Journal of
Kerman University of Medical Sciences

https://jkmu.kmu.ac.ir
10.34172/jkmu.2023.31
Vol. 30, No. 3, 2023, 189-198

Review Article

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Fluoride; An Updated Review

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Abstract

Background: Fluoride can arrest dental caries and prevent its progression. The most important advantage of fluoride is that there is no need for cavity preparation; in this respect, it eliminates the utilization of air motors. Furthermore, it provides a good choice for younger children without cooperation ability and patients requiring special care. This study aimed to review the literature about fluoride and to advise public health specialists about the types of fluoride and that fluoride is still a right and safe choice in the COVID-19 pandemic.

Methods: Through a search in electronic databases containing Medline, Scopus, Web of Science, and PubMed, a total of one hundred forty-two systematic reviews and original articles in the period of 2008-2021 were selected. The following keywords were used: pediatric dentistry, coronavirus, oral health, tooth remineralization, COVID-19, fluoride, dental fluorosis, and preventive dentistry.

Results: Data from selected papers was extracted and classified to evaluate the importance of fluoride in the prevention of dental caries. Fluoride has been selected as a good choice for the prevention and control of dental caries during the coronavirus pandemic.

Conclusion: The research has focused on increasing the awareness of public health specialists, advising them that any type of fluoride use is expedient and safe during the COVID-19 pandemic.

Keywords: Pediatric dentistry, Oral health, COVID-19, Fluoride, Tooth remineralization, Dental fluorosis

Citation: Jahanimoghadam F, Shokrizadeh M. Fluoride; An updated review. *Journal of Kerman University of Medical Sciences*. 2023;30(3):189–198. doi:10.34172/jkmu.2023.31

Received: May 29, 2022, **Accepted**: December 22, 2022, **ePublished**: June 26, 2023

Introduction

Coronavirus has spread worldwide since 2019. The World Health Organization (WHO) declared the expansive increase in COVID-19 cases a public health crisis. Hence, there has to be a major shift in the way healthcare procedures are done across the world in concordance with the guidelines set by WHO.

Fluoride is the most popular element used to prevent caries. Fluoride ions improve the stability of mineralized tissues like enamel, dentin, and bone (1-3). The protective effect of fluoride on teeth was indicated in 1930. Given the beneficial effect of fluoride, it was applied in dentistry in 1940 (4). Fluoride can facilitate calcium and phosphate infiltration into enamel lesions for better remineralization of these lesions. The crystalline structure, which is rebuilt with fluoride, is referred to as fluoridated hydroxyapatite and fluorapatite (5). Fluoride therapy has been the first step in arresting early lesions (6). Certainly, both children and adults will benefit from the regular use of fluorides in that dental caries can be prevented and managed by fluorides. Numerous controlled clinical trials have revealed that fluorides can prevent cariogenic activities in different ways (7).

The primary caries preventive actions of fluoride result from its topical contact with enamel and its antibacterial properties (8). The antimicrobial action of fluoride is mediated through acidification of the bacterial cytoplasm by the release of hydrogen (H^+) and F^- ions from hydrogen fluoride, disrupting the bacterial metabolism through inhibition of bacterial enzymes, like proton-releasing adenosine triphosphatase and enolase.

Furthermore, fluoride could reduce the pH value. Therefore, bacterial species have to use more energy for maintaining an environment with a neutral pH value, which leaves inadequate energy for their growth and acid production activity (9). The mechanisms for the oral activity of fluoride include decreasing the demineralization of sound enamel through inhibition of bacterial proliferation and metabolism, increasing the remineralization of demineralized enamel, and the formation of fluorapatite which is more resistant to demineralization and acid attacks, inhibition of the synthesis of enzymes, such as immunoglobulin A protease, and decreasing extracellular polysaccharide production, which participates in reducing bacterial adherence to dental hard tissue.

There are several types of fluoride applications. Fluoride can be used in a systemic form, like water

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fluoridation, milk or salt fluoridation, or fluoridated tablets or drops (9,10).

Another type of application is topical use that can be home-used, like mouthwashes, toothpaste, and sometimes gels. Also, the professional application in the office includes foams, gels, and varnishes (5).

One of the most commonly used methods is water fluoridation. Many people, especially children and adolescents, can benefit from its advantages, including easy access, safety, and cost-effectiveness. Children with low socioeconomic status will benefit more (10). Fluoride can exist in water, either naturally or added. Furthermore, fluoride concentration varies between different areas, which should be considered when topical application or water fluoridation is prescribed. Water fluoridation has a systemic effect (11). Also, topical fluoride includes toothpaste, mouthwashes, and fluoride varnishes/gels (12).

Professionally, topical fluorides like fluoride varnishes, gels, and foams are used in offices by clinicians. Fluoride varnishes are mostly used for younger children with low cooperative skills who need more behavioral management. Furthermore, they can reduce early childhood caries (ECC) (13,14). Gels and foams are prescribed for school-aged children. Fluoride can be added to salt, milk, and juices, but milk fluoridation is not as efficient as other products due to insoluble complexes between the fluoride and calcium (15,16).

Fluoride-releasing restorative materials are another window in dentistry. Recurrent caries is responsible for more than 50% of replacement restorations. Fortunately, some of these materials, as well as releasing fluoride, can recharge with the fluoride of other sources in the oral cavity. The most common one is glass-ionomer cement; other fluoride-releasing restorative materials are compomers, giomers, silicate cement, and fluoride-delivering mucoadhesives (17).

Toxic effects, in terms of excessive ingestion of fluoride, are classified into acute and chronic. Acute fluoride poisoning has occasionally been reported. The symptoms consist of nausea, vomiting, gastric disturbances, generalized or localized muscle tetany, hypotension, hypersalivation, bronchospasm, dilated pupils, and hyperkalemia; along with coma and seizures that lead to death. Chronic toxic effects are more common than acute toxicity. Chronic effects are dental fluorosis, skeletal fluorosis, renal effects, gastrointestinal tract (GIT), CNS, and fetal defects. Dental fluorosis is the earliest result of chronic fluoride toxicity. A daily intake of > 1 mg/L or 0.1 mg/kg during tooth development leads to dental fluorosis. Excessive fluoride use results in the hypomineralization of enamel with more sub-surface and surface porosity (18-20).

Moreover, dentinal tubules would be affected, with irregular distribution and the lamina of tubules becoming narrower and more disputed. The clinical appearance ranges from mild opaque white and brown mottling enamel to pits and enamel fractures in both dentitions. Generally, the lesions are symmetrical. Knowledge about fluoride application and its ultimate effects helps us have safe prescriptions, fewer caries, and more intact enamel surfaces in both dentitions (21).

The present study aimed to evaluate the importance of several uses of fluoride in the prevention of dental caries and arresting incipient caries during pandemics.

Material and Methods

Data was collected from PubMed, WoS, Scopus, Cochrane Library, and Medline for original articles and review articles (literature, systematic, umbrella) from August 2008 to February 2021. The following keywords were used: pediatric dentistry, oral health, tooth remineralization, dental fluorosis, fluoride, and preventive dentistry. One hundred forty-two articles were selected. The inclusion criteria consisted of the year of publication, article title, study findings, and clinical appraisal. In vitro studies, animal studies, case reviews, studies with insufficient sample size, studies published in languages other than English, historical articles, editorials, letters, and commentaries were excluded. The included studies were the ones in which authors published information regarding the significance of fluoride in the prevention of dental caries and its several applications. Fluoride substitutes (casein phosphopeptide-amorphous calcium phosphate [CPP–ACP], xylitol) and the effects of lasers were considered too. Furthermore, fluoride side effects like dental fluorosis are also included in this study. Ninety papers were retrieved. The title and full texts of all retrieved articles were double-checked by two authors based on the inclusion and exclusion criteria. Data extracted from selected papers were classified to evaluate the importance of fluoride in the prevention of dental caries. Moreover, recent developments including non-fluoridated agents were discussed independently.

Discussion

Water fluoridation

Water is a crucial agent for fluoride delivery. It is the most cost-effective and safe source which can be the easiest method for children because there is no need for the child's cooperation. All people, particularly those in low socioeconomic areas, can benefit from water fluoridation (22). The optimal concentration of fluoride for drinking water with minimal risk of fluorosis is 0.7–1.2 ppm (23) however, the recommended concentration could vary concerning the different geographical areas. The WHO determined 1.5 ppm as the maximum concentration to prevent dental fluorosis in drinking water (6). According to the American Dental Association (ADA), fluoridation of drinking water sources is noted as the most effective

form of decreasing dental caries because it affects all the individuals in the community, especially children (5).

However, the most adverse effect of water fluoridation is the increase in the incidence of dental fluorosis (6). Water fluoridation can be more useful for permanent teeth compared to primary teeth due to more extended contact with permanent teeth during the development and after the eruption of permanent dentition. The caries reduction effect on primary teeth was 40% – 50%, whereas the range for permanent teeth was 50% – 60% (24).

Another noteworthy point is the climate; in warm areas where children drink more water, it is necessary to decrease the fluoride concentration to reduce the odds of fluorosis. In areas with cold weather with less need for drinking water, it is possible to increase the concentration of fluoride for optimal cariostatic effects of fluoride, but not > 1.5 ppm (25).

Milk fluoridation

Milk fluoridation has also been noted to be successful in dental caries prevention, especially among children. To protect and decrease caries in deciduous dentition, fluoridation milk was advised for children aged under four years before the eruption of the first permanent molars (1). The daily dose of fluoride ranges from 0.5 mg to 0.85 mg. Children are suggested to drink 200 mL of fluoridated milk daily, 200 days per year. However, fluoride delivery through fluoridated milk will not be efficient compared to other fluoride delivery methods. Fluoride tends to bond with calcium and form an insoluble complex, making fluoride absorption difficult (26,27).

Salt fluoridation

Given the successful use of iodized salt in the prevention of goiter, salt fluoridation was instituted in Switzerland in 1955 to reduce dental caries risk (1). Fluoridated salt contains a mixture of sodium fluoride and potassium fluoride to achieve a concentration of 250–300 mg of fluoride/kg salt (28). These concentrations lead to salivary levels of fluoride, similar to those in individuals drinking fluoridated water at a concentration of 1 mg/L (29). To achieve considerable caries control, the minimum level of fluoride should be 200 mg/kg. Besides, it is possible to control salt fluoridation compliance and the odds of excessive fluoride doses through urine as a biomarker (30). However, there are concerns with the use of salt, since excessive salt consumption is associated with hypertension; but with accurate doses or combined with iodide, no adverse health effect has been noted. Nonetheless, combining water fluoridation and salt fluoridation is not recommended (31).

Fluoride supplements

Fluoride tablet, drop, and lozenge

At present, there is not enough evidence to make reliable recommendations. The fluoride–vitamin supplements are not, in essence, superior to supplements without vitamins, and might develop parental compliance, consequently providing more benefits. These fluoride–vitamin combinations should only be advised for children deficient in fluoride consumption. Administration of fluoride–vitamin supplements to children who already have access to optimally fluoridated water sources exposes them to the risk of fluorosis (32).

Liquid products are advised for young children who might have difficulty swallowing. Liquid supplements are divided into two groups: with vitamins and without vitamins. Liquid supplements with vitamins provide a fluoride dose of 0.125 mg/drop, 0.25 mg/drop, or 0.5 mg/drop; liquid supplements with vitamins are presented in 0.25 mg/mL and 0.5 mg/mL doses. However, their effectiveness depends mostly on the degree of parental compliance (24,33,34).

Home-used prescription

Toothpaste

Fluoride toothpaste has been recommended for five decades for preventing caries. Toothpaste is the most extensively used fluoride product and is very useful for decreasing dental caries in children and adolescents; they serve as a cariostatic agent, especially in children. A critical factor in caries prevention in toothpaste is the concentration of fluoride. The usual concentration of fluoride is 1000–1100 ppm, with 5000 ppm for specialized uses (35).

Many studies have shown that fluoride toothpaste decreases the incidence of dental caries in school children; however, in children aged under six years, it might increase the incidence of tooth fluorosis. The ADA recommended that children aged under two years brush only with water, and children aged 2–6 years should use a pea-sized piece of toothpaste (36). Studies have shown that fluoride toothpastes increase the risk of tooth fluorosis in young children (37). Fluoride toothpastes are available in various concentrations consisting of low (500 ppm), standard (1100–1500 ppm), and high (1500–5000). Low concentration is prescribed for younger children, standard concentration is prescribed for adults, and high concentration is prescribed for therapeutic goals, like reducing tooth sensitivity, root caries, and better cariostatic effect in individuals with hyposalivation or special health care needs (12-14). Fluoride toothpaste is effective in high-risk children (38). For this reason, the appropriate amount of fluoridated toothpaste depends on age (1): for children under two years, the size of a grain of rice, and for children aged 3–6 years, a pea-sized amount of fluoridated toothpaste is appropriate. The high concentration of fluoride (5000 ppm) in toothpastes has been shown to be more effective in remineralization of both the enamel and dentin in comparison with low-

concentration ones; it decreases plaque accumulation, develops fluorapatite crystals which help prevent dental caries and decrease *Streptococcus mutans* and *Lactobacillus* counts (39).

Twelve-year-old children gain more benefits from high-concentration fluoride toothpastes because of better protection of the newly erupted premolars and second molars with immature enamel. Furthermore, there is no risk of dental fluorosis after this age. Besides, a high concentration of fluoride can be advised for optimal prevention during orthodontic treatment (40).

Toothpaste manufacturers also produce flavored dentifrices, which are believed to increase the fluoride intake compared to regular toothpastes. A systematic review and meta-analysis study showed that flavored dentifrices do not augment fluoride intake in younger children (39).

Mouthwash

Therapeutic mouthwashes (MW) are adjunctive tools along with regular oral hygiene of two times brushing and daily flossing. Mouthwashes are applied universally for their antimicrobial and anticariogenic effects. The most commonly prescribed preventive and therapeutic ones in children are sodium fluoride and chlorhexidine, for their anticariogenic and antimicrobial effects, respectively (41). Sodium fluoride MW is the most commonly prescribed complementary home care agent in children aged under six years for anticariogenic activities, especially on smooth surfaces of immature enamel. Also, for high-risk individuals, such as those with orthodontic appliances, patients with hyposalivation, and patients with impaired immune systems, sodium fluoride MW is commonly prescribed. Fluoride mouthwashes are available in two concentrations: 0.05% and 0.2% for daily and weekly uses, respectively. Daily ones have been recommended more frequently because children could remember them better (42).

In very young children, MW is not suggested due to the probability of ingestion and the additional risk of fluoride toxicity and poisoning. According to ADA recommendations, sodium fluoride is suggested for schoolchildren who can spit it out after washing (5).

Sodium fluoride MW also could be combined with other anticariogenic and anti-inflammatory agents, like essential oil MW like Listerine, which has been shown to increase anti-biofilm properties and promote enamel remineralization and fluoride uptake (41).

Topical fluoride

Gels and foams

Fluoride gels and foams are applied in trays professionally (43). In the United States, flavored acidulated phosphate fluoride (APF) gels and foams were the most commonly used products in offices from the 1960s to the 2000s, until they were replaced by varnishes. They are more advisable for school-aged children who are more cooperative and can spit out the extra amount (44).

The APF foams have the same concentration (12 300 ppm) and pH as the APF gels. The foams are professionally used in disposable trays or trimmed sponge-lined ones. The patients are asked to bite down on the trays of two jaws for four minutes, simultaneously, with a saliva ejector in the mouth to evacuate the extra amounts. One of the advantages of foams compared with gels is that foams with only one-fifth of the amount (by weight) of gels are enough for sufficient coverage of the teeth. Professional application of fluoride foams could exert a caries-preventive effect, similar to fluoride gels. Fluoride therapy does not completely prevent acidic bacterial attacks (45,46).

Fluoride varnish

Fluoride varnish was developed in the 1960s to improve the efficacy of topical agents by increasing them substantively on the enamel (47,48). The fluoride in varnish is bonded to calcium elements in enamel to make calcium fluoride (CaF2) which is stronger than calcium in the enamel. The fluoride varnish is the most convenient means for pre-school children, which can be applied professionally by clinicians because it is easy to apply and is tolerated well (49).

The other advantages of varnish fluorides are: being easy to handle because of greater thickness, being rapid setting which decreases fluoride ingestion, and having high fluoride concentration (1%–5%) of sodium fluoride. It comes in various flavors, needs less chair time, and could be prescribed 2-4 times yearly. The fluoride varnish may contain CPP–ACP to increase enamel resistance to erosion (50).

ECC is a rampant caries involving the maxillary primary incisors during the first months after the eruption (51) which infects other primary teeth. Topical fluoride can reduce *Streptococcus mutans* and *Lactobacillus* counts in children (52). Many studies have reported that fluoride varnish prevented ECC effectively with both 1% and 5% concentrations (53). Varnish fluorides reduce the caries rate by 30%-40%; therefore, they will be helpful for children with immune deficiency, hyposalivation, and decalcified enamel and orthodontic patients with white spots around their brackets (50).

According to some reports, prophylaxis before applying varnishes improved fluoride varnish effects; however, other studies indicated no differences in effect, claiming that just toothbrushing before the topical application would be sufficient. After applying the fluoride varnish, it is necessary to avoid drinking and eating for 30 minutes. In the first 24 hours, yellowish stains will be seen, and toothbrushing should not be prescribed. In terms of caries risk assessment, fluoride varnishes could be recharged

monthly, four times a year, or twice a year. Many studies have shown that applying fluoride varnish only once a year has no cariostatic effects (49).

Silver Diamine Fluoride (SDF): A new approach in pandemic

The importance of SDF as a minimally invasive and nonaerosolizing management during the COVID-19 pandemic has highly increased (3). Many studies have demonstrated that SDF controls caries in pre-school children (54,55). It can even be more effective than fluoride varnish. SDF is an effective agent that could be used for uncooperative children in terms of dental care, especially in children with medical challenges and young children with ECC (56,57). SDF is applied at a concentration of 38% initially. A concentration of 12% is available too, but it is not as effective as the 38% variant in reducing children's caries. Serum concentrations of fluoride and silver after topical application showed no toxicity (58).

SDF increases the mineral density of enamel lesions and the microhardness of dentin lesions. Silver and fluoride infiltrate 25 microns into the enamel rods and 50–200 microns into the dentinal tubules. SDF application on the arrested dentinal lesion of primary teeth resulted in the formation of a highly remineralized rich zone of calcium and phosphate (56). It can also inhibit biofilm formation, especially in the first week after application (6). The mechanism of action is an inhibitory effect on matrix metalloproteinases and a decrease in the degradation of the organic collagen matrix (59). While SDF was used only for carious surfaces, it had a proper preventive effect on other intact tooth surfaces, although SDF has a short-lived bind to intact surfaces adjacent to the treated surface (60). Annual recharging of SDF in children could be more effective in preventing carious lesions than applying fluoride varnishes four times a year. The effectiveness of arresting caries lesions in anterior teeth is more than that in posterior teeth. Also, in children with erosion or abrasion lesions who have dentinal hypersensitivity, SDF can be helpful (61,62). Available literature suggests that 38% SDF stops caries progression without inducing any pulp reaction. It is cost-effective, and since it is easy to use, it is very helpful in the management of ECC in young children (63,64). Silver allergy is an absolute contraindication. Relative contraindications include any mucositis or considerable desquamative gingivitis, which disrupts the epithelial protective barrier. Also, SDF darkens carious lesions; however, SDF-treated lesions could be covered with glass-ionomer or composite resin, particularly in children. The parents can follow up on the color changes as a positive sign showing the treatment is effective (65,66).

Another new effective production is propolis fluoride. The application of propolis fluoride showed positive effects in arresting dentinal caries lesions; the interesting advantage of this combination is leaving no black discoloration surfaces, unlike SDF (3).

Recent developments: Non-fluoridated agents

Non-fluoridated agents, like CPP–ACP, chlorhexidine, and xylitol, have been suggested as alternatives to fluoride products in caries prevention due to the possible fluoride toxicity, particularly in children who are more prone to overdose. However, recent evidence-based reports indicated that these agents should be used in conjunction with fluoride, rather than as a substitute, especially in high-risk individuals (67,68).

CPP-ACP

CPP–ACP is a nano-complex material derived from milk, which can provide higher concentrations of calcium and phosphate with an amorphous pattern to promote mineralization. Recently, reports have shown its potential effects on the remineralization of the ECC (69) and its anticariogenic effects; hence, it can control infections and decrease dental procedures for removing caries with rotating instruments (1). Based on some systematic reviews, CPP–ACP will be a good choice for ECC on occlusal tooth surfaces. The combination of fluoride and CPP–ACP might result in the same outcomes as fluoride monotherapy on smooth surfaces, whereas for occlusal lesions, CPP–ACP and fluoride combination might improve the efficacy (70,71).

In addition to fluoride, products with calcium and phosphate bases could be an option for halting tooth enamel erosive lesions. The topical application of CPP–ACP releases free calcium and phosphate ions, resulting in a supersaturated state that helps enamel surfaces by preventing demineralization and improving the remineralization of dental caries or enamel erosive lesions. It shows the synergistic effect of CPP–ACP and fluoride on erosion and ECC, which could be an adjunctive protocol in arresting ECC in younger children (2,72-74).

Xylitol-containing products

Xylitol is a non-cariogenic alcohol sugar with antibacterial features (75). It acts by interfering with *Streptococcus mutans* colonization and reducing the counts of periodontopathic bacteria (*Helicobacter pylori*). It might decrease plaque acidity, xerostomia, tooth erosion, and gingival inflammation. Studies have shown a considerable reduction in plaque adhesiveness and insoluble extracellular polysaccharides generated by *S. mutans* (76). It can be applied in different ways, like gums or lozenges, mouthwashes, and dentifrices. A direct relationship has been found between chewing xylitol gums in mothers and the reduction in their children's caries (77). Until the age of three years, children have an undeveloped immune system, which is significantly susceptible to bacterial

invasion (78). Due to kisses from the parents, *S. mutans* is transmitted from their mouths to the child's mouth. Regular use of xylitol has been shown to decrease the vertical transmission of bacteria from the mother to the child (77). The effective recommended doses are 6–10 g of xylitol gum 3–5 times daily for 5 minutes. Fortunately, these chewing gums have long-term anticariogenic activity even 2–3 weeks after chewing (79).

Pregnancy can be a golden time to reduce mother-to-child transmission of *S. mutans*. Reports have noted that children with mothers who chewed xylitol gums exhibited considerably less *S. mutans*-negative levels on teeth, tongue, and gingival ridges. The children with mothers who did not chew xylitol gums received *S. mutans* approximately nine months earlier than children whose mothers did chew the gums (80).

Effect of laser on the fluoride uptake

Lasers are widely used in dentistry for cavity preparation, periodontal surgeries, endodontics, removing white spots in orthodontics, and other dentistry fields (81).

Lasers have been introduced as adjunctive techniques to inhibit caries because they enhance the resistance of enamel to acid attacks. Furthermore, laser irradiation on the hard tissues of teeth results in structural changes and alterations in tooth permeability, which might increase the resistance of enamel against acids (82). In general, a combination of fluoride and laser might exert a significant effect on fluoride uptake, leading to more acid-resistant tooth surfaces (83).

Several types of laser, such as carbon dioxide (CO_2) (84), argon, erbium-doped yttrium aluminum garnet (Er:YAG) (80), and neodymium-doped yttrium aluminum garnet (Nd:YAG) (85), have been applied for caries inhibition and remineralization. Despite a large number of studies on the inhibitory effects of lasers on caries, limited data are available on their effect on the remineralization of demineralized enamel (86).

One of the recent laser applications is the demineralization of white spots around brackets, the spots which could cause aesthetic concerns. A combination of lasers with topical fluoride might reduce enamel solubility more than applying lasers or topical fluorides alone. Consequently, it appears that, apart from an emphasis on instructing about oral health and modifying the children's dietary habits, topical fluoride therapy can have a superior role in reducing the caries rate. Efforts are underway now to determine the factors that can increase and lengthen the effect of fluoride on dental structures. Additionally, since caries is more common in deciduous teeth, which in itself is one of the most significant factors in transferring caries to newly erupted permanent teeth, laser therapy was undertaken to increase the efficacy of fluoride, decrease the dose and frequency of fluoride therapy, and prevent fluorosis because the improper and excessive use of fluoride increases the risk of fluorosis. Furthermore, Er:YAG lasers are solid-state lasers whose lasing medium is erbium-doped yttrium aluminium garnet. Numerous studies have revealed the beneficial effects of laser beams on the inhibition of dental caries. In addition, the efficacy of laser in combination with fluoride has not been completely clarified (14). Despite abundant in vitro studies, more research is necessary on the absolute efficacy of all types of lasers in caries inhibition of lasers (14,86).

Dental fluorosis

Dental fluorosis is defined as hypo-mineralization of the enamel that can happen during the first few years of life due to extreme exposure to fluoride (87). The severity of this condition depends on the fluoride dose, duration of exposure, and age of the person. Yellowish or brownish striations on teeth, abnormality of enamel and dentin, and interference with enamel mineralization are the primary clinical manifestations of dental fluorosis. In 1934, Dean made an index usually used for classifying different types of dental fluorosis. Generally, young children tend to swallow toothpaste and are at a higher risk of developing dental fluorosis because they are typically unable to wash out toothpaste from their mouths. Consequently, the main source of dental fluorosis is oral hygiene products. The severity of dental fluorosis lesions increases when the amount of fluoride in drinking water is more than 0.7 ppm. However, the mechanism of chronic fluoride toxicity in the whole body is not yet obviously explained. Some studies stated that oxidative stress is one of the important mechanisms of toxicity in dental fluorosis. Oxidative stress is determined as the imbalance between the production rate of free radicals and the properties of protective antioxidants in the body. Chronic fluorosis can induce the generation of free radicals and also prevent the enzymatic antioxidant defense system in the body which can cause cellular impairment. Dean made an index frequently used for classifying different types of dental fluorosis in 1934. Table 1 shows the Dean's fluorosis index (88).

The European Academy of Pediatric Dentistry (EAPD) recommends the preventive use of fluoride toothpaste, as a main preventive measure against dental caries, for everybody including pregnant women. The most effective method to prevent caries is toothbrushing twice a day. Parents should start brushing children's teeth as soon as the first tooth erupts with fluoride toothpaste in the concentration and quantity suggested by the EAPD (89). Parents should use the recommended amount of toothpaste and help or supervise their children with toothbrushing at least up to the age of seven years (90). Table 2 shows the recommended use of fluoride toothpaste in children (89).

Conclusion

The available literature suggests that fluoride is effective

Table 1. Classification of dental fluorosis

Diagnosis	Criteria
Normal	A usual translucent semi-vitriform type of structure is seen: smooth, glossy, and usually a pale creamy-white color.
Questionable	A slight deviation from normal translucency, ranging from a few white "fecks" to occasional white spots is seen.
Very Mild	Less than 25% of the tooth's surface is affected. Small, opaque, paper-white areas are scattered irregularly over the tooth. Tips of cusps often show "snow capping".
Mild	More than 25% but less than 50% of the tooth's surface is affected. More extensive, opaque, paper-white areas are seen.
Moderate	The whole surface of the enamel is affected, frequently with brown staining.
Severe	The whole surface of the enamel is affected, with widespread brown staining and discrete or confluent pitting. Teeth may exhibit a "corroded" appearance.

Table 2. Recommended use of fluoride toothpaste in children

Age (years)	Fluoride(ppm)	Frequency	Amount (g)	Size
First tooth- up to 2 years	1000	Twice daily	0.125	Grain of rice
2-6 years	1000*	Twice daily	0.25	Pea
Over 6 years	1450	Twice daily	0.5-1.0	Up to a full length of the brush

*For children aged 2–6 years, 1000+fluoride concentrations may be considered based on the individual caries risk.

in caries prevention. It stops the caries progression. Based on several reports, topical fluoride application does not lead to any pulp reaction. It is easy to use and cost-effective and can be applied in different forms, at home or in the office. Fortunately, it can be used with other products, like chlorhexidine, and along with other techniques, like lasers. However, more studies on fluoride are required to prove it as an ideal choice for caries progression.

Authors' Contribution

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Competing Interests

The authors declare no financial or non-financial conflict of interests.

Ethical Approval

Not applicable.

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