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Fluoride in Dentistry: Use, Dosage, and Possible Hazards

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Abstract

Fluoride (F) therapy is the delivery of fluoride to teeth, either topically or systematically, to protect them from dental caries. Extensive evidence proved that fluoride toothpastes and water fluoridation reduce dental caries. Fluoride and water fluoridation in dentistry were classified as one of the 10 most important public health measures of the 20th century. This article briefly addresses the fluoride's issue in dentistry, its use and dosage, and possible hazards due to excess fluoride.

INTRODUCTION

In 1901, when Dr. Frederick McKay started his dental practice in Colorado Springs, USA, he noticed that many of his patients had a mysterious brown staining of their teeth, He investigated the issue for 30 years and was stunned to notice that the strangely stained or "mottled" teeth were also decay free, and he strived to determine the drinking water as the cause of this strange phenomenon [1].

In 1931, Dr. H. Trendley Dean, a dentist working for the US Public Service, was studying the harmful effects of fluoride, and in 1950, he demonstrated that fluoride therapy, in small amounts, has obvious large benefits with negligible side-effects resulting in an enamel staining ("mottling" of teeth), known later as "fluorosis". At that time, Dean suggested that a water supply fluoride concentration of about 1mg/L or 1 part per million (1ppm) (roughly equivalent to a grain of salt in a gallon of water) will be associated with substantially fewer cavities [2].

The safety of Fluoride has been the subject of much discussion indeed; it is one of the most extensively researched health measures. What can be said is that the balance of evidence suggests that Fluoride, when properly used, offers a safe and effective route to better dental health.

Dental and oral diseases are important public health problems: pain, disability, and handicap resulting from them are common, and the costs of treatment are a major problem. One of the most efficient elements in prevention of dental decay is Fluoride.

Fluoride reduces the incidence of dental caries and slows or reverses the progression of existing ones. Fluoride has made enormous contribution to declines in dental caries over the past 80 years. Fluorine (F) is an element of the halogen family, which also includes Chlorine, Bromine, and Iodine. It forms inorganic and organic compounds called Fluoride. Living organisms are mainly exposed to inorganic fluorides through food and water. The most relevant inorganic Fluorides are Hydrogen fluoride, Calcium fluoride, and Sodium fluoride.

How does fluoride act in dental caries prevention?

Three theories prevail:

1. Fluoride becomes incorporated into the hydroxyapatite crystals of teeth, rendering them more resistant to acid attack.
2. Presence of saliva promotes remineralization of early carious lesions. By mean of having the molecule F replace the molecule OH in the hydroxyapatite and transform it to fluoroapatite; this process will make the enamel more resistant to caries, only of the fluoride is given for a long period of time on regular bases.
3. Fluoride interferes with metabolic pathways of bacteria, thus reducing acid.

F can be provided either systematically (in water, salt, and milk) or locally (use of topical fluoride such as toothpaste, gel, varnish and mouth rinse). However, there are additional sources of fluoride in the environment which can occur naturally, or as result of industrial process.

The US National Academy of Sciences (NAS) Institute of Medicine has recommended an adequate intake of fluoride from all sources as 0.05 mg F/Kg body weight/day.

METHODS OF FLUORIDE DELIVERY

Water fluoridation

- Life-long resistance produces the greatest caries-protective effect.
- 20-40% reductions in caries over lifetime.
- As of 2012, about 435 million people, worldwide, received fluoridated water at recommended level, and about 214 million

of them live in the USA.

• Caries increases after fluoridation cessation.

• Advantages: safe, cost-effective, consistent. Low risk of over-dosage.

• Disadvantages: no freedom of choice removed, requires complex infrastructure and initial capital outlay.

• Dosage requirement average: 1 ppm.

Fluoride tablets and drops

• 40-50% reduction in caries (in both adults and children).

• Although NaF is the compound of choice, it is not the only form of fluoride that exist (Amino Fluoride can also be used in toothpastes). NaF remains the only alternative in mouth rince.

• Care required in prescribing to minimize over-dosage and fluorosis.

• 0.5 mg F/day in children under 4 years and 0.75 to 1 mg for older.

• Advantages: effective, freedom of choice.

• Disadvantages: compliance needed, consistency of delivery needed, risk of overdose.

Recommended total dietary fluoride intake (Table 1)

Fluoride salt

• Effective.

• Caries protective as good as fluoridation.

• Dose: 250 ppm.

• Advantages: effective, freedom of choice.

• Disadvantages: conflict with general health messages advising reduction in salt intake.

Topical fluoride

• Examples include aqueous solutions of sodium fluoride and stannous fluoride, low pH solutions such as t h e acidulated phosphate fluoride system.

• 20-35% reduction in caries.

• Used usually in school-based mouth rinsing programs.

• Varnishes may be applied directly to teeth in high concentrations

• Gels may be applied directly to teeth, as well.

• Advantages: effective in individuals at high risk for dental caries, freedom of choice.

• Disadvantages: need personnel, time consuming.

Fluoridation Toothpastes

• Simplest method of fluoride delivery.

• Worldwide declines in caries (attributed to toothpastes).

• Commercially available as of the late 1960s, 95% by late 70s are fluoridated pastes.

• Typical concentrations used: 1000-1500 ppm of fluoride per gram of toothpaste; a lesser dose is used in children: 100-550 ppm (based on the age and the assessment of carious risk).

• Advantages: easy, effective, freedom of choice.

CONCLUSION

In a NAS September 1997 report (23rd workshop), F was repeatedly regarded by speakers and panel members as an "essential nutrient". F is obviously incorporated into mineral matrix of bones and teeth, and, without question, ingestion of even milligram amounts of F during infancy and early childhood may produce the "unmistakable toxic effects of dental fluorosis" [3]. Disruption of normal enamel formation is stated (in the 1997 report) not to be "of Public Health Significance" if the F concentration in drinking water is below 2mg/ liter (2ppm), and reports of disfiguring dental fluorosis with staining and pitting of the enamel in areas with 1-2 ppm F in drinking water were evidently overlooked.

Most authors and clinicians estimate that crippling skeletal fluorosis occurs when 10-20mg of F have been ingested on a daily basis for at least 10 years: in that case, calcification of

Table 1: Recommended total dietary fluoride intake.

Age	Systematic Use		Local or Topical Use			
	Tablets and Drops	Salt	Toothpastes	Mouth Rinsing	Varnishes (22000 PPM)	Gels (22000 PPM)
0-6 Months						
6-12 Months	0.5 mg					
1-3 Years	0.75 mg	0.12 per/meal	100-250 ppm			
4-8 Years	1 mg	0.12 per/meal	500 ppm		2 times/year	2 times/year
> 9 Years		0.12 per/meal	1000-1500 ppm	250 ppm	2 times/year	2 times/year

Age	Reference weigh Kg	Adequate Intake mg/day	Tolerable upper Intake mg/day
0-6 Months	7	0.01	0.7
6-12 Months	9	0.5	0.9
1-3 Years	13	0.7	1.3
4-8 Years	22	1.1	2.2
> 9 Years	40-76	2-3.8	10

ligaments often precludes joint mobility and numerous exostosis may appear, and these effects may be associated with muscle wasting and neurological complications due to spinal cord compression (Prof. Garry M. Whitford, Fluoride Expert, Medical College of Georgia, USA - 1996, in "The Metabolism and Toxicity of Fluoride") [4].

Also, unexplained intermittent episodes of gastric pain and muscular weakness have been clinically linked in areas of endemic dental and skeletal fluorosis intakes as low as 2 to 5 mg/day [5-7].

In March and July 2014, Grandjean and Landrigan (in "Lancet Neurology") addressed the issue of F neurotoxicity, and some authors and experts worldwide, are presently conducting studies that aim to classify F as a neurotoxin, in order to push towards removing industrial sodium F from the world's water supply. This trend considers F as a developmental neurotoxicant (same as manganese, chlorpyrifos, tetrachloroethylene, and others) that may cause neurodevelopmental disabilities (such as Attention Deficit Hyperactivity Disorder -ADHD-, dyslexia, etc...) [8,9].

The 2013 findings by Harvard University meta-analysis (funded by the National Institutes of Health - NIH, in Bethesda, Maryland, USA) concluded that children in areas with highly fluoridated water have "significantly lower" IQ scores than those who live in areas with low amounts of fluoride in their water supplies: this 32-page report (written by several researchers) reviewed the findings of 27 studies (published over 22 years) that suggest an inverse association between high fluoride exposure and children intelligence [10]. Researcher's results support the possibility of adverse effects of F exposures on children's neurodevelopment but future research should formally evaluate dose-response relations based on individual-level measures of exposure over time, including more precise prenatal exposure assessment and more extensive standardized measures of neurobehavioral performance.

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