Recent advancements in fluoride: A systematic review

Ankita Bansal, Navin Anand Ingle, Navpreet Kaur, Ekta Ingle

Department of Public Health Dentistry, KD Dental College and Hospital, Mathura, 1Department of Oral Medicine and Radiology, Vasantdada Patil Dental College and Hospital, Sangli, Maharashtra, India

Corresponding author (email: <dr.anuanki@gmail.com>)
Dr. Ankita Bansal, Department of Public Health Dentistry, KD Dental College and Hospital, Mathura, Uttar Pradesh, India.

Abstract

To review advancements of fluoride in dentistry, a search of 21 electronic databases and World Wide Web was conducted. Relevant journals were hand searched and further information was requested from authors. Inclusion criteria were a predefined hierarchy of evidence and objectives. Study validity was assessed with checklists. Two reviewers independently screened sources, extracted data, and assessed validity. Fluoride has become an important tool in preventive dentistry. Current research is focused on the development of strategies to improve fluoride efficacy. Fluoride therapy in the form of varnish, gel, mouth rinse, or toothpaste has been used extensively as a caries-preventive intervention for over three decades. The purpose of this review is to inform the reader about new research related to the use of fluoride for the prevention of dental caries.

Key words: Fluoridation, fluoride, varnishes

INTRODUCTION

Main benefit of fluoride is in reducing the risk of dental caries. In recent years, rapid changes have occurred in the prevalence of dental caries across countries. Today countries show a decline in the prevalence in dental caries and more children are becoming caries free. Decline in dental caries may be attributed to the cariostatic efficacy of fluoride.[1] Research into the mechanisms of anticaries efficacy of fluoride is ongoing, which may lead to better prevention strategies. New and/or improved fluoride products are entering the marketplace at an increased rate; these products include toothpastes, fluoride varnishes, fluoride-containing whitening agents, and other fluoride-containing cleaning products.

In early 2011, after years of review and evaluation, the Centers for Disease Control and Prevention (CDC), Environmental Protection Agency (EPA), and the American Dental Association (ADA) CDC, EPA, and the ADA proposed a modification to their recommendations for the amount of fluoride in drinking water to be 0.7 μg/ml (ppm) at all places in the United States. Thus, until 2011, the CDC and the ADA had recommended that the amount of fluoride in drinking water should range from 0.7 ppm in warmer climates to 1.2 ppm in cooler climates.

Studies have shown that some brands contain sufficient amounts of fluoride; therefore, when mixed with optimally fluoridated water, they result in greater than

Access this article online

Quick Response Code:  
Website: www.jispcd.org  
DOI: 10.4103/2231-0762.165927

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Bansal A, Ingle NA, Kaur N, Ingle E. Recent advancements in fluoride: A systematic review. J Int Soc Prevent Communit Dent 2015;5:341-6.
optimal amounts of fluoride in the formula. The CDC and ADA have varied their recommendations regarding this in recent years. In 2006, the CDC and ADA had recommended that low-fluoride water be used to reconstitute infant formula to guard against exposing the infant to excess amounts of fluoride. Recent evidence reviewed by the CDC suggests that “mixing powdered or liquid infant formula concentrate with fluoridated water on a regular basis may increase the chance of a child developing the faint, white markings of very mild or mild enamel fluorosis.”

There are some recent studies in which the amount of fluoride made available in the oral cavity during tooth brushing (for approximately 2 min) was measured. It seems that in developing regions of the world, there are toothpastes marketed that contain the total fluoride as indicated on the label, but they do not release sufficient fluoride during use to prevent caries. This is due to the composition of the toothpaste which can render a significant amount of the fluoride unavailable.\(^2\)

A clinical study in 2006 by Weintraub also confirmed that fluoride varnish is efficacious in reducing early childhood caries incidence. Clinical studies have demonstrated that varnishes can supply fluoride more efficiently than other topical agents.\(^3\)

A recent comprehensive systematic review by Twetman et al. summarized literatures on “fluoride toothpaste” from 2002 to 2008 and concluded, “There was strong evidence that daily use of fluoride toothpaste has a significant caries-preventive effect in children, compared with placebo (prevented fraction 24%). The effect was boosted by supervised tooth brushing, increased brushing frequency to twice daily, and use of a toothpaste concentration of 1500 ppm fluoride.”\(^4\)

The aim of this study is to describe the knowledge currently available on this topic and to suggest how this information could be used by clinicians to advise their patients on the ideal use of the currently available products.

RESULTS

A total of 334 potentially relevant records were found in the seven databases, 75 of which were duplicated. A total of 157 references were excluded based on the abstracts and 65 were selected for full-text analysis, 25 which were selected for inclusion in the study.

Worldwide, extensive fluoridation programs have been introduced in Australia, Brazil, Chile, Colombia, Canada, Hong Kong Special Administrative Region of China, Ireland, Israel, Malaysia, New Zealand, Singapore, the UK, and elsewhere. More recently, new programs have been introduced in large conurbations in the south and west of the USA, including Los Angeles (in 1999), Las Vegas (in 2000), Sacramento (in 2000), and San Antonio (in 2002).

In 2000, a report from California’s Children’s Dental Health Initiative Advisory Committee stressed the benefits of water fluoridation and recommended that access should be expanded.\(^5\)

Two evidence-based reviews (Yeung et al., 2005; National Health and Medical Research Council, 2007) indicate that there is limited support that fluoridated milk has a caries-preventive effect.\(^6\)

Currently milk fluoridation programs exist in several countries including Bulgaria, Chile, China, Peru, the Russian Federation, Thailand, and the UK.\(^7\)

In 1994–2004, salt fluoridation was introduced as a caries-preventive measure.\(^8\) Fluoridated salt is widely used in Germany, France, and Switzerland, with 30–80% of the marketed salt for domestic use being fluoridated (Marthaler and Petersen, 2005). More than 30 other countries worldwide use fluoridated salt and this type of fluoride delivery is highly recommended by the World Health Organization (WHO). There is no randomized clinical trial (RCT) conducted on this topic, according to recent reviews (Swedish Council on Technology Assessment in Health Care, 2002; National Health and Medical Research Council, 2007; Espelid, 2008). Some cross-sectional studies and controlled clinical trials do indicate the caries-preventive effect of salt, but fluoridated salt is probably less effective among small children due to the low-salt diet now recommended for this age group.\(^6\)

Fluoridated dentifrices undoubtedly have been the cornerstone of caries prevention worldwide and account for the caries decline observed in the past few decades in industrialized countries. It is found to cause 15–30% decrease in caries experience (CDC, 2001), while a recent systematic review concluded that the caries reduction was 24% (Marinho et al., 2003).\(^9\)

In 2005, a stannous fluoride sodium hexametaphosphate (SFSH) formula was introduced offering protection against a broad range of health and cosmetic conditions commonly experienced by patients. Sodium hexametaphosphate was first introduced in a dentifrice in 2000. It provides better coverage and retention on the
tooth surface, thus increasing its ability to inhibit both calculus and stain formation on the enamel surface.\[10\]

A clear evidence of caries-inhibiting effect of fluoride gel in permanent dentition with 28% reduction in decayed, missing, and filled tooth surfaces (DMFS) has been found (Marinho \emph{et al.}, 2002).\[9\]

Some studies have compared fluoride varnishes with other topical fluoride delivery vehicles. Tewari and associates compared Duraphat with a 2% NaF solution, a 1.23% acidulated phosphate fluoride (APF), gel, and a negative control. They reported that after 2.5 years, the varnish resulted in a higher percentage of caries reduction (74%) than did the NaF solution (28%) and the APF gel (37%).\[11\]

Fluoride-releasing dental restorative materials may provide an additional benefit in preventive dentistry. Comparison of fluoride ion release was made from four different dental restorations (Fuji VII, Fuji II LC, Dyract, and Z350) in de-ionized water from day 1 until day 5. The result showed significantly different fluoride ion release from all of them. The fluoride release was highest in Fuji VII, followed by Fuji II LC, Dyract, and Z350. The result also revealed a significant association of fluoride ion release from dental restorations in de-ionized water and artificial saliva, except for Z350 ($P = 0.787$). There was greater amount of fluoride release by all the tested materials in de-ionized water compared with artificial saliva.\[12\]

Various studies found that silver diamine fluoride is used as a caries-arresting agent. Hiraishi \emph{et al.} and Mathew \emph{et al.} (2012) found that silver diamine fluoride is used as an endodontic irrigant.\[13\]

A new system has been introduced in dentistry for achieving a constant rate of continuous fluoride release for a longer period in the oral cavity which is the intraoral fluoride releasing device to be used in high-risk groups (Mirth \emph{et al.}, 1982; Kula \emph{et al.}, 1987; Toumba and Curzon, 2005).\[14\]

Moberg Sköld \emph{et al.} studied the effect of additional fluoride rinses and varnishes given and supervised in a school environment and observed that even in groups of adolescents with moderate caries experience, caries initiation and progression were significantly reduced.

All published RCT data when combined, give the conclusion that fluoride toothpastes, mouth rinses, gels, and varnishes have similar effectiveness in preventing caries.

A summary of RCTs on fluoride concentration in toothpastes showed a positive dose response: Pastes with 1000–1500 ppm F showed 23% caries reduction compared to fluoride-free placebo; this value increased to 36% for pastes with around 2500 ppm F. For pastes having below 1000 ppm F, no significant difference was found with placebo, probably due to the small number of studies.\[15\]

Theobromine is used as a caries-preventing agent and it is present in cocoa. Sadeghpour (2007) stated that the cocoa extract is more effective than fluoride in reducing dental caries. Similar to fluoride, theobromine can prevent demineralization and improve resilience of tooth by acid.\[16\]

Recently, new fluoridated products have been introduced in the market, which are presented in Tables 1 and 2.

**DISCUSSION**

The most serious defect of the studies was the lack of appropriate design and analysis. Many studies did not present an analysis at all. There are a limited number of studies on advancements in fluoride, so it was difficult to correlate different studies.

Fluoride is still the cornerstone of modern noninvasive dental caries management. The prevalence of dental caries has steadily declined over the last 20 years due to dental hygiene practices and the increased use of fluoride-containing products. Health surveys still estimate the percentage of adults with DMFS to be 98.3% (Brown).

In 2008, extensive water fluoridation programs were introduced in Australia, Denmark, Ireland, England, New York, Brazil, and Lithuania.

Zorec Karlovsek \emph{et al.} conducted a study as a project to introduce salt fluoridation. In the study, the authors analyzed urine of children residing in different parts of Slovenia. They concluded that fluoride exposure was low, as the mean daily urinary F excretion was found to be 0.19 mg F/24 h.

Recently, milk fluoridation program was launched in Thailand in 2000 and in Macedonia in 2009.

In 2002, Nakamoto proved that theobromine can increase the size of apatite crystals and increase resistance of tooth to acid dissolution. The conclusion is fluoride and theobromine increase resistance of enamel
to acid dissolution as well as influence the hardness of enamel surface.

Many reports have been published throughout the world about the pros and cons of fluoride. After many years, the scientific conclusion has been reached that fluoride toothpaste and fluoridated water, salt, and milk are of great benefit to dental health, help to reduce decay, and cause no harmful side effects to general health.

Thus, fluoride in various forms, i.e., varnishes, rinses, foams, gels, dentifrices, slow releasing devices, prophylaxis paste, remineralizing agents, and in restorative materials, is now available to dental professionals for use in clinical practice and to be used by patients at home.

Their different formulas and concentrations make them suitable for therapeutic management of a...
number of dental problems including prophylactic prevention of dental caries, dentinal hypersensitivity, control of all caries from incipient to rampant, and reduction in the rate of dental erosion. For the dental professional to be able to choose the formula and concentration of the topical agent that is most effective in managing a specific dental problem for a particular patient, it is necessary to be aware of a number of properties of the agent selected. Despite its long-standing history and use, clinicians should have basic knowledge of the products and safe use of these products. Communication to the patient is an important adjunct to maximize the benefits and minimize the risks.

Many studies have been published throughout the world about the defluoridation methods. Few investigators have studied reverse for arsenic and fluoride removal. However, recent work by Fox and Huxstep has shown reverse osmosis to be effective in reducing the concentration of fluoride. The improvements in design and materials of the membranes have made the water treatment process economically competitive and highly reliable. Thus with improved management; this new technology for drinking water production might be the best option. On the basis of results and extensive investigations, different researchers had developed a simple and economical domestic defluoridation processes.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Pradeep K, Rao PK. Remineralizing agents. Int J Dent Case Reports 2011;1:73-84.
2. Carey CM. Focus on Fluorides: Update on the use of Fluoride for the prevention of Dental Caries. JEBDP 2014;1:27.
3. Fluoride Varnish: A Useful Dental Public Health Tool. Available from: http://www.thedbgelearning.com/UserFiles/File/Articles/Paedodontics/P277_Fluoride_Varnish_A__Useful_Dental_Public_Health_Tool_.pdf. [Last accessed on 2015 Mar 10].
4. Fluoride toothpaste. Available from: http://www.allianceforacavityfreefuture.org/Caries/Tools/en/us/downloads/Fluoride_Toothpaste_Full.pdf. [Last accessed on 2015 Mar 11].
5. Jones S, Burt BA, Petersen PE, Lennon MA. The effective use of fluorides in public health. Bull World Health Organ 2005;83:670-6.
6. Guidelines on the use of fluoride in children. EAPD 2009;10;129-35.
7. Milk Fluoridation. ACFF. Available from: https://www.yumpu.com/en/document/view/32283248/milk-fluoridation-alliance-for-a-cavity-free-future_pdf. [Last accessed on 2015 Mar 10].
8. Marthaler TM, Pollak GW. Fluoridated salt in Central Europe. SMZ 2005;115;670-4.
9. Shani Ann Mani. Evidence – based clinical recommendations for fluoride use: A review. AOS 2009;4:1-6.
10. Sensabaugh C, Sagel ME. Stannous Fluoride Dentifrice with Sodium Hexametaphosphate. JD 2009;83;70-8.
11. Eugenio D. Beltrán-Aguilar, Goldstein JW, Stuart A. Lockwood. Fluoride varnishes. JADA 2000;131:589-96.
12. Nik Noorul Azam bt Nik Yusoff, Ariffin Z, Hassan A, Alam MK. Fluoride Release from Dental Restorations in De-Ionized Water and Artificial Saliva. IMJ 2013;20;635-8.
13. Silver Diamine Fluoride: A Review and Current Applications. JOMOR 2014;5;1-21.
14. Dupare R, Kumar P, Dupare A, Jain R, Chitguppi R. Intraoral Slow Release Fluoride Devices. I J Pre Clin Dent Res 2014;1;37-41.
15. J. M. ten Cate. Contemporary perspective on the use of fluoride products in caries prevention. BDJ 2013;214:161-7.
16. Abdillah Imron Nasution AI, Cút zawil. The comparison of enamel hardness between fluoride and thebromine application. Int J Contemp Dent Med Rev 2014;1-4.
17. Shannon Pace Brinker. Indications of in office topical fluoride treatments. CPS. Available from: http://www.voco.com/us/product/voco_profluorid_varnish/FluorideTreatment_CE-course-by-Shannon-Pace.pdf. [Last accessed on 2015 Mar 09].
18. Jaana Gold. Fluoride Varnish Products in the U.S. Market. Gold J of Res Development 2013;1;1-2.
19. Rethman J. Focus on Sealants. DDH. Available from: www.dimensionsofdentalhygiene.com. 2010 April. [Last accessed on 2015 Mar 09].
20. Focus on Prophy pastes. Available from: http://www.dimensionsofdentalhygiene.com. 2015 Feb. [Last accessed on 2014 Mar 09].
21. Rethman J. Focus on Sealants. DDH. Available from: http://cpsmagazine.com. 2015 Feb [Last accessed on 2010 Mar 09].
22. Ingle NA, Dubey HV, Kaur N, Sharma I. Defluoridation techniques: Which one to choose. J Health Res Rev 2014;1;1-4.