

Biomimetic oral care: Preventing oral diseases with hydroxyapatite

Hydroxyapatite is the main mineral component of tooth enamel and dentin. Used as an active ingredient in oral care products, **Dr Bernard Siew**, together with Dr Joachim Enax and Dr Frederic Meyer, discuss its effectiveness in the prevention of tooth decay and gum disease.

Oral health in Singapore remains a big issue. Dental caries and periodontal diseases do not only affect children but also adults and the elderly. As the proportion of children with dental caries decreased between 1970 and 1994, recent data suggest an increase of this disease in children.

Studies indicate a prevalence of dental caries of up to nearly 50% of young children (18 months to four years of age)¹. Early childhood caries is a very serious problem². A worse oral health status were reported in adults and the elderly. In a cohort of people aged 60 or older, the proportion of people with

natural teeth was only 10.3% in women and 12.8% in men, and many of them were edentulous (37% of women and 24% of men)³. The high level of tooth loss can be attributed to dental caries and periodontal disease⁴⁻⁶.

Apart from the loss of teeth from oral diseases, other issues can affect the quality of life⁷. Dentin hypersensitivity, usually due to excessive enamel loss by attrition, abrasion or acid erosion, is well known to have a negative impact on an individual's sense of well-being. Dentin hypersensitivity is a result of exposed dentinal tubules. Patients with dentin hypersensitivity often experience short

and sharp pain when consuming cold or hot food and beverage⁸.

The simplest process to prevent oral diseases and their resultant symptoms is with correct regular oral care. Tooth brushing for at least two minutes twice a day using an effective toothpaste is the basic standard of care.

As more is understood of the demineralisation-remineralsation process of our tooth structure, more research and development has led to the concept of pH control and supersaturation the tooth surfaces with minerals.

These minerals were traditionally different types of fluoride such as monofluorophosphate,



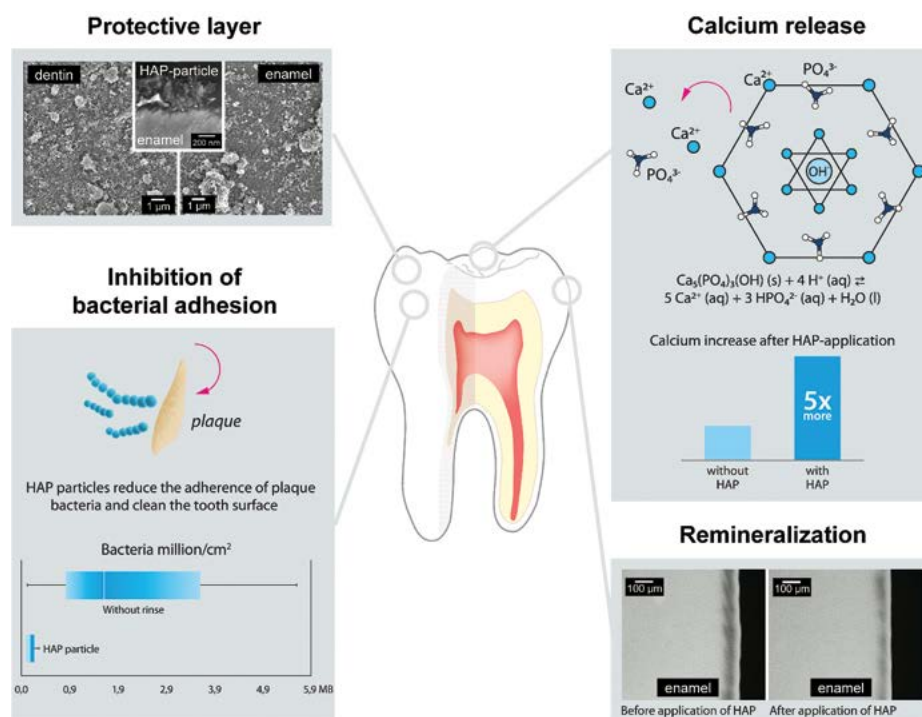


Fig. 1: Modes of action of HAP used as active agent for the prevention of oral diseases. HAP does not only form a protective layer on enamel and dentin, but also occludes dentin tubuli. The figure was originally published elsewhere¹⁵.

sodium fluoride or stannous fluoride. However, fluoride has certain limitations, as calcium and phosphate are needed for the remineralisation-process⁹. Additionally, fluoride has to be applied in only small amounts for children (due to its toxicity), but rice-sized or pea-sized amounts of toothpaste have a limited cleaning efficacy¹⁰.

The concept of biomimicry and its efficacy in toothpaste formulation was studied since the 1980s¹¹. There have been developments of a biomimetic toothpaste with the aim of tackling early childhood caries as excessive fluoride exposure have traditionally led to dental fluorosis and fluoride toxicity¹²⁻¹³.

HYDROXYAPATITE

One possible option is choosing a hydroxyapatite-based toothpaste. Hydroxyapatite (HAP) is not only known to be the hardest material in our body as enamel (approximately 97% HAP), but also to

be the main part of dentin (approximately 70% HAP), and it can be synthetically produced to be used as active ingredient in oral care products^{7,14}.

Recently published studies, including clinical trials and meta-analyses report of HAP containing oral care products to be effective in preventing various oral diseases^{7,15-18}. While fluoride, an active ingredient to prevent tooth decay¹⁹, has many confirmed or discussed side-effects (e.g. fluorosis)^{12-13,20-22}, HAP shows good biocompatibility as it is the main part of human teeth^{15,23,24}. In the scientific literature including in situ studies and clinical trials, HAP is described as an effective agent used in oral care²⁵. Figure 1 shows the modes of action of HAP as published elsewhere¹⁵.

Caries prevention

Placebo-controlled clinical trials, and comparative in vivo and in situ studies with fluoride toothpaste used as positive

control, confirmed the efficacy of HAP containing toothpastes as anti-caries agent. Limeback et al. recently published a meta-analysis summarising these results¹⁶. The results from this analysis confirm the efficacy of HAP as caries-preventive agent. HAP has been shown to remineralise enamel defects²⁶⁻²⁷, and to reduce bacterial adhesion on dental surfaces²⁸⁻²⁹. Furthermore, HAP can buffer acidic (caries) biofilms and simultaneously release calcium which can prevent the teeth from demineralisation and increase remineralisation³⁰.

Gum health

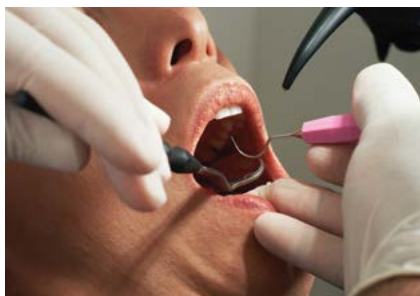
Besides anti-biofilm (anti-adherence) properties of HAP, clinical trials report of improved gum health, when HAP-products are used for daily oral care. A German multi-centre trial has confirmed these results³¹.

Erosion protection

Dental erosion is increasingly prevalent as the reason for accelerated loss of enamel and dentin. When the pH of the oral environment drops below 5.5, the HAP crystal structure of the enamel dissolves leading to demineralisation of the enamel. Among others, Fabritius-Vilpoux et al. used a cyclic demineralisation-remineralisation model, with or without the application of HAP. The results confirm that HAP is able to protect the teeth from mineral loss¹⁸.

Prevention of dentin hypersensitivity

Several clinical trials have shown that HAP can relieve sensitivity effectively after only three to five days when used twice daily^{11,32}. Compared to other actives used for dentin hypersensitivity prevention, such as stannous fluoride, HAP does not stain teeth, but has a natural whitening effect³³. Stannous fluoride is known to reduce dentin hypersensitivity, but at the same time leading to a yellow or brown stain on teeth³⁴. Clinical trials and case-reports, and a recently published meta-analysis come to the conclusion that HAP is effective at reducing sensitivity from external stimuli¹⁷.



CONCLUSION

Hydroxyapatite (HAP) is an effective active ingredient used in oral care products (toothpaste, gel, mouth rinse) to prevent tooth decay and gum disease. Further benefits are well known from clinical trials, such as preventing dentin hypersensitivity. Compared to other actives (i.e., fluorides), HAP shows good biocompatibility and is safe if swallowed. **DA**

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