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Original Article

Tooth wear and cleaning effect of an abrasive-free dentifrice

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Abstract *Background/purpose:* To evaluate the degree of wear on human teeth and the cleaning effect of abrasive-free dentifrice. A sodium pyrophosphate and cellulose-containing abrasive-free dentifrice and calcium carbonate-containing control dentifrice were evaluated.
Materials and methods: Dentin and enamel specimens were subjected to 109,500 successive double strokes and 5480 double strokes in pH-cycling condition. A profilometer measured abrasion depth. The cleaning effect of dentifrices on artificial stain was evaluated by cleaning power (modified Stookey method) and by removal of colored stain on artificial tooth.
Results: The experimental results were evaluated using Mann–Whitney *U* test. The abrasion depth in dentin specimens was 13.97–26.73 times smaller with abrasive-free dentifrice than with control dentifrice. The abrasion depth of enamel specimen was 2.17 ± 0.66 μm with control dentifrice. The values for abrasive-free dentifrice were too small to measure. In pH-cycling conditions using dentin specimens, abrasion depth was 14.28–19.00 times smaller with abrasive-free dentifrice than with control dentifrice. The cleaning power and removing effect of colored stain were statistically insignificant between abrasive-free dentifrice and control dentifrice ($P > 0.05$).
Conclusion: The abrasive-free dentifrice was as effective as control dentifrice in its cleaning effect on artificial stain and can significantly reduce tooth wear more than control dentifrice.

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Introduction

The basic function of dentifrices is to remove dental plaque physically on the surface of the teeth. In general, people who have hypersensitive teeth because of gingival recession or marginal tooth wear should be cautious when using a highly abrasive dentifrice, although it has a substantial cleaning effect.[1] On the other hand, because residual plaque causes dental caries by bacteria and chronic gingivitis by plaque calcification process, people who have healthy teeth should be cautious when using a dentifrice that is too low in abrasivity since it is unable to remove dental plaque properly.[2] The number of patients with tooth hypersensitivity is increasing every year, and primary reason for this is the high abrasivity of dentifrices, based on a study by Moon et al.[3] The global standard by the International Standard Organization (ISO) and American Dental Association have announced only upper limit values, compared to standard dentifrice, by using radio trace method or surface profile method. Based on measurement methods, the global standard (ISO 11609) recommends upper limit value of abrasivity 2—2.5 times less for dentin and 2—4 times less for enamel.[4] The British Standard (BS 5136) represents upper limit of abrasivity value as 2 times less for dentin and 4 times less for enamel, compared to standard dentifrice.[5] These guidelines indicate that excessive abrasivity of dentifrice can be harmful to the teeth. It is surely ideal to use dentifrice that minimizes abrasivity while maximizing the cleaning effect. Dental plaque can be removed by brushing without using dentifrice, but it is not as effective as using dentifrice, according to study by Dudding et al.[6] In previous studies focusing on tooth wear, Miller[7] was the first to investigate the abrasion of tooth powder; afterwards, many studies investigated how to measure the abrasivity of dentifrice. Liljeborg et al.[8] have recently reported that the surface profile method was useful in obtaining quantitative and qualitative results such as surface roughness on the brushed tooth surface. Franzo et al.[9] studied the degree of tooth wear by using various concentrations of dentifrice and brushing strokes. Philpotts et al.[10] also compared the degree of tooth wear for different abrasive dentifrices on human teeth. Hooper et al.[11] and Kim et al.[12] evaluated the influence of abrasion with an acidic beverage. The higher abrasivity of dentifrice in general represents higher cleaning effect, but it can create different pattern, depending on the composition of dentifrice. With respect to this, we designed dentifrice that can remove dental plaque without causing tooth wear. It would be an ideal dentifrice and become a new paradigm dentifrice in the future market. The objective of the present study was to evaluate the degree of tooth wear on human teeth and cleaning effect of artificial stain by abrasive free dentifrice containing cellulose powder and sodium pyrophosphate.

Materials and methods

Test materials

The experimental dentifrice (i.e., abrasive-free dentifrice) consisted of 3.0% cellulose powder and 3.4% sodium pyrophosphate ($Na_4P_2O_7 \cdot 10H_2O$) without conventional abrasives. The control dentifrice consists of 40.0% calcium carbonate as abrasive (Table 1).

Removing effect of colored stain

The dental model (D51DP-TRM.444; Nissin Dental Products Inc., Kyoto, Japan) was dipped in colored stain solution for 10 s, coated, and dried in constant temperature and humidity chamber (25 °C, 55%) to maintain same coating condition. The colored stain solution (consist of poly vinyl pyrrolidone K-90, Red No. 40, ethyl alcohol and water) was made in accordance with the modified method by Volpenhein et al.[13] The coated dental model was placed in brushing instrument, which is especially designed to control brushing speed, force, and length. Table 2 presents details of brushing condition. The removing effect of the colored stain was calculated by measuring the removed area of colored stain on the surface of dental model by using a microscope that could automatically analyze and calculate the area (Sometech Co., Seoul, Korea) (Fig. 1).

Cleaning power

Cleaning power was measured by the modified Stookey method (i.e., the Pellicle cleaning ratio [PCR]).[14] Artificially stained bovine enamel specimens were prepared and initial lightness values were measured with a colorimeter (Minolta CR-321; Minolta Camera, Osaka, Japan). They were brushed for 800 double strokes under 250 gF[15] at a rate of 90 double strokes per minute in 2:1 slurry mixtures of artificial saliva solution and each dentifrice. L* (Lightness), a* (degree of redness and greenness) and b* (degree of yellowness and blueness) values after brushing were measured.

The abrasion depth in continuous brushing

The method used in this study was based on the surface profile method (BS 5136)[5] to quantify the degree of surface

Table 1 Ingredients of experimental and control dentifrice.

Test ingredients	Experimental dentifrice	Control dentifrice
	Cellulose powder 3.0% Sodium pyrophosphate 3.4%	Calcium carbonate 40.0%
Glycerin	30.0%	30.0%
Sodium carboxyl methyl cellulose	2.5%	1.5%
Colloidal silica	3.0%	3.0%
Sodium lauryl sulfate	2.0%	2.0%
Flavor	1.0%	1.0%
Purified water	To 100%	To 100%

Glycerin is humectant. Sodium carboxyl methyl cellulose and Colloidal silica are viscosity controlling agents. And Sodium lauryl sulfate is foaming agent.

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