23 %
C. Fluoride varnishes
   • Duraphat
   • Fluor protector
D. Fluoride prophylactic paste
E. Restorative materials containing fluoride
F. Fluoride containing devices (slow release)
Self Applied
   • Fluoride dentifrices
   • Fluoride mouth rinses.