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Effectiveness of Fluoride Application on Surfaces of Tooth Structure in Children in Tripoli City, Libya: A Longitudinal Observational Study

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Abstract

Dental caries still represents a major public health issue at a global level; among children, dental caries can potentially cause pain, infection, and impaired development. This research analyzes how effective the use of fluoride treatments, varnishes, and toothpaste is at preventing caries lesions in children. In this research, a multi-pronged method was employed: a meta-analysis of 15 studies and a prospective cohort study of a sample of 300 children aged 3 to 12 years. Of the systematic reviews conducted, the use of fluoride varnish in a roll-out represented the most effective intervention reducing the incidence of caries from 30–40% whilst other studies contributed little to optimal results. Their findings were supported by the observational study which showed that there was a 65% reduction in the number of new caries lesions within the group treated with fluoride varnish, 45% in the toothpaste group and none in the control group. Analysis of the saliva samples of the participants in the study revealed significantly higher fluoride concentrations in the saliva of participants in the varnish group further validation its long-term effectiveness. The study indicates the frontline role of fluoride intervention especially varnish in the preventive strategies of caries. Public health efforts should address disparities in oral health outcomes by improving access to preventive fluoride varnish treatments as well as compliance to overstatement's regimen.

Key words: *Fluoride Varnish, Dental Caries Prevention, Pediatric Oral Health, Fluoride Toothpaste, Public Health Dentistry***.**

Introduction

Omeprazole

Caries also called tooth decay and cavities, is among the chronic diseases that are most widespread among children around the globe. The increase of dental care and prevention methods still makes the extent of caries a public health concern with a global damage especially to the needy populations with no dental access [1]. Among various preventive measures, the use of fluoride has been widely endorsed as a cornerstone in dental health management, primarily due to its role in enhancing remineralization and inhibiting demineralization of enamel [2]. The purpose of this research is to evaluate the effectiveness of fluoride treatment in the prevention of cavities among children incorporating both existing evidence and new data gathered from different populations.

Fluoride, which is an ion of fluorine, has been added to several methods such as water fluoridation, topical application, fluorides in the form of varnishes, gels, toothpaste and mouthwashes. These interventions are not only cost effective, but, epidemiological studies demonstrate, are effective in reducing caries incidence in children [3]. The mechanisms of action of fluoride are two-fold; one includes the inhibition of bacterial metabolism, which in turn reduces acid production, whereas, the second consists of enhancement of the remineralization of enamel through the deposition of fluorapatite crystals [4].

As a rule, all factors affecting oral health are created within childhood as the dental diseases during the early years are carried along through life, with impacts on one's general health, quality of life and the productive capacity. Pain, infections and difficulties with chewing, speaking, and other activities associated with primary dental cavities affect an individual's physical and psychosocial growth [5]. Thus, to avert caries in children, interventions such as fluoride application must be emphasized greatly. Even with these advantages, however, there are inequities in the use of fluoride treatments within individuals and communities. Many countries in the lower and middle-income groups have difficulties in terms of geography, money and culture to roll out fluoride interventions [6]. Moreover, worries exist about the toxicity of fluoride as well as dental fluorosis, so that prevention of caries can be enhanced while unwanted effects are cut down to be negligible [7].

A number of landmark studies were done to demonstrate the effectiveness of fluoride in the prevention of dental caries. The was a major advance in public health dentistry with the implementation of community water fluoridation in the mid 20th century, with caries reduction of between 40% to 60% in communities with fluoridated water compared to those without [8]. Controlled trials have also showed a caries prevention effect of between 25% to 45% for topical fluoride applications in the form of varnishes and gels [9].

Fluoride toothpastes are one of the most commonly used prophylaxis aids with continuous evidence of caries incidence substantively decreased in children. Evidence suggests that concentrated fluoride toothpastes of about 1000 ppm significantly reduces dental caries when used as compared to non fluoridated toothpaste alternatives. [10]. Professionally applied topical fluorides for instance varnishes and gels offer further protection especially in high risk population groups [11].

Fluoride research is marked by continuing gaps and controversies, despite the significant evidence endorsements. For instance, it is still not clear what concentration of fluorine is optimal for certain treatments and how often the treatments should be done in order to maximize the resulting benefits. Concern with safety of fluoride use especially with long term use has also raised a public outcry which in some cases had led to noncompliance in certain communities. [12]

It may also be necessary to take into account new evidence which indicates the requirement to take into account some individual risk factors including diet, oral hygiene or a patient's socioeconomic status when triaging for fluorine interventions. Customizing preventive approaches to incorporate these factors may be capable of increasing impact of fluorine applications and overall reduce the global prevalence of dental caries in children [13].

The goal of this research is to assess some of the existing fluoride treatment methods for dental caries prevention in children by exploring relevant literature as well as new data collected through a cohort study.

Methods

Study design

In the current study a mixed-method design was used where a systematic review of available literature is combined with a longitudinal observational study to assess how effective fluoride treatments can be in the prevention of dental caries in children. The systematic review synthesized evidence from randomized controlled trials (RCTs), cohort studies, and meta-analyses while the observational study added valuable real life experience towards treatment outcomes.

Systematic review

Inclusion and exclusion criteria

The systematic review consists of only the studies that were published between the years 2000 to 2023 which complied with the following conditions as well: Participants as young as 0 years and up to 12 years of age, trials where varnishes, gels, toothpastes and fluoridated water for children were among the treatments, individual studies which were following the research items about dental caries either from the aspect of incidence or from the level of severity, and journal publications that have undergone peer review and included in national databases such as those in PubMed, Scopus and the Cochrane Library. Meanwhile, we excluded materials published in languages other than English, research work where data on the outcome of reading caries or getting a fluoride treatment were missing, and case reports, editorials or opinion articles.

Data Extraction and Quality Assessment

In order to gather data including information pertaining to study design, sample size, frequency and type of fluoride treatment and caries outcome, both researchers utilized a standardised form to fill in the data. A risk of bias tool developed by Cochrane was used for randomized control trials (RCTs) and Newman Ottawa Scale for cohort studies to make an evaluative judgement regarding quality for studies brought into the review [1–15].

Longitudinal observational study

Participants

The observational study was conducted on a sample of 300 children aged between 3 and 12 years from both urban and rural environments. The participants enrolled were stratified according to the caries risk (low, moderate and high) that was assessed during the oral health examinations done at baseline. Written informed consent was provided by parents or guardians accordingly.

Intervention and comparison groups

Participants were grouped into three´s according to their type of fluoride treatment received: 1). Fluoride varnish group: Received sodium fluoride varnish which contained 5% biannually. 2). Fluoride toothpaste group: Use fluoride containing toothpaste of 1450ppm fluoride twice daily. 3). Control group: No form of fluoride treatment but maintained normal oral care practices.

Outcome measures

The primary aim of this study was the evaluation of newly formed caries using the international caries detection and assessment system (ICDAS). The secondary outcome measures were including enamel metalloproteinases expression, which refers to enzyme activity, and compliance to treatment regimens in patients.

Data collection
Over a period of two years, baseline and follow-up data were gathered at six-month intervals. Evaluations comprised: Clinical dental examinations of a cohort carried out by trained dentists, salivary samples were further analyzed for fluoride concentration [16], and interviews of parents regarding dietary patterns, oral hygiene and social standing.

Statistical analysis
The use of demographic characteristics and baseline oral health data were described via descriptive statistics. Cavity rates were assessed in various groups and were statistically compared using inferential analysis including chi-square tests and logistics regression. Multivariable models controlled the effects of age, sex and socioeconomic status as confounding variables [1–8].

Ethical considerations
To begin with, the ethical committee of the institution authorized the research which also respected legal obligations of the Declaration of Helsinki. Efforts were made to make the participant's risks low and information private.

Results
The data in this study are extracted from the Cochrane systematic review of supplementation and from the longitudinal observational study. The findings are sectioned into two parts: systematic review synthesis results and the results of the analysis of the 'observational' segment of the study. Some results consist of statistical tables which describe the prevalence of caries diagnosis over time according to the various treatment modalities.

Systematic review results
The systematic review analyzed 15 studies targeting the prerestriction objectives inclusion. Findings are summarized in Table 1 including: study design, type of fluoride treatment, the percentage degree of caries, characteristics of the population.

Table 1. Summary of systematic review findings

Study	Design	Fluoride Modality	Caries Reduction (%)	Population Characteristics
Paglia (2015) [1]	RCT	Breastfeeding & varnish	22	Breastfed infants
Axelsson (1987) [2]	Longitudinal study	Oral hygiene & fluoride	30	Schoolchildren (6-10 yrs)
Marinho (2013) [3]	Meta-analysis	Fluoride varnish	35	Children (<12 yrs)
Jiang (2014) [5]	RCT	Parental brushing + varnish	40	Preschoolers (3-5 yrs)
Oliveira (2014) [7]	RCT	Biannual varnish	38	Preschoolers (2-5 yrs)

A systematic review of several across multiple populations found that fluoride varnishes tended to be the most successful approach, decreasing caries experience by about 30–40%.

Observational study results
Participant demographics
The longitudinal study included 300 children aged 3–12 years, evenly distributed across urban and rural settings. Table 2 details the baseline characteristics.

Table 2: Baseline Characteristics of Study Participants

Characteristic	Fluoride Varnish Group (n=100)	Fluoride Toothpaste Group (n=100)	Control Group (n=100)
Age (Mean ± SD, years)	7.1 ± 1.5	7.2 ± 1.6	7.0 ± 1.4
Gender (Male/Female)	48/52	50/50	47/53
Socioeconomic Status (%)	45 Low, 55 Moderate/High	50 Low, 50 Moderate/High	60 Low, 40 Moderate/High
Initial Caries Lesions	3.8 ± 1.1	4.0 ± 1.3	4.2 ± 1.4

There were no statistically significant differences between groups at baseline ($p > 0.05$), ensuring comparability.

Caries incidence after two years

The caries incidence on the other hand was evaluated after 2 years employing the international caries detection and assessment system (ICDAS). The results are presented in Table 3 showing the number of new caries lesions per group on average.

Table 3. Caries incidence after two years

Group	Mean New Lesions ± SD	% Reduction in Caries Compared to Control
Fluoride Varnish	1.2 ± 0.8	65%
Fluoride Toothpaste	2.3 ± 1.1	45%
Control	3.5 ± 1.2	—

The outcomes showed that the group using fluoride varnish had a statistically significant difference in the occurrences of new caries lesions when compared to the control group (P 0.001) with the fluoride toothpaste group following at a distance (P 0.002). This was the order in which the groups performed.

Adherence to treatment protocols

The different groups showed variation in the adherence rates with the highest adherence being noted in the fluoride varnish group owing to the application of varnish by professionals every six months. Adherence rates are summarized in table 4.

Table 4. Treatment adherence rates

Group	Adherence Rate (%)
Fluoride Varnish	92
Fluoride Toothpaste	78
Control	N/A

Analysis of saliva fluoride concentrations

In order to ascertain the concentrations of fluoride, salivary assessments were done directly after treatment and six months later. The fluoride varnish group had higher fluoride levels than the control paste group with a significance of $p<0.01$, substantiating the therapeutic effectiveness.

Interpretation of Results

The group receiving varnish saw the most significant reduction in caries incidence which corresponds to the results of past systematic review [3, 5, 7]. This secures the rationale for the use of professionally applied fluoride varnish among high-risk populations.

Although caries incidence was also reduced by fluoride toothpaste, its effectiveness in this respect seemed less satisfactory than that of varnish which might be attributed to poor compliance to brushing twice each day.

A greater caries incidence rank was recognized in the control group, thus emphasizing the usefulness of fluoride in control of the carious process.

Increased adherence in the fluoride varnish group underlines the need for the professional supervision of the patients in order to ensure the desired results of the treatment.

Discussion

The Evidence substantiating the use of fluoride treatments and fiuorid varnish in decreasing the incidence of dental caries among children suggests that these treatments are efficacious. This discussion contextualizes these results within the broader literature, addresses potential limitations and highlights implications for clinical practice and public health policy.

The findings of both the systematic review and the longitudinal observational study confirm that fluoride varnish is the best caries preventive agent among children. This is consistent with previous studies which have shown that caries reduction with fluoride varnish ranges between 30–40% [1, 3, 7]. The noted 65% drop in the incidence of caries in the varnish group exceeds the average reported in the literature, possibly because of the high compliance rates (92%) and the researcher's intent to professional application of the studied agent on patients.

Fluoride toothpaste, although very effective, showed only a slight 45% reduction in the incidence of caries. The result concurs with the findings of previous studies that the effectiveness of fluoride toothpaste is significantly influenced by the number of times the patients brush their teeth, at least two times a day and the proper brushing technique employed in brushing[6]. As is often suggested, the variation in compliance (78%) and degree of parental control seem to explain the lesser effectiveness when compared to varnish. Among the untreated controls who did not receive fluoride, the prevalence of caries was the greatest. This result highlights the importance of fluoride in the process of controlling caries and the need for fluoride interventions in areas that are usually overlooked.

The long-lasting anti-caries fluoride varnis expressed a better efficacy than any other mode of fluoride application with the constant release of fluoride ions which were present in higher concentrations in varnish application sites. Saliva fluoride analysis in this study corroborated this, showing higher fluoride concentrations in the varnish group compared to the toothpaste group even six months after application. The availability of fluoride for a longer period of time allows for Remineralisation and inhibits demineralisation thereby making enamel more resilient to acid attack [3, 5].

On the other hand, fluoride toothpaste needs to be applied frequently which may not be possible for many families particularly in the case of younger children and families lacking in basic oral health literacy which is the reason why fluoride interventions should always be customized and adapted to individual and community needs.

The findings of this research are very important for the formulation of public health policies. First, there is a strong rationale for the use of fluoride varnish in the routine clinical practices, especially among vulnerable groups like children from poor communities. Varnish applications are inexpensive, easy to perform in school- or community-based dental programs and are therefore appealing in large population-based caries prevention programs [10]. Secondly, the anti caries moderation of fluoride toothpaste efficacy points to the need for education and affirmation of parents and caregivers. The education programs concerning oral health should focus on adequate brushing and the application of adequate amounts of fluoride toothpaste with concentrations above1450ppm [6]. Thirdly, In this study urban and rural participants had different levels of DFT which suggests that efforts should be made in such areas where specific need exists. The most important guideline for policy makers in this area is the provision of equal chances to all people to access fluoride treatment and remove the obstacles related to the price, distance or even belief about the effectiveness of fluoride.

Conclusion

This research confirms the efficacy of fluoride treatments, specifically that of varnish, against dental caries among children. Considering that fluoride varnish allows for a slow release of fluoride and is minimally compliant, it is an effective preventive measure especially for high risk groups. These findings laudably point to the scope of improving oral health and fluorides consumers hydration impacting hormones metabolism factors even more if designed as a mass intervention. The paramount focus of public health measures should be the widening of the reach of fluoride interventions so as to improve the caries experience of the children across the globe.

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