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Tooth Whitening Effect of Toothpastes Containing Nano-Hydroxyapatite

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Abstract

The aim of this in vitro study was to evaluate the tooth whitening effect of toothpaste containing nano-sized hydroxyapatite (HA). There were 3 types of dentifrices, which had a different level of abrasive components. For group 1, a newly developed toothpaste containing Nano-sized hydroxyapatite (Nano-HA) was used. Commercially available toothpastes were used in groups 2 and 3. Group 2 used toothpastes containing silica and multi phosphate. Group 3 used toothpastes containing abrasives with silica and micro-sized HA. In order to simulate 6-months of tooth brushing, the tooth specimens in all 3 groups were placed on a V8 Cross Brushing Machine (Sabri Co. U.S.A.) and brushed 10,000 times with the toothpaste slurries. The tooth specimens were then soaked in artificial saliva for 24 hours to create conditions similar to those encountered in vivo. The whitening efficacy was assessed before and after tooth brushing using the VITA shade scores of Shadeeye-EX NCC Dental Chroma meter (Shofu Co. Japan). All toothpastes produced significant differences in the mean shade change in the teeth before and after tooth brushing ($p<0.05$). However, there were no significant differences in the change in the shade between each group ($p>0.05$). Although the new Nano-HA toothpaste did not have superior whitening effects to the commercially available whitening toothpastes, they had a similar whitening efficacy to commercially available whitening toothpastes. These effects might come from the physical properties of Nano HA, which increase the surface dimension more than the Micro-sized HA and have the potential of remineralization.

Introduction

Recently, tooth whitening has become one of the most rapidly growing oral care sectors. There are two methods that involve self-directed and professional approaches for achieving tooth whitening. The representative method for tooth bleaching was to use hydrogen peroxide, which plays a role as an oxidant and a remover of organic substances. However, there are side effects such as damage to the hard tissue, an increase in tooth hypersensitivity and the possibility of chemical burns if placed in direct contact [1]. The self-directed bleaching method delivers active bleaching components via toothpaste.

Hydroxyapatite (HA) is a major component of the hard tissue in human teeth. Recently, a new toothpaste containing HA has been developed and marketed. It was claimed that this HA-containing toothpaste can help prevent caries or periodontal disease, eliminate mouth odors and whiten teeth

[2]. However, previous commercially available whitening toothpastes usually contain micro-sized HA at trace elements.
Nano-technology has been introduced to a variety of fields including dentistry. The application of Nano-technology brings various physical properties that were unavailable with conventional large-sized particles. In addition, many researchers investigated toothpaste for delivering an active bleaching substance. If nanotechnology can be applied to dentifrices, it is possible that nano HA particle can remove tooth stains without damaging the surface damage and produce remineralization.
The aim of this study was to evaluate the tooth-whitening efficacy between toothpaste containing Nano-HA and commercially available toothpastes using an in vitro test.

Materials and Methods

Three types of dentifrices, which contained different compositions of abrasive components, were used in this study. In group 1, a newly developed tooth paste containing Nano-sized hydroxyapatite (Nano-HA, 30%) was used. Commercially available toothpastes were used in groups 2 and 3. Group 2 included toothpastes with silica (15-20%) and multi phosphate (1-2%). Group 3 was consisted of abrasives with silica (15-20%) and micro-sized HA (5%). The tooth specimens used in this study were extracted human molars. The extracted permanent teeth were cleaned and stored in a 0.1% tymol solution for at least 24 hours after their root and pulp had been removed. The cervical part of the teeth was sectioned with a diamond wheel disk and the crown portions were embedded in epoxy resin (18㎜×13㎜) with the labial side upward for fixation of the tooth surface.
The whitening efficacy of the teeth was assessed before and after tooth brushing using the VITA shade scores of Shadeeye-EX NCC Dental Chroma meter (Shofu Co., Japan). The VITA shade guide was composed of 16 stages of color (B1-C4). These shade ranks were converted to numerical ranks (from 1 to 16) for statistical analysis. Before tooth brushing, a total of 66 specimens were assigned to the 3 groups (22 specimens per group) by matching the baseline shade.
A V8 Cross brushing Machine (Sabri Co., U.S.A.) was used to simulate tooth brushing. This machine can install 8 toothbrushes simultaneously, which makes it possible to examine the test and control toothpaste simultaneously. A standard manual toothbrush, which has 4 columns and 12 rows, was used. A 150 gram force was used for tooth brushing, which is similar to that produced by normal people. The V8 Cross brushing Machine also contained 8 tubes for toothpaste slurries. The toothpaste slurries were prepared by mixing 100 grams of toothpaste with 100 ml distilled water.
Each tooth specimen was brushed 10,000 times with toothpaste slurries, which simulated 6 months tooth brushing. The brushing velocity was 50 times/min.
Subsequently, the tooth specimens were soaked in artificial saliva for 24 hours in an attempt to create the conditions similar to those observed in vivo. The shades were then measured and compared to the baseline using a Shadeeye-EX NCC Dental Chroma meter.
Non-parametric statistical analysis was used because of the scale used for measurement and the skewed distribution of the data. The Wilcoxon-signed rank test was used to evaluate the changes in the shades before and after tooth brushing. The Kruskal-Wallis test was used to compare the shade changes between the groups. Statistical analysis was carried out using the Window SAS (statistical analysis system) 8.2 statistical package (SAS Institute, Inc. U. S. A.).

Result

All the toothpastes were quite effective in lightening the tooth shade from the baseline (Table 1, Wilcoxon-signed rank test, $p<0.05$). After tooth brushing, group 2 showed 3.05 improvement in shade score from the baseline. Groups 1 and 3 showed 2.91 and 2.50 improvement of shade scores, respectively. However, there were no statistically significant differences in the shade changes between each group (Kruskal-Wallis test, $p>0.05$).

Table 1. Changes in the VITA shade scores after tooth brushing with various whitening toothpastes

Group	N	Baseline		After toothbrushing		p-value*
		Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	
1	22	5 (2-12)	6.36 (2.88)	2 (2-12)	3.45 (2.64)	0.0012
2	22	5 (2-12)	6.59 (2.75)	2 (2-9)	3.54 (1.92)	0.0001
3	22	5 (2-12)	6.50 (2.63)	5 (2-12)	4.00 (2.30)	0.0017

* comparison of the before and after shade score using the Wilcoxon-signed rank test

Discussion

Recently, there has been increasing patient demand for whiter teeth. Self-directed home bleaching has become a more popular dental procedure for whitening teeth than professional treatment in a dental office [3]. The tooth color is affected by both intrinsic and extrinsic causes, which are due to an acquired pellicle [4].

Many whitening toothpastes have developed and marketed with incorporated abrasive systems because an abrasive system in toothpaste helps remove or reduce tooth stains.

A toothpaste containing HA has been reported to be effective in removing dental plaque, promoting the remineralization of tooth surfaces, and arresting the progress of incipient caries [5,6]. The bleaching mechanisms of a HA-toothpaste are filling and remineralization effect as a result of the filling and smoothening the irregular surface porosity [2].

These results show that although the Nano-HA toothpaste did not have superior whitening effects than the commercially available whitening toothpastes, the newly developed Nano-HA toothpaste showed a similar significant shade improvement after tooth brushing to the other control toothpastes. These effects might be due to the physical properties of Nano HA, which have a higher surface area than Micro-sized HA and a potential for remineralization. The increased surface area is believed as more effective in removing tooth stains and organic substances. However, a comparison between nano-HA and micro-HA toothpastes, which contain the same composition, will be needed to prove this hypothesis.

The second hypothesis for the mechanism of Nano-HA was the acceleration of remineralization, which involved filling the micro pores of the tooth surface. Therefore, it might be possible to lighten the tooth shade. However, our study period is too short to evaluate remineralization. This nano-HA toothpaste also have fluoride which strongly affects to remineralization. Therefore, there might be the synergistic effect of remineralization. Further study will be needed to examine the chemical or microbial pH cycling model, which involves repeating the demineralization and remineralization procedures and additional synergistic effect of remineralization with fluoride.

Conclusion

The newly developed Nano-HA toothpaste showed a similar significant shade improvement after tooth brushing to the other commercially available whitening toothpastes.

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