Original Study

ASSESSMENT OF FLUORIDE UPTAKE BY TOOTH ENAMEL FROM DIFFERENT FLUORIDE DENTIFRICES

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ABSTRACT

For the past century, the researcher began looking into the effect of fluoride on oral health and hygiene. Topical fluoride treatment has been found to prevent dental caries in children by 25%. After that discovery, fluoride was implemented into the drinking water supply and toothpaste to fight off caries in children and adults. Fluoride makes enamels more resistant to an acidic environment and inhibits bacterial enzymes by replacing OH- by F- in hydroxyapatite making fluorapatite. We reviewed the literature reviewing Enamel fluoride uptake from different fluoride dentifrices. PubMed database was used for articles selection, and papers were obtained and reviewed. Toothpaste remains one of the integral ways of introducing fluoride, and thus the enamel fluoride uptake from them is crucial. In conclusion, this mechanism depends on many factors, starting from the concentration, length of brushing, and up to pH of the toothpaste. Nevertheless, detailed, thorough studies are still needed to shed light on many other possible factors that may play a role in the enamel fluoride uptake.

Key words: Fluoride, Fluoride uptake, Enamel fluoride uptake, Dentifrice, Toothpaste.

Introduction

For the past century, the researcher began looking into the effect of fluoride on oral health and hygiene [1]. Topical fluoride treatment has been found to prevent dental caries in children by as much as 25% [2]. After that discovery, fluoride was implemented into the drinking water supply and toothpaste as a measure to fight off caries in children and adults. Fluoride makes enamels more resistant to an acidic environment and inhibits bacterial enzymes by replacing OH^- by F^- in hydroxyapatite making fluorapatite [3]. Continuous research has proven that topical fluoride application in varnishes, gels, foams, and rinses is more effective than systemic application of fluoride [1, 4]. While most manufacturers of dentifrices, which are the most accepted form of fluoride supplementation, use an amount that is as per regulations, the difference between the ratio of organic and inorganic fluoride leads to different uptake in the enamels [5]. In this paper, we will review the recent literature on the fluoride uptake by enamels from different fluoride dentifrices.

Materials and Methods

PubMed database was used for articles selection, and the following keys were used in the search (((Fluoride uptake) AND (Fluoride dentifrice)) AND (Tooth enamel). Regarding the inclusion criteria, the articles were selected based on the inclusion of one of the following topics; Fluoride uptake by enamels, Fluoride dentifrice. Exclusion criteria were all other articles, which did not have one of these topics as their primary endpoint.

Results and Discussion

Globally, dental caries have been a global problem, and multiple measures have been taken to fight against it. This disease happens due to interactions between many factors including, microbial biofilm, tooth structure, diet (mainly sugars), along salivary and genetic factors. Caries occurs due to alternating demineralization and remineralization processes. However, the carious lesions form when the demineralization net is much more than the remineralization over a long period [6, 7]. Recently, and after discovering fluoride's role in its prevention, topical fluoride application in public and products was implemented. Moreover, arrest and even reverse caries were noted with continuous admission of fluoride to the tooth surface. This is why fluoride products have been studied for their overall role in decreasing incidence and prevention. Moreover, the bacterial count of Streptococcus Mutans and Lactobacillus are associated with caries. In addition, decreased bacterial acid production, enamel apatite solubility, fluoridation of apatite crystal surfaces, and dissolution rate have been noted. These studies have also proven that this prevention method is more efficient than treating caries [8, 9]. Generally, it has been proved that topical application of fluoride is better than systemic. Thus, toothpaste (dentifrices) has been accepted as the recommended form for topical application of fluoride. Nevertheless, public health policies such as introducing

fluoride to drinking water, oral preventive programs, encouraging good oral hygiene, and regular check-ups still play a major role [9].

Many studies have been made regarding the different fluoride dentifrices from different brands. A study by V. H. Patil compared the uptake of four different brands of dentifrices. Each brand used different types of fluoride in their dentifrices; sodium fluoride (NaF), sodium monofluorophosphate (NaMFP), stannous fluoride (SnF_2), and amine fluoride (AmF). They found that the dentifrice using amine fluoride had the highest uptake by enamels (21.6793 mg/L), followed by stannous fluoride, sodium monofluorophosphate, and sodium fluoride, respectively.

This can be due to the organic nature of amine fluoride, which explains the higher distribution in the demineralized enamel. In addition, it has a hydrophilic part, which attaches to the tooth surface, with a hydrophobic part toward the oral cavity. These parts will prevent saliva from washing out the fluoride and result in a higher window of bioavailability [1, 6].

Another study was performed by T. Sedlacek, which compared five different dentifrices. They used three varnishes containing sodium fluoride and acidulated fluoride gel and foam. The group that had the most fluoride uptake was one of the varnishes using sodium fluoride (8.32 $\mu g/cm^2$), followed by the gel group, foam group, and the remaining two varnishes. While the second study's highest fluoride uptake group used sodium fluoride, its level was less than that of the first group's sodium fluoride containing dentifrices [2].

These fluoride bioavailability levels are very important for preventing caries, and it is based on the solubility of fluoride-containing compounds, which results in a higher adhesion to the tooth surface. Moreover, the amount of toothpaste and the duration of the brushing has a significant effect on the absorption and remineralization of enamel fluoride. This dose-related response effect was well documented in many studies. Some studies reported around five times increase in the effect (from 250ppm to 1150ppm). More recent studies suggested an enamel fluoride uptake increase rate of up to 140% [10, 11]. The longer duration of brushing enhances the fluoride effect by improving the overall penetration of the fluoride into the plaques and the surrounding soft tissue, which leads to higher remineralization and enamel fluoride uptake. Thus, studies recommend 120 seconds or more of brushing with 1.5g of toothpaste. Moreover, including a fluoride mouth rinse with toothpaste has resulted in an additive effect and up to 23% of better protection against caries [12, 13].

In addition, many other factors may affect enamel fluoride uptake. The CaCl2 compound is one of them; it releases as the pH decreases and acts as a reservoir of fluoride. Thus, some studies have identified acidulated dentifrices as more effective measures than neutral ones. This has been implemented as a possible mechanism to decrease the risk of fluorosis in children by lowering the fluoride concentration in toothpaste and lowering the pH as the anticaries mechanism [14, 15]. Some other agents have been tested for the uptake and remineralization with carbomer and arginine as the most notable. Arginine is naturally in the saliva and catabolizes the bacteria in the mouth into ammonia, resulting in higher pH and equilibrium of microbial environment in the mouth. Thus, arginine was suggested as a component in fluoride dentifrices to reduce the overall hypersensitivity by easing the dentinal tubule occlusion. On the other hand, carbomers have also been incorporated; however, they did not prove any significant result (positive or negative) in studies [16, 17].

Conclusion

Within the limitations of available studies, the role of fluoride and its importance as a core component in battling against caries has been proven. This has been reflected in a public policy to include fluoride in many aspects of life and make it accessible and possible. However, toothpaste remains one of the integral ways of introducing fluoride, and thus the enamel fluoride uptake from them is crucial. In conclusion, this mechanism depends on many factors, starting from the concentration, length of brushing, and up to pH of the toothpaste. Nevertheless, detailed, thorough studies are still needed to shed light on many other possible factors that may play a role in the enamel fluoride uptake.

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References

1. Patil VH, Anegundi RT. An in vitro assessment of fluoride uptake by tooth enamel from four different fluoride dentifrices. Eur Arch Paediatr Dent. 2014;15(5):347-51.
2. Sedlacek T, Yu E, Nunez R, In Suh B. Comparison of Enamel Fluoride Uptake from Five Fluoride-Containing Topical Treatment Products. Online J Dent Oral Health. 2020;3(5).
3. Buzalaf MAR, Pessan JP, Honorio HM, Ten Cate JM. Mechanisms of action of fluoride for caries control. Monogr Oral Sci. 2011;22:97-114.
4. Petersen PE, Lennon MA. Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. Community Dent Oral Epidemiol. 2004;32(5):319-21.

5. Arnold WH, Dorow A, Langenhorst S, Gintner Z, Banoczy J, Gaengler P. Effect of fluoride toothpastes on enamel demineralization. BMC Oral Health. 2006;6(1):8.
6. Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, et al. Dental caries. Nat Rev Dis Primer. 2017;3:17030.
7. Bagramian RA, Garcia-Godoy F, Volpe AR. The global increase in dental caries. A pending public health crisis. Am J Dent. 2009;22(1):3-8.
8. Prabakar J, John J, Arumugham IM, Kumar RP, Sakthi DS. Comparing the Effectiveness of Probiotic, Green Tea, and Chlorhexidine- and Fluoride-containing Dentifrices on Oral Microbial Flora: A Double-blind, Randomized Clinical Trial. Contemp Clin Dent. 2018;9(4):560-9.
9. Pessan JP, Toumba KJ, Buzalaf MAR. Topical use of fluorides for caries control. Monogr Oral Sci. 2011;22:115-32.
10. Walsh T, Worthington HV, Glenny AM, Marinho VC, Jeroncic A. Fluoride toothpaste of different concentrations for preventing dental caries. Cochrane Database Syst Rev. 2019;3:CD007868.
11. Moreno-Radic V, Sanchez Gonzalez J. Protocol of toothbrushing based on bioavailability of fluoride in toothpaste: a systematic review. Int J Odontostomat. 2016;10(3):433-41.
12. Creeth JE, Kelly SA, González-Cabezas C, Karwal R, Martinez-Mier EA, Lynch RJM, et al. Effect of toothbrushing duration and dentifrice quantity on enamel remineralization: An in situ randomized clinical trials. J Dent. 2016;55:61-7.
13. Marinho VCC, Chong LY, Worthington HV, Walsh T. Fluoride mouth rinses for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2016;7:CD002284.
14. Friberger P. The effect of pH upon fluoride uptake in intact enamel. Scand J Dent Res. 1975;83(6):339-44.
15. Nobre-dos-Santos M, Rodrigues LKA, Del-Bel-Cury AA, Cury JA. In situ effect of a dentifrice with low fluoride concentration and low pH on enamel remineralization and fluoride uptake. J Oral Sci. 2007;49(2):147-54.
16. Cheng X, Xu P, Zhou X, Deng M, Cheng L, Li M, et al. Arginine promotes fluoride uptake into artificial carious lesions in vitro. Aust Dent J. 2015;60(1):104-11.
17. Zero DT, Lippert F, Hara AT, Creeth JE, Newby EE, Butler A, et al. In situ anticaries efficacy of dentifrices with different formulations - A pooled analysis of results from three randomized clinical trials. J Dent. 2018;77:93-105.