EFFECT OF NANO-HYDROXYAPATITE ON REMINERALIZATION OF ENAMEL - A SYSTEMATIC REVIEW

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ABSTRACT

The application of nano–hydroxyapatite in the repair of early carious lesion has received considerable attention. Neither the remineralization effect nor the protective mechanism has been comprehensibly investigated and has been left to an open debate still. The primary objective of this review was to evaluate the remineralization potential of a toothpaste containing nano–hydroxyapatite on early carious lesions of enamel. The Cochrane database of systematic reviews, PubMed, LILACS / BBO, MEDLINE, SCIENCE DIRECT, electronic retrieval systems and databases were selected for identification of studies. Ten in-vitro studies were found in the search, of which only 5 studies met the inclusion criteria. Of the studies included, 3 studies provided data on surface micro hardness, 2 studies for comparison of lesion depth and 2 studies provided data for comparison of loss in mineral content. Results of the review showed that nano–hydroxyapatite paste was effective in reducing the initial carious lesions of enamel and can be used as an alternative to fluoridated toothpastes.

KEYWORDS: Dentifrice, Nano-Hydroxyapatite, Enamel Remineralization

INTRODUCTION

Dental caries is a complex disease that affects a large proportion of the world’s population, regardless of gender, age and ethnicity.1 Caries is not just a disease but instead a disease process.2 The current concept considers caries as a dynamic and reversible process and is the result of the interplay of a number of etiological factors. The understanding of this basic fact has opened up newer avenues of interception of this disease process through re-mineralization.3, 4

Deminerlization and remineralization is a dynamic process and is governed by the degree of saturation of oral fluids (saliva and plaque) with respect to apatite minerals. Tooth mineral is composed mainly of calcium and phosphorous. Methods for providing these constituents of mineral to facilitate re-mineralization of teeth have been the backbone for newer re-mineralization strategies.1 given an appropriate change in conditions; remineralization may become the predominant process, thus leading to lesion repair .5, 6

Enamel remineralization has been studied for about 100 years, and it has been suggested that the non-invasive treatment of early caries lesions by remineralization has the potential to be the major advance in the clinical management of the disease.7 Remineralizing agents are dispensed through a variety of ways mainly in the form of restorative material, pit and fissure sealants, dentifrices, chewing gums and mouth rinses. Dentifrices have now been commonly used as a
vehicle for remineralizing.

Fluoride (F) has been a useful instrument and is one of the most effective remineralizing agents in caries prevention. Nevertheless, some concern has been expressed that with the wide array of both prescription and over-the-counter fluoride products now being marketed in every country, the total fluoride intake has increased to perhaps harmful levels. The prevalence of dental fluorosis, on the other hand, has increased noticeably in non-fluoridated areas and to a lesser extent in optimally fluoridated areas. Therefore, it is still necessary to seek alternative, effective non-fluoride agents that can provide a complete cure for caries.

In recent years, alternatives to fluoride such as nanohydroxyapatite (HA) and casein phosphopeptide (CPP) have been proposed for their anticariogenic properties. It has been shown that CPP with calcium and phosphorus, which has a high affinity for the HA of tooth enamel, can enhance tooth remineralization and is safe for clinical use.

Nano-hydroxyapatite (n-HAP) is considered one of the most biocompatible and bioactive materials, and has gained wide acceptance in medicine and dentistry in recent years. Owing to its chemical and structural similarity with enamel minerals, the application of nano-hydroxyapatite to biomimetic repair the damaged enamel directly have been received great attention in today’s dental research. Nanoparticle hydroxyapatite containing toothpastes were first introduced and tested in Japan in the 1980s (e.g. Apadent, Apagard, and others by Sangi Co., Ltd., Tokyo).

However, evidence is still incomplete to substantiate claims by manufacturers and so far none of these products have been comparable to fluorides. Therefore, the aim of the present systematic review was to evaluate how effective is the remineralization potential of nanohydroxyapatite toothpaste on enamel.

MATERIAL AND METHODS
Criteria for Considering Studies for this Review

We included studies which tested the re-mineralization potential of nano-hydroxyapatite toothpaste on human enamel. The main inclusion criteria being

- In-vitro studies
- Relevant to review objective of the particular nano-hydroxyapatite topic
- Language of publication comprehensible by the reviewer
- Studies with parameters like lesion depth, Surface micro hardness and loss of mineral were included for this review.

The included articles were reviewed in depth and excluded according to the following criteria:

- Clinical trials
- Animal studies
- Review articles, letter to editors (not containing primary data).

Types of Material:

The test tooth paste consisted of nano-hydroxyapatite dentifrice and the control mostly in all studies was a
fluoridated dentifrices or an equivalent test solution.

**Types of interventions:**

In all studies nano-hydroxyapatite toothpaste was used and compared to a test or control group. The studies made use of a similar pH cycling model, which was carried out for a period of 12 days, thought to replicate the oral environment. The teeth were sectioned and the initial carious lesions were created with the help of the demineralizing solution. After which it was treated by the remineralizing agent, either directly by immersing it into slurry of the toothpaste prepared or to a diluted solution mostly in the ratio of 1:3. Following the completion of the pH cycling the specimens were subjected to different tests to analyze various parameters.

**Types of Outcome Measures**

The primary outcome was to see the effect of nano-hydroxyapatite toothpaste on re-mineralization of enamel. Clinical parameters like difference in Lesion depth, Surface micro hardness and loss of mineral content (baseline and post-test) were assessed.

**Search Methods for Identification of Studies**

A comprehensive literature search of the following databases were done which included studies of the Cochrane database of systematic reviews, PubMed, LILACS / BBO, MEDLINE, SCIENCE DIRECT.

We also searched websites of product manufacturers, as well as Google scholar.

**The following Electronic Search key Words**

**Materials:** nano-hydroxyapatite, nano-hydroxyapatite toothpaste, nano-hydroxyapatite dentifrice, toothpaste and dentifrice

**Measures:** Tooth re-mineralization and Enamel re-mineralization

**Variables of interest**

- Lesion depth, Surface micro hardness and Loss of mineral content (baseline and post-test).

Figure 1 depicts the search strategy used in the present systematic review. A final review of five studies was done

**Data collection and analysis**

The records retrieved by the searches were screened for potential relevance against stated inclusion criteria and the following information was extracted from each study: Lesion Depth, Surface micro hardness and mineral loss (baseline and post-test).

**RESULTS**

This report aimed to review the in-vitro trials of nano-hydroxyapatite dentifrices used in dentistry. Five studies (in vitro) were identified that focused on remineralization of early carious lesions of enamel. All of the studies showed that nano-hydroxyapatite toothpaste was effective in remineralizing early enamel when comparing with control group.

The studies, which assessed the re-mineralization potential of nano-hydroxyapatite toothpaste on enamel were, the studies carried out by S.B. Huang et al 2009, Itthagarun et al 2010, Shengbin et al 2010, Peter et al 2011, S. Huang et al...

For all the three studies which measured the surface micro hardness (S.B. Huang et al 2009, Shengbin et al 2010 and S. Huang et al 2011) there was a significant improvement in hardness of the enamel surface following the use of nano-hydroxyapatite paste and for the two studies used for assessment of lesion depth there was a significant improvement in the studies by Peter et al and Itthagarun et al. Increase in mineral content after treatment with nano-hydroxyapatite paste was evident in the study of Peter et al 2011 while no significance was found to be in the study of Itthagarun et al 2010. Given the high proportion of heterogeneity present in the studies reported, a sensitivity analysis was performed using a random-effects model.

The level of evidence of included studies was of evidence level III (In-vitro studies).

DISCUSSIONS

While the healing effects of fluoride containing toothpastes are well established only limited literature, as seen in this review, exists assessing the re-mineralization potential of nano-hydroxyapatite toothpaste on enamel. The results of the studies included for review showed that hydroxyapatite toothpaste produced similar results to the positive control and also exhibited similar ability to reduce the progress of demineralization, while simultaneously enhancing the artificial caries like lesions.

The surface chemical properties and morphological structure of hydroxyapatite has been claimed to play the most important part in re-mineralization of early caries lesions. Three studies showed significant improvement in surface micro hardness post treatment with nano-hydroxyapatite toothpaste (S.B. Huang et al 2009, Shengbin et al 2010 and S. Huang et al 2011) similar to a review by Kim et al 2007.19

Evidences from the studies (Itthagarun et al 2010, Peter et al 2011) has shown that lesions can be re-hardened by deposition of hydroxyapatite that is initially deposited near the surface layer of the enamel and this was found to be significant. Future studies are required for further assessment of the potential of nano-hydroxyapatite toothpaste on enamel in-vivo.

CONCLUSIONS

Given the small number of experiments and limitations of the in-vitro studies comparing the re-mineralizing potential of nano-hydroxyapatite toothpaste on enamel, the effectiveness of this toothpaste seems to be obvious in improving the initial enamel carious lesions. More research is needed to be carried out with clinical studies to substantiate the effectiveness of nano-hydroxyapatite on enamel.

REFERENCES


APPENDICES

Table 1: Characteristics of Studies Included for Review

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<thead>
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