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Systemic Methods of Fluoride and the Risk for Dental Fluorosis

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1. Introduction

The benefits from ingesting fluoride for controlling dental caries have been suggested more than a century ago. Later in the 1940s, the well conducted water fluoridation program developed in the United States established the potential for delivering fluoride in public water supplies which opened the opportunity for other systemic methods: salt, milk and supplements (Hunstadbraten, 1982; Hoffmann-Axthelm, 1981). Due to its systemic effect, fluoride has been regarded as effective only if ingested for a long period. The low doses proposed were regarded as safe enough to guarantee the most beneficial effect against dental caries with minimal fluorosis.

From a historical perspective, the use of fluoride can be divided into two periods: 1) the earlier era, which goes from 1940s up to 1960s, when water fluoridation was basically the only source of fluoride ingestion and 2) the later era when fluoride could be ingested from multiple sources (soft drinks, infant formulas, vitamins, tablets) (Murray et al., 1991). Hence, due to the widespread of fluoride and the updated knowledge about its mechanisms of action, the general opinion about effectiveness and risk of systemic methods of fluoride are completely different from decades ago. Nevertheless, these methods are still recommended in many countries and receive support from recognized international committees and associations. In contrast, many dental practitioners have conflicting opinions about the safety and benefits of having a water fluoridation program in their city.

In addition to the multiple sources of fluoride, the systemic methods for delivering fluoride are also questioned because several studies have consistently indicated that fluoride's action relies mainly on its post-eruptive effect from topical contact with the tooth structure. The situation gets more obscure when the emerging problem of dental fluorosis can also be attributed to early uncontrolled ingestion of fluoride toothpaste by children as well as other sources (Hellwig & Lennon, 2004; Sampaio & Levy, 2011). This may give the impression that a widely used topical method of fluoride such as dentifrice is the solely contributor for dental fluorosis whereas a systemic method of fluoride such as water fluoridation is ineffective since it is a systemic method to deliver fluoride and most of fluoride effect comes from topical sources. These are points of view which can jeopardize the use of fluoride on an individual basis or in a community level.

One of the main problems when studying fluoride in Dentistry is its paradox of combining beneficial and pathological effects in the same chemical element. Taking other water contaminants such as arsenic, there is no doubt about its deleterious effects on human health. Moreover, no beneficial effect exists when considering an ingestion of low doses of arsenic (Hughes, 2002). For fluoride the situation is different. There is an evident advantageous clinical effect when low doses are used together with the concomitant risk for dental fluorosis. Since the borderline of benefits and risks of fluoride can be rather close, researchers around the world have focused on strategies for controlling the amount of fluoride intake. In addition, other aspects on the use of fluoride must be discussed. For instance, there are many epidemiological and biological evidences that ingestion of high amount of fluoride can result in aesthetically undesirable dental fluorosis; how much of this effect is unacceptable is a matter of debate. As a result of the fluoride debate, more and more clinicians and researchers regard this issue as an important topic for discussion and a challenging problem for dental professionals.

Thus, the aim of this paper is to critically review the current role of systemic methods to deliver fluoride considering the risk for dental fluorosis.

2. The mechanism of action of fluoride

Although the mechanism of action of fluoride is well established today, a series of studies was necessary to recognize its cariostatic effect.

Fluoride is an ion naturally found on soil, air and water due to chemical weathering of minerals that contains this element (Murray at el., 1991). This ion has the capacity of inhibiting and activating enzymatic systems as well as a tendency to fixate on hard tissues (bones and teeth). On the teeth this fixation occurs through the substitution of the hydroxyl ion from the hydroxyapatite by the fluoride ion resulting on fluorapatite during the demineralization–remineralization process of the enamel. One interesting observation is that the fluoride effect on the de-remineralization equilibrium is of outmost relevancy, being more important than the incorporation of fluoride in the dental tissue. Actually, this incorporation is an obvious consequence of the fluoride effect on the demineralization-remineralization process and not the beneficial aspect in itself as it has been thought previously (Fejerskov, 2004). One important study that demonstrated that fluoride incorporated into enamel (structurally bound fluoride) was not effective in inhibiting demineralization of a hard tissue was carried out in Scandinavia (Øggard et al., 1988). The researchers prepared in situ devices and placed human and shark enamel slabs in oral appliances. Why shark enamel? The shark enamel is composed of pure fluorapatite (30,000 ppm) whereas the maximum amount of fluoride in human enamel is much lower (4,800 ppm). The oral removable appliances were used by volunteers that allowed bacterial plaque accumulation (oral biofilms) and the development of carious lesions. Microradiographic analyses showed that carious lesions were present in both types of enamel tissues (human and shark). One first conclusion of this study was that incorporation of fluoride into enamel is not the main mechanism for controlling dental caries development. Moreover, the authors compared the mineral loss data obtained to previous data of enamel exposed to 0.2% of sodium fluoride. The results showed that the mineral loss in human enamel exposed to sodium fluoride was lower than that of shark enamel without any additional treatment. In summary, this work provided evidence that the primary mode of action of fluoride is

topical. The fluoride present in the fluid phases of the oral environment is the most important strategy for controlling dental caries (Buzalaf, 2011).

Since fluoride may inhibit the demineralization or enhance remineralization mainly by topical processes, the most effective fluoride regimens are those when frequent low fluoride concentrations are achieved in the oral environment. As a result, topical methods for delivering fluoride gained a status of most effective ones (Limeback, 1999). However, one must bear in mind that traditional systemic methods such as water fluoridation cannot be excluded because its effectiveness can be also topical though in general it is classified as systemic fluoride method. Another point of remark is that regardless the method (topical or systemic) fluoride treatments do not introduce a new substance but rather increase the concentration of an existing one in the oral environment. It must be pointed out that fluoride may also have some antibacterial effect when high concentrations are maintained in the oral cavity. This effect is mainly achieved in topical applications of very high amount of fluoride incorporated in the formula such as varnishes and gels. Hence, it can be suggested that fluoride has more than one mechanism of action for caries arrestment and these mechanisms can be simultaneously in action when exposure to fluoride takes place. Since dental caries is a multifactorial disease caused by the interplay of different factors of the oral environment the duration and cessation of a fluoride exposure must be considered when searching for its mechanism of action.

The beneficial interference of fluoride in the caries development is directly dependent on a constant and permanent level of fluoride in the oral environment (Fejerskov, 2004). There is no need for a high concentration of fluoride because low concentrations can be sufficient for the control of mineral tooth loss. This is a key point when considering the use of fluoride for caries preventive purposes which is different from caries arrestment (Sampaio & Levy, 2011). According to Buzalaf (2011), a good understanding of the mechanism of action of fluoride can be achieved if you consider five "pools" of fluoride categories in the oral environment: 1) outer fluoride (present outside enamel, in the biofilm or saliva), 2) fluoride in the solid phase (incorporated in the mineral structure, also known as fluorhydroyapatite), 3) fluoride in the enamel fluid, 4) fluoride adsorbed in the crystal surface, also known as loosely-bound and finally 5) calcium fluoride material (Ca_2F, globules that are formed just after the application of high concentrated fluoride products such as varnishes and gels) (Figure 1). Our current understanding about the mechanisms of action of fluoride can be summarized when these categories are evaluated in two aspects: fluoride effect on the inhibition of demineralization and its effect on promoting remineralization. Both are processes of the same chemical reaction and both are equally important for caries control.

2.1 Inhibition of demineralization

The fluoride category known as loosely-bound fluoride is the "pool" that effectively protects the dental enamel from mineral dissolution. Note that the fluoride incorporated in the solid phase has little or no effect. However, the fluoride present in the enamel fluid is also important since this is the fluoride category that can increase the loosely-bound fluoride which protects the enamel crystal by inhibition of demineralization (Arends & Christoffersen, 1990). The calcium fluoride category is also an important source of fluoride and it is formed when there is more than 100 ppm of fluoride in the oral environment. This means that this type of fluoride is available when dental products are used. The mechanism of action of this fluoride category can be explained by the formation of calcium fluoride

(Ca_2F) and its dissolution when there is a pH fall (acidic challenge). During this acid attack, the calcium fluoride material (globules) are dissolved releasing an ionic fluoride, in other words, a fluoride that will be present at the enamel fluid which can be adsorbed by the enamel crystal avoiding the demineralization process. In summary, the loosely bound and calcium fluoride material are sources of fluoride that will protect the enamel from the mineral loss.
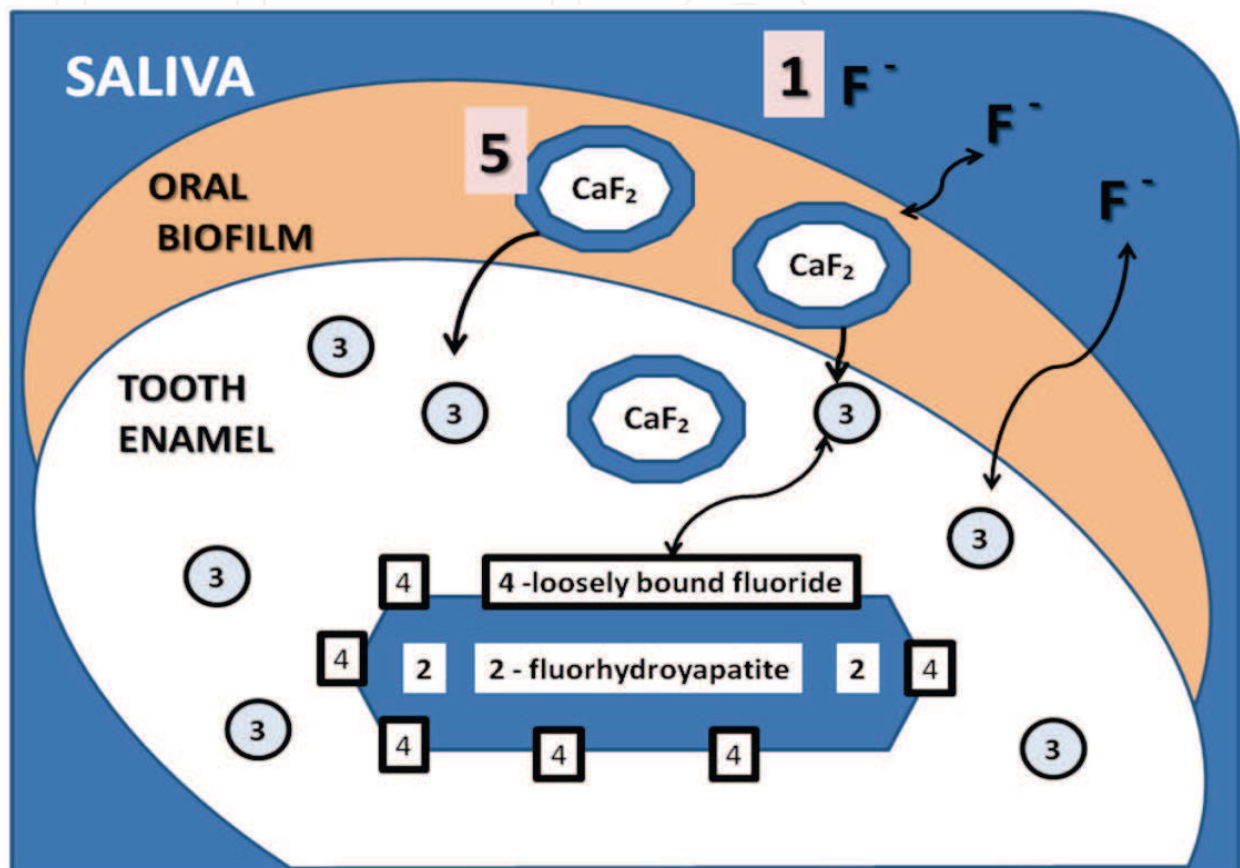

Fig. 1. Schematic representation of fluoride effect on tooth enamel. Note that the numbers represent different categories of fluoride: (1) outer fluoride, (2) fluoride incorporated in the mineral structure, (3) fluoride in the enamel fluid, (4) fluoride adsorbed in the crystal surface, also known as loosely-bound, (5) calcium fluoride material (Ca_2F, globules that are formed just after the application of high concentrated fluoride products)

2.2 Promoting remineralization

When a carious lesion is already present, an acidic challenge is frequently occurring. Under this circumstance, when pH is below 5.5 – a critical pH for dental enamel, the remineralization can naturally take place since saliva is generally supersaturated with respect to dental enamel. If fluoride is present in this acidic medium during dissolution of hydroxyapatite, the solution will be highly supersaturated with respect to hydroxyapatite and all potential mineral loss will actually be preserved in the partially demineralized dental crystals. In other words, traces of fluoride in the fluid phase can control mineral loss. After several cycles of dissolution and reprecipitation, the enamel crystals will be somehow more resistant to future acidic challenges. At this point one may argue that the incorporation of

fluoride will provide a more resistant tissue to dental caries which is not in tune with the actual understanding of fluoride's mode of action (Fejerskov, 2004). However, it must be emphasized that the incorporation of fluoride in this situation is only possible due to the fact that there is a partial dissolved crystal which presents free calcium for fluoride incorporation. Thus, the frequent presence of fluoride in the oral environment during the acidic challenge is as relevant as it is its effect of incorporation. Hence the presence of fluoride at high concentrations is a key strategy for caries control or arrestment of carious lesions (Featherstone, 1999).

2.3 How much fluoride is necessary?

In addition to the understanding of fluoride modes of action, it is also important to observe the concentrations of fluoride used in different methods. The ideal or 'optimal' concentration of fluoride will be the one that will have maximum preventive effect with a minimal risk for dental fluorosis. This is rather difficult to consider since individual variations in fluoride bioavailability and cultural habits may influence the intake of fluoride from systemic methods such as water, salt or milk (Newbrun, 2010).

It must be pointed out that the classification of 'systemic' and 'topic' is related to its way of delivery and not to its mode of action. In other words, the mode of action of water fluoridation for caries control is explained by the topical contact of water fluoride on the teeth when someone is drinking water and eating food prepared with fluoridated water. One additional effect is the redistribution of fluoride in the oral cavity by means of saliva (Whitford, 1996). Hence, as stated before, fluoride acts mainly by its topical effect but this is not an argument to invalidate the systemic methods of fluoride. On the other hand, topical and 'systemic' methods of fluoride delivery may be involved with a high rate of fluoride ingestion. Taking fluoride toothpaste as an example, it is classified as a topical method but there is no guarantee that some ingestion of fluoride may occur when a child is under toothbrushing procedure.

So, if low sustained levels of fluoride is maintained in the oral fluids, some level of loosely bound fluoride will be available and a significantly control of caries progression and also reversal of carious lesions may occur. The low levels of fluoride are those found after many hours on resting dental plaque and saliva, and resulting from the regular use of fluoride toothpastes. Another source of low levels of fluoride are the constant exposure to this substance from water, milk, salt or whatsoever source is available on the oral environment (Lynch et al., 2004).

3. Dental fluorosis

The only recognized side effects of high ingestion of fluoride are dental and skeletal fluorosis (Whitford, 1996). Since skeletal fluorosis occurs only in naturally fluoridated regions where extreme high concentrations of fluoride are found in the water, the focus of this chapter will be on dental fluorosis. In addition to the dose differences for the risk of dental and skeletal fluorosis, one must bear in mind that individuals with dental fluorosis are those who were exposed to fluoride from birth up to 6-7 years of age, exactly the period of tooth formation. For skeletal fluorosis the context is much more complicated. The dose-response outcome is not clear since the different ages reflect different "turn-over" of fluoride in bones. In addition to age and fluoride dose, variables such as gender, calcium intake from the diet, duration of fluoride intake and renal efficiency in fluoride handling are relevant

factors which influence the outcome. The bone lesions are a combination of osteosclerosis, osteomalacia and osteoporosis of varying degrees which can also make diagnosis a difficult task (Krishnamachari, 1996).

Dental fluorosis is an enamel opacity due to a long-term ingestion of fluoride during tooth formation period. The tooth appearance can vary from narrow white lines to "cloudy" white spots or brown areas with pits. Loss of enamel is also frequent in more severe cases (Figure 2).

Fig. 2. This is a case of severe dental fluorosis in a 13-year-old child who consumed naturally water fluoride with 4.8 ppm. Note that the dark brown stains are limited to upper incisors. The lower incisors were the less affected teeth

The severity of the disease will depend on several factors such as dosage, duration of exposition, the activity stage of the protein, age and individual susceptibility. Fluorotic enamel is characterized by the retention of amelogenins in the early maturation stage of development and the formation of enamel which have a hypomineralized subsurface and more porous tissue. This is a conflicting point. Since dental fluorosis is related to high consumption of fluoride during tooth development, many dental professionals make the assumption that this tooth condition is related to a high concentration of fluoride in the dental tissues (enamel and dentin). Actually, it is the opposite situation. The white chalk appearance of the enamel is related to the light refraction of this tissue that presents a high porous appearance due the hypomineralized subsurface (Levy, 2003).

There are many individual and environmental variables that may interfere with the severity of dental fluorosis. Malnutrition has been one of these variables (Murray et al., 1991). However, in a study performed in the semi-arid region of Brazil where there was a 20% prevalence of malnutrition the prevalence of dental fluorosis was virtually the same regardless the fluoride level in the drinking water (Sampaio et al., 1999). However, the observation that malnutrition prevalence was not related to dental fluorosis cannot be disregarded since this is an epidemiologic observation for a specific group.

Genetic background appears to have a role in the pathogenesis of dental fluorosis. Moreover, altitude, renal problems and individual cultural habits may also be considered (Buzalaf, 2011).
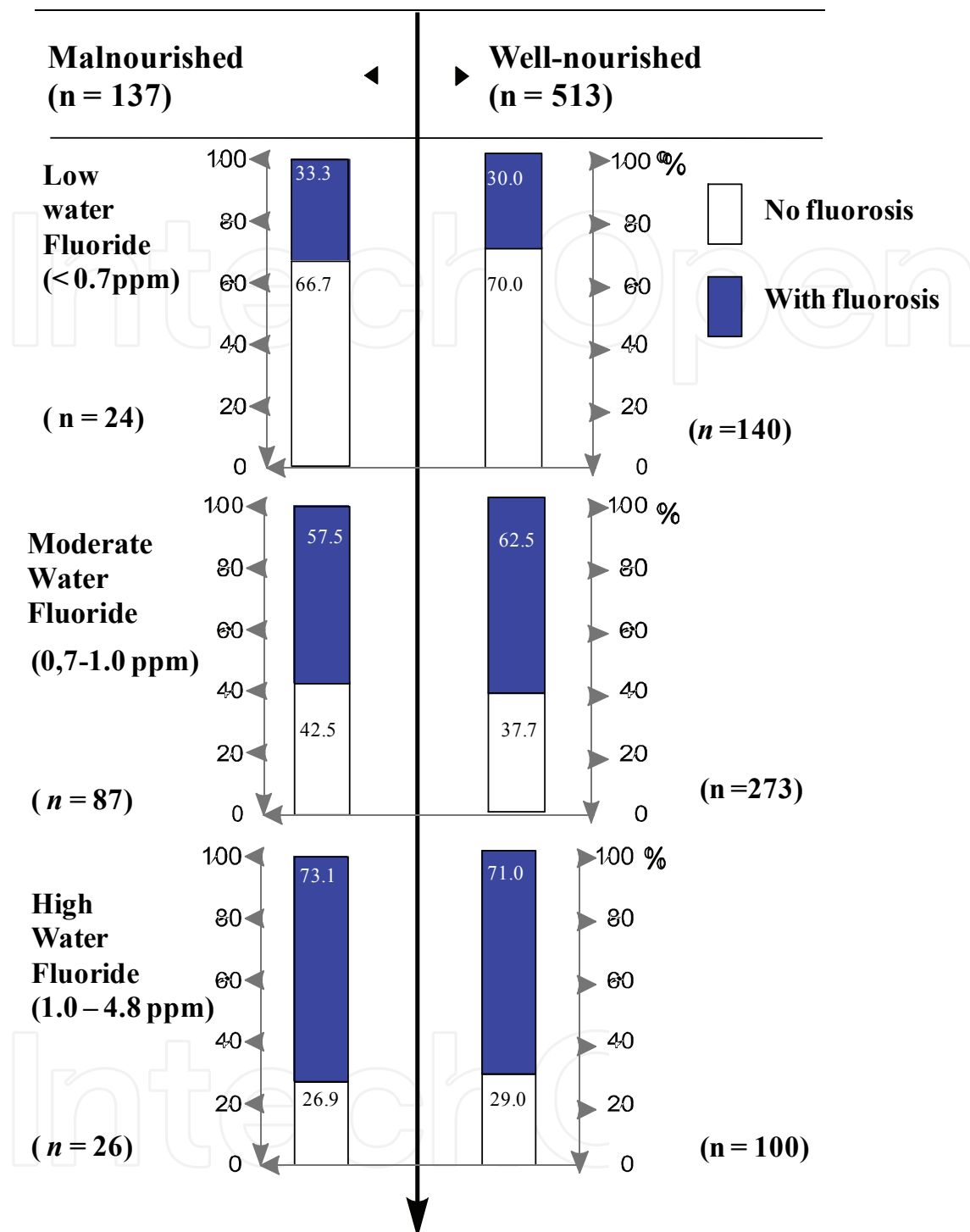
Fig. 3. Distribution of children with and without dental fluorosis in an epidemiologic study assessing the influence of malnutrition on the risk for dental fluorosis. (Source: Sampaio et al., 1999)

There is some consensus that the mechanism by which fluoride interferes with the enamel maturation process that can result in fluorosis is a multi-factorial model (den Besten & Li, 2011). The major theory behind this mechanism is the retention of amelogenin proteins that delay the maturation of the enamel. As a result, the enamel becomes hypomineralized and

porous. The understanding of these events is important because the dental fluorosis diagnosis is sometimes complicated by other enamel defects (Levy, 2003).

Discoloration of the enamel, as seen in figure 2, is due to a secondary uptake of colored substances into the porous enamel. Thus, this is actually a posteruptive condition due to dietary habits and not an indication of fluorosis severity (Sampaio & Levy, 2011).

During the examination for dental fluorosis, the enamel surface must be clean and dry. When the enamel surface is dried, the water in the enamel pores will be replaced by air. Hence, even slight enamel opacities can be observed. This procedure, which is used for scoring fluorosis with a fluorosis index (Dean index or Thysltrup and Fejerskov index), can classify dental fluorosis on different degrees, and differentiate fluorosis from other enamel opacities (Murray et al., 1991).

Fig. 4. The clinical appearance of carious lesions known as white spots. Note the opaque aspect of the lesions, the curved shapes close to the gingival margin. These are some of the points to consider that these white lesions are not related to dental fluorosis. In addition, the lesions are limited to gingival margin. The patient has also gingivitis in a clear indication that these are active carious lesions. The final diagnosis is confirmed by the fact that the patient did not live in areas with water fluoridation systems and avoided the use of fluoride toothpaste since childhood

Enamel hypoplasias are the most common opacity to be confounded with fluorosis. However, hypoplasias are generally enamel lesions of round or oval shapes with marked borders. In addition, hypoplasia may affect a single tooth in contrast to fluorosis that can be observed in contralateral teeth or in the whole dentition. These basic features can help the clinician to differentiate these opacities from fluorosis.

In recent years it has been noticed that the prevalence of enamel fluorosis is increasing in several countries. However less than 40% of dental fluorosis is caused by ingestion of water while the majority is caused by the halo effect that is the addition of the other sources of fluoride such as industrialized food and beverages (Buzalaf, 2011). In Brazil, soft drinks are

beverages consumed less than tap water, but these products can be a source of fluoride. Considering that the highest industrialized part of the country is receiving fluoridated water, a 'halo effect' is likely to be significant. In fluoridated areas, powder milk and infant formulas can be extra sources of fluoride due to the additive effect of the fluoridated water (Sampaio et al., 2010).

Estimates of infant fluoride intake from Brazilian food are considered to be low and seldom more than 0.25 mg daily. However, in a fluoridated city (0.7 ppm), the estimated fluoride intake including the fluoride products (toothpaste and rinse) may increase and possibly reach the threshold for dental fluorosis according to the fluorosis index for the community (Omena et al., 2006).

How much fluoride can result in dental fluorosis? This is a general question that is always present among dentists, patients and health authorities. First it must be pointed out that even individuals with a very low fluoride intake from the water might show some degree of dental fluorosis. Considering the intake solely by water, the amount of fluoride can be directly related to some effect. However, this is not that simple anymore since other sources of fluoride are available nowadays (Levy, 2003). Therefore the 'optimal' fluoride level that would prevent caries without resulting in fluorosis is somehow a theoretical value since bioavailability of fluoride varies among individuals (Sampaio et al., 1999). Nevertheless, the dose that may cause dental fluorosis is within the range of 0.05-0.07 mg F/Kg body weight per day. This means that children who present a fluoride intake above the threshold of 0.07 mg F/Kg per day will probably present some degree of dental fluorosis (Buzalaf, 2011). The upper central incisors are the teeth of more aesthetic concern. The risk period of fluorosis for maxillary central incisor teeth is between 15 and 24 months for males and between 21 and 30 months for females (Bårdsen, 1999).

4. Systemic fluoridation methods and the risk for dental fluorosis

In spite of the safety of most methods of fluoride delivery, an overlap of systemic methods may take place. There is also the risk of a high intake of fluoride due to a combination of water fluoridation and the ingestion of fluoride from toothpastes (Sampaio & Levy, 2011). These are important aspects that a dental professional must consider before establishing a fluoridation program on an individual basis or as an authority in public health office. This is a specific relevant issue regarding systemic fluoride methods. In most circumstances, the dental professionals just follow political decisions about these methods. In many cases the information is scarce and most part of the population is not aware of fluoridation programs. In spite of the general decisions taken by groups or general assemblies, the professional must be aware if a systemic fluoride method is being applied in their own community. For instance, most Brazilian dentists are not aware if there is a water fluoridation program in their hometown in spite of the fact that there is a national program for water fluoridation (Sampaio et al., 2010). This is also valid for countries where salt fluoridation is available and the dentist do not ask if the patient is a fluoride salt consumer. Some authorities consider that systemic fluoride methods are advantageous in comparison to topical methods because the beneficial effect occurs without the evident knowledge of the patient and also the dentist. This is rather disturbing since the lack of knowledge on whether a systemic method is available can create at least two negative interpretations. First, not knowing if someone is drinking fluoridated water or consuming fluoridated salt can jeopardize any community program since most people will not be aware of the beneficial aspect of the measure. Second,

the ignorance can be an opportunity for a problem of overlapping methods. This was the case of Brazil in the 90´s when a national water fluoridation program would overlap with a proposal of salt fluoridation for the majority of the population (Kalamatianos & Narvai, 2006).

Another issue regarding the risk of dental fluorosis is: how much of fluorosis is acceptable? This is a real dilemma that can be solved by accepting that the use of fluoride products may result in mild dental fluorosis in the population. On the other hand, if fluoride is not used at all there is the inconvenience of not preventing the appearance of a disease (caries) that could be prevented if such product was used. This dilemma can be solved by admitting that the use of such products would be reasonable and that its benefit would exceed its damages. Moreover, the mild fluorosis that is produced in most cases has no significance at all for the majority of the population.

In addition to the fact that dentists must be aware of the systemic methods in their places of work, it is also important to know the types of fluoride that are used and the respective concentrations. Table 1 provides some of the fluoride salts that are commonly used for 'systemic method'.

F-methods	F-compounds	F-concentrations
Water fluoridation	hydrofluorosilicate (FSA), sodium fluorosilicate, sodium fluoride	0.7 - 1.2 mg/L
Salt fluoridation	potassium fluoride , sodium fluoride	250-300 mg/kg
Milk fluoridation	Sodium fluoride or disodium monofluorophosphate	5 mg/L
Dietary F-supplements	sodium fluoride, acidulated phosphate fluoride, potassium fluoride, calcium fluoride	0.25 – 1.0 mg/day

Table 1. Fluoride compounds and concentrations that are usually used in different 'systemic' fluoride methods. (Source: Sampaio & Levy, 2011)

Here we have a review of most important aspects about some community systemic methods.

4.1 Water fluoridation

The water fluoridation is one of the most common delivery methods of fluoride. It presents a lower cost and long range. However for water fluoridation to be effective it has to be a continuous process and the concentration of fluoride has to be well controlled. The recommended concentration varies between 0.7 and 1.2 ppm, depending on the average regional temperature. The lower levels of fluoride are recommended for warmer regions. In these locations the intake of water tends to be higher (Sampaio et al., 2010).

Fluoridation of public water is considered to be one of the ten most important public health measures in the last century being recommended by international health organizations. In addition, there is scientific evidence proving beneficial and safe effects of fluoridation on human health. The inverse relationship between higher fluoride contents of drinking water and lower levels of dental caries experience demonstrated by Dean half century ago is still

true today. A general estimate indicates that over 300 million people in almost 40 countries are exposed to fluoride from adjusted fluoridated water supplies. Most of the individuals of this estimation are located in the United States (195 million people). In spite of being a safe method, recently, the Department of Health and Human Services of the United States proposed a new standardized level of 0.7 ppm fluoride throughout the country as an appropriate level for maximizing benefits while minimizing any risks associated with excessive ingestion (Department of Health and Human Services, 2011). This a precaution measure and must not be interpreted as a limitation of water fluoridation. Actually, the precaution is based on the fact that temperature is no longer a good indicator of fluoride intake. First, most American children in summer live in air conditioning environment most part of their lives. Second, there is an evident raise in the use of dental fluoride products which can result in an increase in the fluoride intake.

In the early seventies several industrialized countries went through a bitter emotional fight about water fluoridation. In some countries, the anti-fluoride people were the winners of the public debate and fluoride was discredited. The fluoride fight did not subside until the people were able to see by themselves the dramatic improvements in their children's dental health and also the decline in their own dental bills due to topical fluoride and fluoride toothpastes. Even though water fluoridation is much more popular in the Americas than in European countries, this method can be regarded as a low cost method to deliver fluoride, particularly for those communities where oral health care and particularly fluoride dentifrices are not available and/or not affordable. Variables that influence the costs per capita of a fluoridation project include: a) the size of the community (the smaller the community, the higher the per capita cost); b) the prevalence of dental caries in the population; c) the number of water sources; d) the type of equipment; e) the fluoride compound and f) the availability of technical support (Sampaio & Levy, 2011). In general, there is a consensus that water fluoridation can be most advantageous for more deprived communities where other health policies are less available, however, at least for the Brazilian situation, water fluoridation is present in most affordable areas of the country whereas the regions where it is most needed it is not available yet (Gabardo et al., 2008).

Water is by large the main source of fluoride intake for human beings (Whitfrod, 1996). In general, the natural fluoride present in the fresh-water do not exceed 0.3 ppm (mg/L). This is a matter of confusion. Most people do not differentiate the natural fluoride from the controlled water fluoridation programs. This is important since most severe cases of dental fluorosis are related to rural areas where the patients have been consuming high amount of fluoride in the water for a long time (Sampaio et al., 1999). On the other hand there is the urban patient who is not exposed to high amounts of fluoride, in general the mother was careful enough to avoid ingestion of fluoride toothpaste and possibly only a mild fluorosis may occur. These are different situations and must be taken under different interpretations because dental fluorosis perception is also different (Murray et al., 1991).

For rural areas or more desert types of climate, one interesting strategy for public health is to monitor water fluoride levels in order to estimate the fluoride intake. Mapping fluoride in areas is very important because in many tropical areas the chances of finding severe cases of dental fluorosis is higher (Levy, 2003).

Finally, it is already evident that the percentage level of effectiveness of water fluoridation in many areas is lower than in others due to the more widespread use of other fluoride modalities. Nevertheless, water fluoridation is still a valuable health measure and must not be underestimated (Sampaio & Levy, 2011).

4.2 Salt fluoridation

This method was introduced in the 1950s following the successful program of iodine against goiter. It was idealized as an option for water fluoridation but reproducing the idea of incorporating fluoride in the tooth (Marthaler, 2005). Today, the aim is to reach communities and regions in the world where oral care prevention measures, and particularly fluoride toothpastes, are not available. This method is successfully implemented in almost all Latin American countries and in some European countries (France, Germany and Switzerland). The levels of 250-300 mg/kg of fluoride in salt are regarded as the ideal range of concentration while the concentration of 200 mg/kg of fluoride is regarded as the minimal acceptable level of fluoride. One positive aspect of salt fluoridation is the very low cost for implementation. However, there is one major point of concern: somehow promoting salt fluoridation could be contraindicated from the perspective of general public health because the greater the salt consumption the greater could be the link to hypertension. On the other hand, most estimates indicate that usually the patients are consuming low salt diets (less than 5 g of NaCl per person per day) and taking this amount of salt, essential hypertension will be uncommon. Moreover, there is no doubt that some salt is required by man, and estimates of normal daily requirements for adults have ranged up to 15 g per day (Dahl, 2005).

Regarding the overlapping of fluoride delivery methods, similar to water fluoridation, some concern has come to a debate. Thus, the simultaneous combination of fluoride ingested from both dentifrice and salt can be a problem? Available data suggest that this combination has not resulted in objectionable enamel fluorosis levels (Menghini, 2005).

In summary, there is no doubt that salt fluoridation is a systemic method of very low cost. Salt fluoridation can be considered as a systemic method of choice when water fluoridation is technically difficult or due to economic or socio-cultural reasons it cannot be implemented (Sampaio & Levy, 2011). Finally, the drawbacks for implementing a salt fluoridation program (such as variation in ingestion, difficulties in maintaining the ideal concentration and concerns with hypertension) are minimal when compared to the advantages of this method.

4.3 Milk fluoridation

The first milk fluoridation experience was developed in Bulgaria, in the cities of Plovdiv and Asenovgrad, in 1988. Then the experience was expanded to other European countries and also to Chile, Peru and China (Bánóczy et al., 2005). Since the amounts of water and milk consumed daily are different, in terms of caries prevention the fluoride concentration should be 1 mg/L and 5 mg/L for water and milk, respectively. These values were considered before the last American resolution of reducing the levels of fluoride in the drinking water (Department of Health and Human Services, 2011). Thus, taking water fluoride as reference new publications are needed for the update of levels of fluoride in milk as well as for other methods. A possible change in fluoride levels in milk is very important since this is the most popular systemic method in some countries. An interesting aspect about milk fluoridation is its use among children. This is the target age group and well conducted school-based programs have been developed (Horowitz, 1982; Rodrigues et al., 2010). As a result, most data available for this method are from studies with children. Milk consumption varies considerably when comparing different regions of the world. The consumption is higher in developed countries (212 kg per person/year) whereas it is lower in developing countries

(45 kg per person/year) (Sampaio & Levy, 2011). Latin America has one of the highest estimates among developing countries with 110 kg per person/year, but this is regarded as low when compared to developed countries. Conversely to salt fluoridation, which can be linked to hypertension, milk fluoridation programs have the appeal of nutrition for children. This is a positive aspect when promoting health. However, the favorable features of milk can be strongly compromised when sucrose is added. In spite of the fact that cow´s milk is essentially non-cariogenic, the addition of sucrose in the milk can promote early caries in young children. Thus, the milk consumption must not increase the sucrose consumption as well. Concerning the effectiveness of fluoridated milk for caries, few randomized clinical studies were conducted. This is also the same for dental fluorosis. However, a recent observation in a Peruvian town with milk fluoridation program showed high consumption of fluoride due to high concentration of fluoride in the drinking water. This is a clear evidence of an overlap of systemic methods that must be avoided (Rodrigues at al., 2010).

5. Risk of fluorosis: What do we know and how to minimize it?

Today, there is clear evidence that fluorosis is increasing worldwide. This concern raises doubts about the beneficial aspects of systemic fluoride methods. But there are clear evidences that these methods have more beneficial effects than risks. For instance, in spite of the potential risk for dental fluorosis, dietary fluoride supplements are regarded as effective in preventing caries and are still available in several countries. This method was not discussed in this paper but this issue is also relevant (Buzalaf, 2011). The recent reduction in fluoride levels in the water communities cannot be interpreted as a limitation of the method. Conversely, this adjustment proves that water fluoridation is still necessary. So, what we know about the risk of dental fluorosis? First, the issue is not as simple as it was before (when water fluoridation started), since today it can involve several sources of fluoride. Second, an 'optimal' dose is a theoretical value, maybe we should work with range of risk and range of concentrations in systemic methods. Third, the classification of systemic x topical methods is no longer valid and might be changed. These major categories might be better classified as: professional methods (varnishes, gels) community methods (salt, water, milk) and individual methods (toothpastes, mouthrinses and supplements). Considering these categories, operational strategies can be more straightforward on the basis of those who are in charge of the method: the dentist, the health authority or the patient.

Other point of concern is that some degree of enamel fluorosis is inevitable with water fluoridation. However, most cases of dental fluorosis are of mild severity. Future studies about fluorosis perception will be valuable for evaluating the level of concern of the population about dental fluorosis. Dean regarded an increased prevalence of fluorosis as an acceptable risk when compared to the preventive benefits.

There are good strategies to minimize the risk of dental fluorosis. The first step is to get the information about the methods of delivering fluoride in a region or town (including toothpastes). Thus, investigating the possible sources of fluoride on an individual basis as well as in a communal basis is important.

The risk of developing fluorosis shows a different trend on urban and rural communities. It is a more common cause of fluorosis on rural communities the high content of fluoride on the drinking water, such as groundwater. On the contrary it is more common on urban

communities the development of fluorosis due to the irrational use of toothpaste by children under 6 years old (Sampaio et al., 2010)

The emerging concern about dental fluorosis must be evaluated in the perspective that systemic methods were already operating when other sources of fluoride were introduced. Thus, the effectiveness of fluoride is not the same for all methods since caries burden is lowering off. It is true that a reclassification to substitute the traditional systemic versus topical methods is necessary. What is not necessary is to simply oppose systemic fluoride methods as long as caries is still the most prevalent disease in many parts of the world.

6. Concluding remarks

- Most studies support the view that the caries-preventive effect of fluoride is mainly post-eruptive. This evidence must not be interpreted as a true limitation of systemic fluoride methods since a topical effect will take place when someone is ingesting fluoride in water, milk or salt or taking a fluoride lozenge.
- Dietary F intake must be considered before any systemic method of fluoridation is implemented. Hence, it is very important to monitor the total fluoride intake of children in the first 3 years of life in order to avoid undesirable aesthetically fluorosis, particularly in central incisors.
- Most systemic methods available are of low cost showing a good cost-benefit relation.
- The overlapping of systemic methods of delivering fluoride must be avoided in order to control caries without the risk of developing dental fluorosis.
- Dental fluorosis related to systemic fluoride methods are of minor concern since mild dental fluorosis is the majority of the cases observed from clinical and epidemiological observations.
- Reclassification to substitute the traditional 'systemic' versus 'topical' methods is necessary. The major categories might be classified as : professional methods (varnishes, gels) community methods (salt, water, milk) and individual methods (toothpastes, mouthrinse and supplements)

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8. References

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Oral Health Care - Prosthodontics, Periodontology, Biology, Research and Systemic Conditions
Edited by Prof. Mandeep Virdi

Geriatric dentistry, or gerodontics, is the branch of dental care dealing with older adults involving the diagnosis, prevention, and treatment of problems associated with normal aging and age-related diseases as part of an interdisciplinary team with other healthcare professionals. Prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation, and maintenance of the oral function, comfort, appearance, and health of patients with clinical conditions associated with missing or deficient teeth and/or oral and maxillofacial tissues using biocompatible materials. Periodontology, or Periodontics, is the specialty of oral healthcare that concerns supporting structures of teeth, diseases, and conditions that affect them. The supporting tissues are known as the periodontium, which includes the gingiva (gums), alveolar bone, cementum, and the periodontal ligament. Oral biology deals with the microbiota and their interaction within the oral region. Research in oral health and systemic conditions concerns the effect of various systemic conditions on the oral cavity and conversely helps to diagnose various systemic conditions.

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