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The anti-caries efficacy of a dentifrice containing 1.5% arginine and 1450 ppm fluoride as sodium monofluorophosphate assessed using Quantitative Light-induced Fluorescence (QLF)

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ABSTRACT

Objective: To compare the efficacy of a new dentifrice containing 1.5% arginine, an insoluble calcium compound and 1450 ppm fluoride to arrest and reverse naturally occurring buccal caries lesions in children relative to a positive control dentifrice containing 1450 ppm fluoride alone.

Study design: Participants from Chengdu, Sichuan Province, China tested three dentifrices: a new dentifrice containing 1.5% arginine, an insoluble calcium compound, and 1450 ppm fluoride, as sodium monofluorophosphate, a positive control dentifrice containing 1450 ppm fluoride, as sodium fluoride, in a silica base, and a matched negative control dentifrice without arginine and fluoride. Quantitative Light-induced Fluorescence (QLF) was used to assess buccal caries lesions at baseline and after 3 and 6 months of product use.

Results: 438 participants (initial age 9–13 years (mean 11.1 ± 0.78) and 48.6% female) completed the study. No adverse events attributable to the products were reported during the course of the study. The subject mean ΔQ (mm^2 %), representing lesion volume, was 27.26 at baseline. After 6 months of product use, the ΔQ values for the arginine-containing, positive and negative control dentifrices were 13.46, 17.99 and 23.70 representing improvements from baseline of 50.6%, 34.0% and 13.1%. After 6 months product use, the differences between the pair wise comparisons for all three groups were statistically significant ($p < 0.01$). The arginine-containing dentifrice demonstrated an improvement after only 3 months that was almost identical to that achieved by the conventional 1450 ppm fluoride dentifrice after 6 months.

Conclusion: The new dentifrice containing 1.5% arginine, an insoluble calcium compound, and 1450 ppm fluoride provides statistically significantly superior efficacy in arresting and reversing buccal caries lesions to a conventional dentifrice containing 1450 ppm fluoride alone.

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1. Introduction

There is no doubt that the introduction of fluoride products, such as dentifrice and mouth rinses, has played a significant role in the dramatic decline in the prevalence and severity of dental caries in many geographies, particularly in developed countries.[1,2] Despite this success, dental caries remains a prevalent oral disease, and cavities remain a global public health problem.[1,3]

The past two decades of caries research has significantly advanced our knowledge of dental caries, and, in particular, has identified that caries is a dynamic, multi-factorial disease process involving the interface of the undisturbed plaque biofilm and the tooth surface when dietary sugars are present.[4–6] The process begins when acid-producing species, such as the mutans streptococci, within the undisturbed plaque biofilm metabolize these dietary sugars to produce lactic and other acids, causing initial de-mineralization, i.e., the first loss of calcium and phosphate ions from the hydoxyapatite structure of the tooth's enamel. This initial step results in a reversible early caries lesion which can be re-mineralized. Fluoride works by promoting re-mineralization of this de-mineralized tissue, reversing the caries process and adding calcium and phosphate ions back into the hydroxyapatite structure, as well as incorporating fluoride, as fluorapatite, to strengthen the mineral lattice.[7,8] If de-mineralization is left unchecked, however, dental caries can progress through various irreversible stages of enamel breakdown to frank cavitation.[9]

Importantly, this new knowledge has led to an understanding that caries is a disease continuum.[1] This, in turn, has begun to change clinical dentistry from a focus on restoration of cavities to investigation of therapeutic approaches to arrest or reverse the caries process by re-mineralizing initial enamel or root caries lesions that are not cavitated.[10] In large part, however, such interventions have focussed on mechanical plaque control measures to remove the biofilm and reduce acid production by cariogenic bacteria, and treatment with fluoride to facilitate re-mineralization and inhibit de-mineralization.[11] Dentifrice is an ideal vehicle for fluoride because it simultaneously facilitates plaque removal during brushing and ensures effective delivery of fluoride for the treatment and prevention of carious lesions. In fact, fluoride dentifrice is the most effective, evidence-based caries preventive measure available today.[12]

During the past decade, a new approach to the management of dental caries has been identified and validated. This new approach combines arginine and an insoluble calcium compound with fluoride to complement and enhance the effects of fluoride by targeting the first step in the caries process, i.e., the first acid attack, modulating the metabolism of the plaque biofilm, neutralizing plaque acids and, thereby, reducing the harmful effects of the plaque biofilm.[1,13] The arginine is metabolized to ammonia through the arginine deiminase pathway in non-pathogenic arginolytic organisms, such as *Streptococcus sanguis*. In turn, this ammonia neutralizes plaque acids and stabilizes the residual plaque biofilm, preventing a shift in the oral flora to aciduric bacterial species and maintaining a non-cariogenic plaque after sugar challenge.[1,13,14] Thus, the less acidic intra-oral pH encourages re-mineralization and reduces de-mineralization.[15] In addition, the insoluble calcium compound is able to provide free calcium ions to supplement the re-mineralization process.[1,13,14,16']

The anti-caries benefits of a new dentifrice containing 1.5% arginine, an insoluble calcium compound, and 1450 ppm fluoride, as sodium monofluorophosphate (MFP), have been demonstrated in a series of clinical studies involving reversible caries lesions in adults, as well as in children.[17–20]

In two studies, the ability of the new arginine-containing dentifrice to re-mineralize non-cavitated primary root caries lesions was evaluated. In one study, the new dentifrice was compared to that of a positive control dentifrice containing 1450 ppm fluoride, as sodium fluoride, in a silica base, and a fluoride-free, matched negative control. After 6 months use of the new dentifrice, one lesion (0.7%) became worse and 61.7% of subjects had lesions which hardened. In contrast, for the positive and negative control dentifrices, 9.0% and 18.2% of subjects became worse, and 56.0% and 27% improved, respectively. The differences between the new arginine-containing dentifrice and both the positive and negative control dentifrices were statistically significant ($p < 0.01$).[17] In the other study, the new dentifrice was compared to that of a matched positive control dentifrice containing 1450 ppm fluoride alone. After 6 months use of the new dentifrice, 70.5% of subjects had lesions which hardened compared to 58.1% of subjects in the positive control group. The difference in the number of lesions being hardened between the new arginine-containing dentifrice and the positive control dentifrices was statistically significant ($p < 0.05$).[18]

In three studies, including the study reported in this paper, the benefits of the new dentifrice containing 1.5% arginine, an insoluble calcium compound, and 1450 ppm fluoride in arresting and reversing buccal enamel carious lesions were demonstrated using Quantitative Light-induced Fluorescence (QLF) methods to measure changes in mineralization of enamel lesions.[19,20] The Quantitative Light-induced Fluorescence (QLF) method is based upon the principle that a tooth fluoresces green when it is stimulated with blue light. Emitted green light is scattered within an early lesion, when caries is present, such that the overlying tooth surface appears dark against a green background. By comparing the loss of fluorescence, due to scattering in the lesion, to the background level of fluorescence, both the area and degree of de-mineralization (ΔF) of the lesion can be quantified. In addition, the volume of the lesion (ΔQ) can be estimated by multiplying the lesion area by the loss of fluorescence (ΔF). This method has now been employed in a number of clinical studies.[21–24]

In one study, the new dentifrice was compared to two matched dentifrices, one with neither fluoride nor arginine as a negative control and the other a 1450 ppm fluoride only dentifrice as a positive control. After 6 months use of the products, the mean lesion size was reduced by 50.7% for the arginine-containing dentifrice, 32.3% for the positive control and 11.4% for the negative control. The differences between the arginine-containing dentifrice and both the positive and negative control dentifrices were statistically significant ($p < 0.01$).[19] In the other study, the new dentifrice was compared to a matched 1450 ppm fluoride dentifrice as a