

Polishing and whitening properties of toothpaste containing hydroxyapatite

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Toothpastes containing hydroxyapatite (HA-toothpaste) have demonstrated efficacy in preventing caries, treating hypersensitivity and curing periodontal diseases, however, their effects on whitening teeth have not been investigated. In this study, the polishing and whitening properties of hydroxyapatite contained toothpastes were evaluated in a combined experimental and clinical study. The polishing properties were evaluated in artificial teeth by polishing with different toothpastes, while the brightening and whitening properties were examined in volunteers using two colorimeters with two specially made fiberscopes. The results revealed that the addition of hydroxyapatite to toothpaste did not alter its polishing properties, while it did result in a marked increase in tooth-whitening. It was also found that the brightening and whitening properties increased as the amount of hydroxyapatite in the toothpaste increased. It is concluded that toothpaste containing hydroxyapatite are effective at whitening tooth and that whitening was not due to their polishing effect on tooth surface.

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1. Introduction

The main components of traditional toothpastes include flavoring, foaming, sweetening, viscous and brightening agents as well as water, and these components should be nontoxic and nonabrasive. Recently a new toothpaste containing hydroxyapatite has been developed and marketed. This hydroxyapatite-contained toothpaste (HA-toothpaste) has three main clinical advantages: efficacy in preventing caries or treatment of periodontal disease, elimination of mouth odor and a teeth whitening effect. The tooth polishing and whitening properties are also significant but have not yet been examined in detail. In order to determine the special tooth polishing and whitening properties possessed by HA-toothpaste, an experimental study on polishing properties was carried out using a polish test with artificial teeth, while brightening and whitening properties were studied in volunteers using two colorimeters with two specially made fiberscopes.

2. Materials and methods

2.1. Polishing experiment

Five blocks of sintered hydroxyapatite, 7 mm × 7 mm × 5 mm in dimension, were used as experimental

artificial teeth. The relative density of the hydroxyapatite blocks was 97%. The total polishing area of the 5 blocks was 2.3 cm². The polishing test apparatus was assembled by the authors (Fig. 1). Before the artificial teeth were fixed on the polishing apparatus, they were carefully polished with sandpaper (No. 1500) to produce an even and smooth abraded surface. The blocks were then cleaned with 99% ethanol and weighed with a fine balance. The blocks were fixed on the polishing apparatus with adhesive agent and a total load of 460 g was placed and fixed above them. The following polishing materials were used; toothpaste containing 15%, 3% hydroxyapatite and 0% hydroxyapatite, a specially made polishing matrix containing of 20% and 60% hydroxyapatite, and pure water. The experimental materials were mixed with an equal amount of water and put on the turning disk. The polishing test was carried out by driving the HA blocks in a circular movement on the turning disk a load of 200 g/cm² in load and a velocity of 60 rpm for 5 h. The different experimental materials and water were used as the polishing matrix separately. The experimental material and equal amount of water were added repeatedly at 15-minute intervals during the test. After a 5 h experiment on each material the blocks were removed from the experimental apparatus and cleaned

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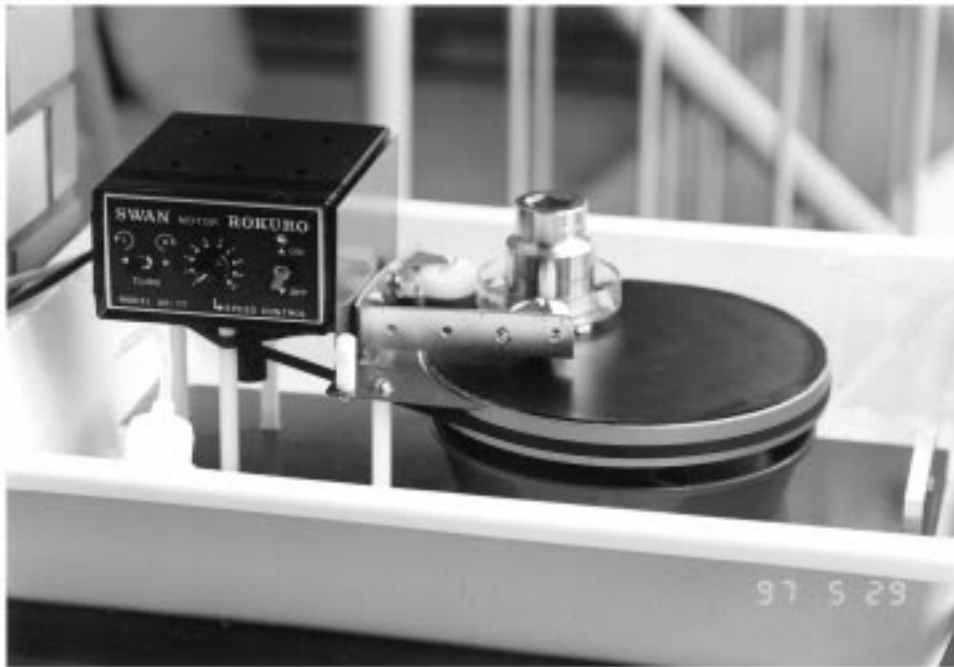


Figure 1 Experimental apparatus for polishing test.

with water and 99% alcohol. The blocks were dried and the weighed again using a fine balance. The same process was repeated 3 times for each material. The weight-loss could be determined by comparing the difference before and after an experiment. The thickness-loss (nm) per cm^2 per hour for the hydroxyapatite blocks was calculated from the weight-loss, density and polishing area.

2.2. Brightening and whitening investigation

Toothpastes containing 0%, 3%, 15% hydroxyapatite by weight were used as experimental materials. Twelve volunteers aged 20 to 50 years old who had never used HA-toothpaste before were selected for the study. Two

colorimeters (SZ-Y-90 and SE-2000) with two specially made fiberscopes (inner diameter of 3.5 and 2.5 mm) were used to detect the changes in brightness and whiteness were (Fig. 2).

The methods for determining the tooth brightness and whiteness were those previously described by Kobayashi [1]. Measurements were carried out five times per tooth. The saliva on the teeth was wiped off in order to obtain stable data. At the beginning of the study, the brightness and whiteness of the upper central incisor were measured using a colorimeter with a fiberscope. The 12 volunteers were then requested to use similar toothpaste without hydroxyapatite twice a day for two weeks before brightness and whiteness were examined again. The volunteers were then divided into two groups. A 7-person



Figure 2 Colorimeter for detecting brightness and whiteness.

group used toothpaste with 15% hydroxyapatite while a 5-person group used toothpaste containing 3% HA. The volunteers were instructed to use the toothpaste twice a day as before. After two weeks, four weeks and six months, the brightness and whiteness of the upper central incisor were examined using the same method as described above.

3. Results

3.1. Polishing properties

Fig. 3 shows the thickness-loss of the artificial teeth after polishing using the different toothpastes. There were no apparent differences between the toothpastes containing various amounts of hydroxyapatite. The thickness-loss using pure water as a polishing matrix was less than that with the other experimental materials

3.2. Brightening and whitening property

Fig. 4 and Fig. 5 present the brightness and whiteness values for central incisor before and after using 3% and 15% hydroxyapatite toothpaste for 2 and 4 weeks.

Fig. 6 shows the increasing percentage after using toothpaste with 3% and 15% HA for 2 and 4 weeks. The calculations were conducted by determining the increasing percentage obtained using toothpaste without HA as 100%.

4. Discussion

Toothpastes have traditionally been used as a flavored cleanser rather than as a preventive and curative agent combating caries or periodontal diseases [2]. Recently, however, the preventive and curative effects have been emphasized and different components, such as fluoride, calcium and herbs, have been added to prevent caries, treat hypersensitivity and cure periodontitis [2–5]. A toothpaste which contains hydroxyapatite was developed

[6, 7] based on this researches and in consideration of the special characteristics of hydroxyapatite particles. The HA-toothpaste has three main clinical advantages: efficacy in preventing caries and the treatment of periodontal disease, the elimination of mouth odor, and tooth whitening properties. The hydroxyapatite component in the toothpaste is reported to be effective at removing dental plaque, promoting the remineralization of tooth surfaces, and arresting the progress of incipient caries [8–10]. The mechanism of elimination of mouth odor has been shown to due to adsorption to proteins, lipids, polysaccharide, and other macromolecules [11]. However, the tooth polishing and whitening properties have not yet been fully examined.

In general, the polishing properties depend on the particle size and hardness of the polishing matrix while the load, polishing time and speed are fixed. Different toothpaste consists of different polishing matrix of which the hardness and amount was not similar to each other. Adding hydroxyapatite to toothpaste may alter the composition of the polishing matrix and may change the polishing properties. In this study, however, it was found that hydroxyapatite in toothpaste does not play a role in changing the polishing properties.

Tooth whitening is generally attained by oxidation with oxide agents, microabrasive method or prosthetic techniques, however, these methods are somewhat harmful to tooth enamel. Teeth whiteness was markedly increased after 2 weeks of use of toothpaste containing hydroxyapatite. In some subjects after 4 months, the brightness and whiteness were stable and a slight decrease was observed. Since brightness and whiteness depend on the reflection rate of light, the smooth surface increased the reflection rate to light. The mechanism of increased brightness and whiteness by HA-toothpaste might be explained by a remineralization effect. Remineralization could turn the tooth surface smoother and glossier. In a previous study on acid etched tooth enamel using SEM and optical microscopy, we demon-

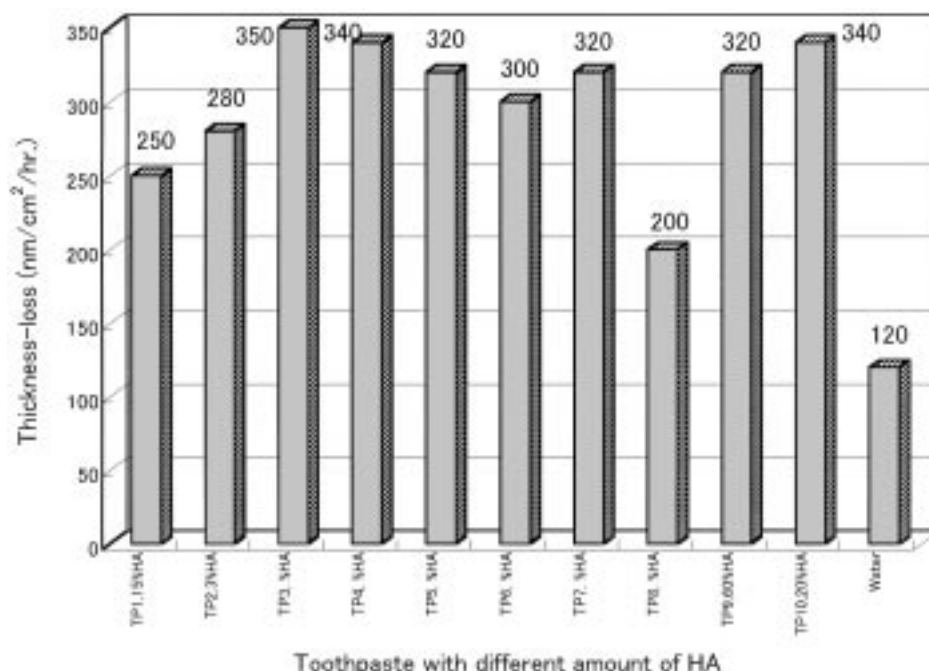


Figure 3 Thickness-loss using different toothpaste.

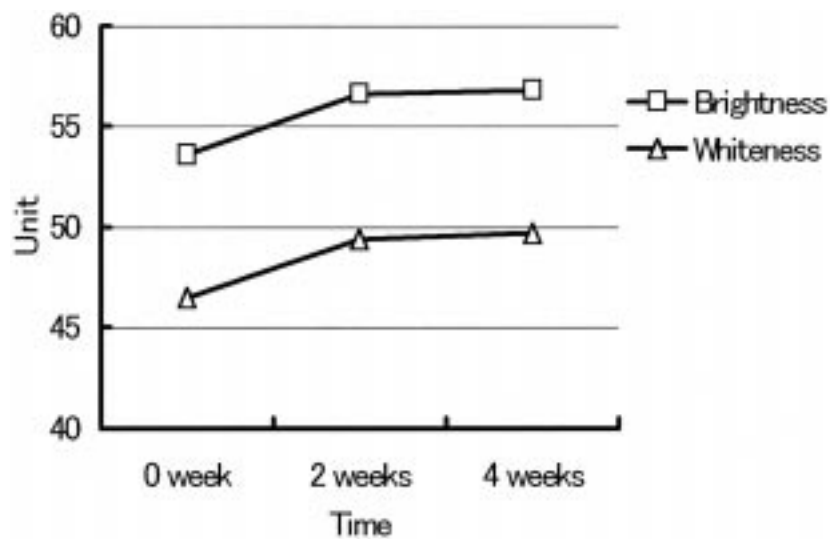


Figure 4 Brightness and whiteness changes after using 3% HA toothpaste.

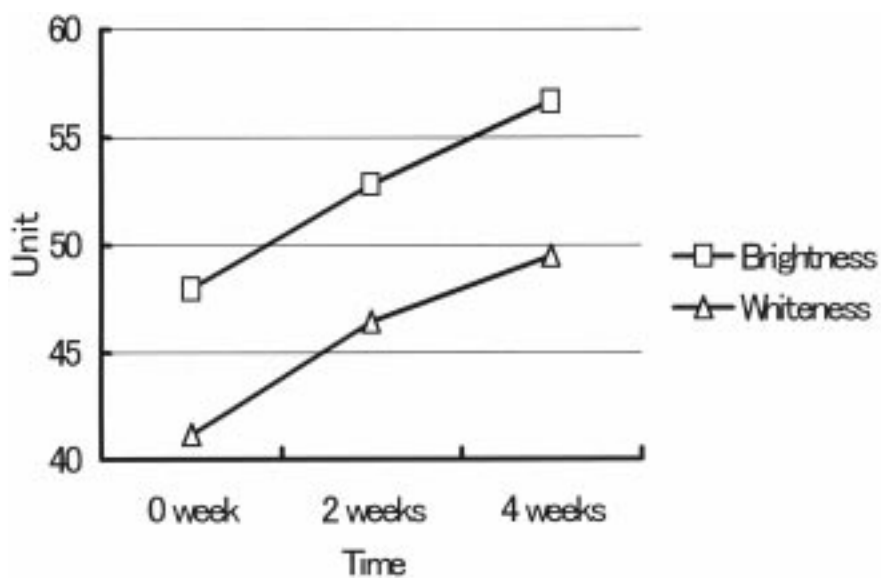


Figure 5 Brightness and whiteness changes after using 15% HA toothpaste.

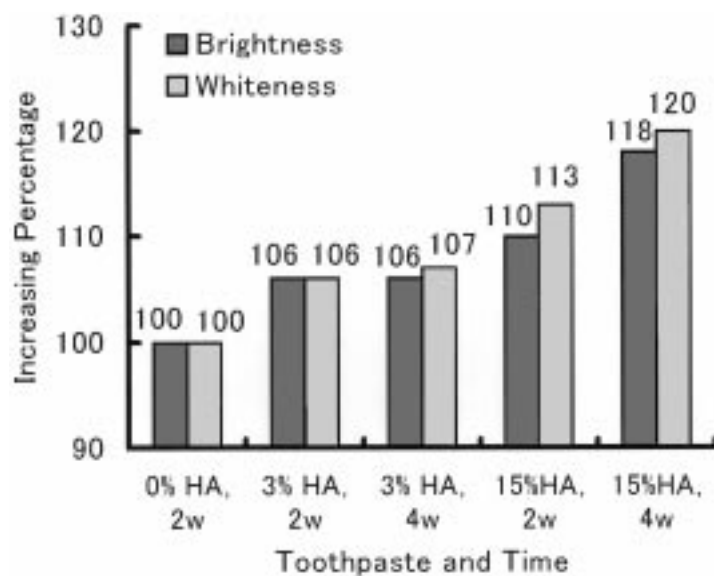


Figure 6 Increasing percentages of brightness and whiteness with different toothpastes.

strated that the acid etched tooth surface turned smoother and glossier apparently after remineralization reaction with hydroxyapatite. One possible explanation for the brightening and whitening properties is that the tooth surface becomes smooth and glossy due to the polishing effect. However, the results of polishing test indicated that adding HA to toothpaste does not alter the polishing properties. It was confirmed that tooth-whitening process by HA-toothpaste, compared with other methods for whitening teeth, was a physiological rather than a chemical or mechanical reaction. In the 1982 patents of Aoki [5], the following reasons were given: the polishing properties of HA-toothpaste were lower than those of the toothpaste without HA and remineralization causes the tooth surface to become smooth. However, it is unclear why the brightness and whiteness of the teeth decreased drastically in a few subjects when they stopped using the HA-toothpaste.

5. Conclusions

1. Adding different amounts of hydroxyapatite to toothpaste does not change the polishing properties.

2. Toothpaste containing hydroxyapatite increased teeth brightness and whiteness. The degree and rate of brightness and whiteness increased in accordance with the increase in the amount of hydroxyapatite in the toothpaste.

3. No correlation between polishing properties and whitening properties in toothpaste containing hydroxyapatite were observed.

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*Received 20 January
and accepted 11 August 1999*