R. Ferro*, A. Besostri*, M.R. Giuca**,
R. Docimo***, R. Gatto****, G. Marzo****

*Surgery Department, Dental Unit, Cittadella Hospital, Health District No 15 "Alta Padovana" (Padua, Italy)
**Department of Surgical Pathology, Unit of Paediatric Dentistry, University of Pisa, Italy
***Department of Paediatric Dentistry, University of Rome "Tor Vergata", Italy
****Department of Life, Health and Environmental Sciences University of L'Aquila, Italy

e-mail: roberto.ferro@ulss15.pd.it

The Italian perspective on fluoride intake in children and adolescents

ABSTRACT

Aim *This paper represents the outcome of the meetings of the Committee composed by Pedodontists (SIOI – Italian Society of Paediatric Dentistry) and Paediatricians (FIMP – Italian Association of Paediatricians) with the aim to share an evidence-based common approach in caries prevention during childhood and adolescence. The most important topic was an update on fluoride administration methods in order to minimise the risk of fluorosis and maximise its caries-preventive effect.*

Conclusion *The conclusions of this work are exposed in a synoptic table (Table 1).*

Keywords *Adolescents; Children; Fluoride; Guidelines.*

Introduction

The prevalence of dental caries is drastically declining in industrialised countries with a remarkable increase of caries-free children. This decrease has been observed in Italy as well, through periodical and epidemiological surveys carried out in the last 30 years [Ferro et al., 2007a,b].

Data from the last 2011 survey (unpublished data) confirm that 3 out of 4 preschool children (3, 4, 5 years of age) in the district pertaining to the AULSS 15 (Veneto region, Italy) are caries free and that the dmft index in this population (n=1070) is similar (0.85 ± 2.20) to the one recorded in other European countries [Health in Europe: Information and Data interface, 2011]. These trends have a common denominator: topical fluoride.

More than 70 years ago Trandley Dean [1942] demonstrated a lower caries prevalence in geographical areas of the USA where drinkable water contained high concentration of fluoride. Three years later (1945) the US National Health Service started the first successful experiment of artificial fluoridation of drinkable water in the area of Grand Rapids, Michigan [Arnold and Knutson, 1953]. For many years scientists linked the fluoride cariostatic action with a "pre-eruptive effect", supposing that fluoride was to be ingested during amelogenesis for caries to be prevented. However the most recent studies, following the caries decline in children and adolescents in industrialised countries that had started in the 70's [Kalsbeek et al., 1993] concluded that the caries-preventive effect of fluoride is almost exclusively posteruptive [Bibby et al., 1955; Fejerskov et al., 1981; Carlos, 1983; Wefel, 1990; Leverett, 1991; Zero, 1992; Ekstrand et al., 1994; Bratthall, 1996; Locker, 1999; Formon et al., 2000; Featherstone, 2000; Centers for Diseases Control [CDC], 2001; Aoba and Fejerskov, 2002; Zimmer et al. 2003; Warren and Levy, 2003; Fejerskov, 2004; Hellwig and Lennon, 2004; Marthaler, 2004, European Commission, 2005; Pizzo et al., 2007; Cheng et al., 2007].

How Fluoride acts

During caries formation, fluoride minerals and organic acids move through the enamel diffusion channels located amongst rod-like structures made of crystals of apatite-like material (especially hydroxyapatite).

Human first formed enamel contains impurities such as carbonate and magnesium that make it more soluble in acid than pure hydroxyapatite. Acid conditions in the mouth cause surface crystals to dissolve and reform and the first to dissolve are the most soluble ones. When fluoride ions are present, the surface crystals will reform without impurities. Carbonate and magnesium are replaced by phosphate, fluoride and calcium making new crystals of hydroxyapatite, fluorohydroxiapatite and fluoroapatite. All of these forms of enamel apatite are more acid resistant than the original carbonated apatite.

All this dissolving and reforming process is called post-eruptive maturation and continues as long as the tooth is in the mouth and in contact with saliva. This phenomenon probably explains the clinical observation that the longer a tooth remains in the mouth, the more resistant it becomes to caries formation.

Fluoride is stored in a plaque "reservoir" as calcium fluoride-like precipitates. Plaque fluid has higher fluoride levels than the saliva and like saliva it is also

supersaturated with calcium and phosphate. Fluoride accumulates in plaque from diet, fluoride toothpaste, fluoridated water, saliva and also from fluoride released from enamel during demineralisation. So, dental plaque acts as an intraoral reservoir for fluoride. When plaque becomes slightly acidic and before enamel starts to dissolve, fluoride ions are released from the calcium fluoride-like precipitates, thereby raising the amount of ionic fluoride in plaque fluid. This amount of fluoride works to inhibit bacterial growth, acid formation and enhance remineralisation.

The continuous use of daily low levels of fluoride is the key to fluoride effectiveness. Fluoride's incorporation into developing enamel is critical, but the continuing presence of fluoride ions at and in the enamel surface is the major factor in caries control [Buzalaf et al., 2011].

Toothpastes and other topical fluoride administration methods

To work as a cariostatic agent fluoride must be in the right place (enamel-plaque interface), at the right time (during an acid attack) and in a sufficient amount (0.01-0.04 ppm) [CDC, 2001]. It is crucial to brush one's teeth twice a day with a fluoride toothpaste to achieve these conditions [Bloch-Zupan, 2001].

According to the directives of the European Union, the concentration of fluoride must not exceed 1,500 ppm [European Cosmetic Toiletry and Perfumery Association [COLIPA], 1995] and the most commonly used salts in toothpaste are: sodium fluoride, stannous fluoride, fluoridated amines and sodium monofluorophosphate.

Fluoride in toothpaste is effective [Marinho et al., 2003a] and harmless both for adults and children; an excessive intake can cause toxicity: acute (intoxication) or chronic (fluorosis).

Acute intoxication is very rare. As the toxic dose is 5mg/kg for a child of 10 kg it is 50 mg; this amount can be reached only after the ingestion of more than half a tube of a toothpaste (90 g) with a fluoride concentration of 1,000 ppm. Moreover scientific evidence recommends a careful parental control on the daily fluoride dose to be assumed by their children in the first three years of life in order to reduce the possibility of developing fluorotic lesions in the upper incisors [Bardsen, 1999; Hong et al., 2006a,b].

As children under 6 do not have a well-controlled swallowing reflex, toothpaste and fluoride are ingested: [Simard et al., 1991; Nacacche et al., 1992]; approximately 65% in 2-year-old children, 50% in 4-year-olds and about 343% in 5-year-olds [Benesty, 1999].

As the amount of ingested fluoride depends on the quantity of toothpaste, the most accredited international guidelines for the first years of life recommend a "smear" or a "pea-sized" to be applied on the toothbrush [American Academy of Pediatric Dentistry (AAPD), 2009, 2012; Australian Research Centre for Population Oral Health, 2006; British Association for the Study of Community Dentistry (BASCD), 2009; British Society of Pediatric Dentistry, 2003; Canadian Dental Association, 2010; European Academy of Pediatric Dentistry, 2009; Irish Oral Dental Health Services Guideline Initiative, 2008; New Zealand Guidelines Group, 2009; Scottish Intercollegiate Guidelines Network, 2012; Scottish Dental Clinical Effectiveness Programme, 2010] .

The minimum concentration of fluoride in toothpaste sufficient to prevent caries formation is 1,000 ppm [Ammari et al., 2003; Walsh et al., 2010]. Furthermore a recent RCT demonstrated that the preventive effect is maintained by an acidulated toothpaste (pH 4.5) with a fluoride concentration of 550 ppm [Vilhena et al., 2010].

Other than toothpastes, several methods of additional application of topical fluoride have been recognized as effective [American Dental Association, 2006; Marinho, 2003], including mouth rinses [Marinho, 2003b], gels [van Rijkorn, 1998; Marinho, 2002] and varnishes [Carvalho et al., 2010].

Mouth rinses have been used since the 1960s both in school health programs and individually; at schools, the average occurrence is one or two rinses per week and the most frequent formulation is sodium fluoride (230-900 ppm). A regular use of fluoride mouth rinses can reduce the formation of new carious lesions in children and adolescents [Marinho et al., 2003b].

Gels, which are used in professional and individual programmes (from the age of 7), contain high fluoride concentrations (≤ 12,000 ppm); their efficacy have been widely demonstrated and the frequency of application can vary from 2 to 4 times per year, depending on the patient's age and risk level [Poulsen, 2009; American Dental Association, 2006].

Professional application of varnishes, with fluoride concentration between 7,000 and 56,300 ppm, are the most used products and they must be applied from 2 to 4 times per year; they are effective in both deciduous and permanent teeth [Marinho, 2002].

A combination of various methods to administer fluoride in a topical form, including daily usage of toothpastes, induces a slight decrease of carious lesions compared to using just toothpaste [Marinho, 2009].

Elwood [2008] classified the different methods of fluoride administration as follows.

- *Self-applied methods*, used at home: toothpastes, mouth rinses, gels (topical fluoride), tablets, drops and lozenges (topical + systemic fluoride).
- *Professional methods*, delivered by healthcare professionals: gels, varnishes (topical fluoride).
- *Community methods*, introduced on a population basis: water, milk and salt fluoridation (systemic fluoride). Fluoridation of drinkable water has never been done in Italy and, generally, with the only exception of some areas in Campania region, fluoride content in water is low. The evaluation

AGE	ALL	HIGH-RISK INDIVIDUALS
0-3 years	» Daily oral hygiene provided or supervised by parents/tutors » "Smear-size" amount of toothpaste with a fluoride concentration of 1,000 ppm » Tooth-brushing twice a day since eruption of first primary tooth » Check the daily frequency and intake of sugared foods and beverages, particularly at night-time » "sugar-free"drugs if possible	» systemic fluoride (drops, tablets)
3-6 years	» regular dental check-ups » tooth-brushing supervised by parents/tutors » "pea-size" amount of toothpaste with a fluoride concentration of 1,000 ppm » Check the daily frequency and intake of sugary foods and beverages, particularly at night-time » "sugar-free"drugs if possible	» fluoride varnishes
> 7 years	» regular dental check-ups » dental floss (from 14 years) » "pea-size" amount of toothpaste with a fluoride concentration of 1,000 ppm	» dental sealants » fluoride varnishes » fluoride gels (also self applied) » fluoride rinses

TABLE 1 Caries prevention in children and adolescents.

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› Scottish Intercollegiate Guidelines Network, 2005.

of fluoride ingestion through water is even more difficult due to the widespread habit of drinking bottled water with different ion concentrations. The same problem occurs with infant formula, as it is actually the concentration of fluoride in the water used in its production that affects the daily dose. The addition of sodium fluoride or calcium fluoride to salt (250 mg/kg) has given the same results of consumption of artificially fluoridated water [Gillespie and Roviralta, 1985]. Just like fluoridated water, also fluoridated salt represents an effective and low-cost method, with the advantage of being used individually and voluntarily, escaping from any ideological or political opposition.

High-risk subjects and fluoride

Additional fluoride therapy (systemic and topical) should be targeted towards individuals at high caries risk, i.e. those with carious lesions or their consequences (conservative restoration).

Fluoride supplements in drops or tablet form are to be swallowed to be effective and are indicated exclusively in high-risk subjects or when an adequate amount cannot be ensured in any other way [Ismail, 2008; Rozier et al., 2010; Tubert-Jeannin et al., 2011].

In pregnant women administration of fluoride tablets has been demonstrated not to be effective in preventing the formation of carious lesion in their offspring [Leverett, 1997; Sa Roriz Fonteles, 2005].

Table 1 summarises the scientific evidence on caries prevention for childhood and adolescence based both on the literature and the most accredited international guidelines as provided in 2013 by the joined Committee composed by SIOI (the Italian Society of Pediatric Dentistry) and FIMP (Italian Association of Paeditricians).

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