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Scanning Electron Microscopic Investigations of the Shape of Toothbrush Filaments with Various Brushing Techniques
I. The most effective case of plaque removal

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Summary

Using 30 second-year students of the Matsumoto Dental College, School of Dental Hygiene as subjects, we performed investigations on toothbrush filament shape changes while using 4 test toothbrushes and 4 different brushing techniques over 2 week periods. Also, observation by scanning electron microscopy was done for the toothbrush which yielded the best plaque removal. The results were as follows:

1. The edge of the brush filament was worn almost rectangularly along the longitudinal axis after 2 weeks of using the Bass and scrub techniques.
2. The filament edge tended to become sharper with the rolling and modified Stillman techniques. The round-cut and moving area of the toothbrush body were worn significantly using the rolling and modified Stillman techniques.

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3. The toothbrush filaments with every brushing technique were worn significantly. Deep ditches, scratches and peeling were frequently observed with the rolling and modified Stillman techniques.

Introduction

Brushing is very important in the prevention and treatment of periodontitis. Toothbrushes are most frequently used for oral hygiene, and for the removal of dental plaque. It is important and informative for effective plaque removal to know the change of the toothbrush filament shape after use.[1~5] Four types of toothbrushes were studied here with 4 different brushing techniques. The change in toothbrush filament shape was microscopically examined and evaluated to determine the brush which yielded the best dental plaque removal.

Materials and Methods

Thirty students of the Matsumoto Dental College, School of Dental Hygiene were requested to use a new toothbrush with 4 different brushing techniques for 2 weeks each, using the rolling, Bass, modified Stillman, and scrub techniques. At the end of each week a dental plaque score was taken and the toothbrush which yielded the best plaque romoval was selected and subjected to scanning electron microscopic observations.

The specification of the test brushes are shown in Table I. The shape of the handle was the same for all of them. The diameter, pitch, and arrangement of the filament holes of brushes S, M, and H were the same, but the diameter and length of the bristles were different. The diameter and arrangement of holes and pitch in the open tufted brush were different from the S, M, and H brushes and its bristled region was rough. The length of the open-tufted brush's filaments was the same as M. The stiffness of the bristles was classified as follows: (Fig. 1, Table 1)

Brush S: soft

Brush M and open-tufted brush: medium

Brush H: hard

One filament each was taken at random from the front, center and base areas(↑), cleaned, dried, and gold-coated. (Fig. 2) Scanning electron microscopic observations were made at a magnification of 200. The filament bundles were separately observed microscopically at a magnification of 80. All toothbrushes had high, end-rounded filaments.

Table 1. Specification of trial toothbrushes used in the experiment

Items / Tested brushes	Diameter of hole(mm)	Pitch of hole(mm)	Arrangement of hole	Diameter of filaments(mill)	Height of filaments(mm)	Length of brush(mm)	Stiffnes of filaments
S	1.8	3.2	2+3 6+2	6	10	24.2	Soft
M	1.8	3.2	2+3 6+2	8	11	24.2	Medium
H	1.8	3.2	2+3 6+2	10	12	24.2	Hard
Open-tufted	1.8	4.2	26	8	11	23.6	Medium

Results

1. The edge of the toothbrush filament was worn almost rectangularly along the axis after two weeks of using the Bass and scrub techniques where the filament edge was in contact with the tooth surface (Fig. 3, 4).

2. The filament edge tended to become sharper with the rolling and Stillman techniques where the side of the toothbrush was in contact with the surfaces of the teeth. The round-cut and the moving areas of the toothbrush especially showed significant wear (Fig. 5, 6).

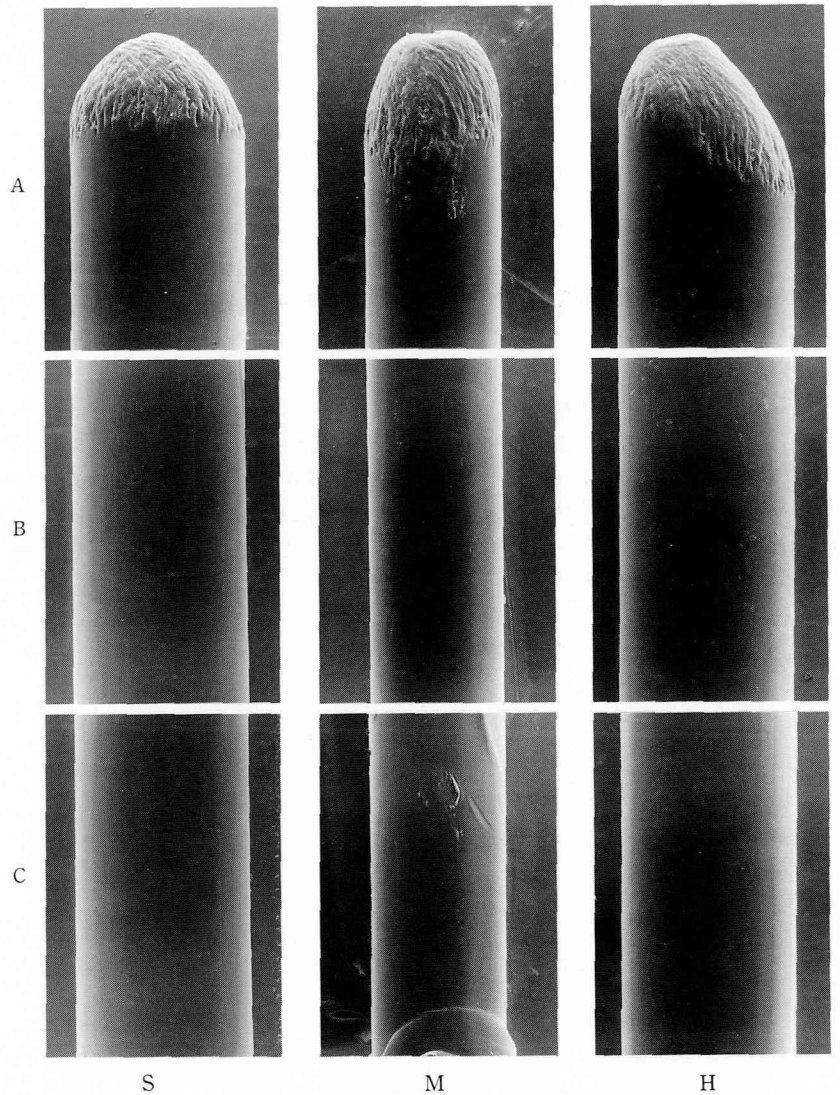

Fig. 1. The shapes of un-used tooth brush filament (SEM×190 magnification)
A. At the 0.3mm from the free end of filaments Toothbrush S : soft
B. At the 3mm from the free end of filaments Toothbrush M and Open-tufted : Medium
C. At the 6mm from the free end of filaments Toothbrush H : Hard

3. Since the toothbrush yielding the best cleaning was selected with each brushing technique, the toothbrush filaments showed significant wear, and deep ditches and naps were observed along the longitudinal axis. Ditches, naps, and peeling were observed frequently with the rolling and Stillman techniques due to their brushing characteristics (Figs. 5, 6).

Discussion

It was difficult to observe changes in the toothbrush filament shape with scanning electron microscopy[1,2] for the different toothbrush specifications. Using scanning electron microscopy, Suda[3] reported the changes in toothbrush filament shape after using the rolling and scrub methods.

The toothbrush filament wears with the period of use. In particular, there was considerable wear at the tip (0.3 mm from free end) of the filaments with the scrub method and the filaments were sharper than with the rolling method. The more the toothbrush was spread, the sharper the tip of the filament. We also confirmed that there was marked attrition of the filaments after two weeks using the Bass and scrub techniques. Suda[3], Ueda[4] et al had the same results.

However, we found that the edge of the brush filament was worn almost rectangularly along the longitudinal axis with the Bass and scrub techniques. We also found that the round area and the moving area of the toothbrush body filament were worn significantly. From these facts it is seen that the side of the toothbrush was in stronger contact with the tooth surface.

Miyashita[5] reported that at a point 0.3 mm from the end of the inner tufts, the decrease in the diameter was greater for the filament taken from the toothbrush with the scrub technique than that with the rolling technique. Our results were the same as Miyashita's[5] who also reported, using scanning electron microscopy, that there was a defect in the surface of the brush filament due to the use of toothpaste.

However, we observed that with the rolling and modified Stillman techniques, where the inside of the filament was used, there were many deep scratches and ditches compared to that with brushing using the edge of the filament. We think this is related to the wear of the brush filaments.

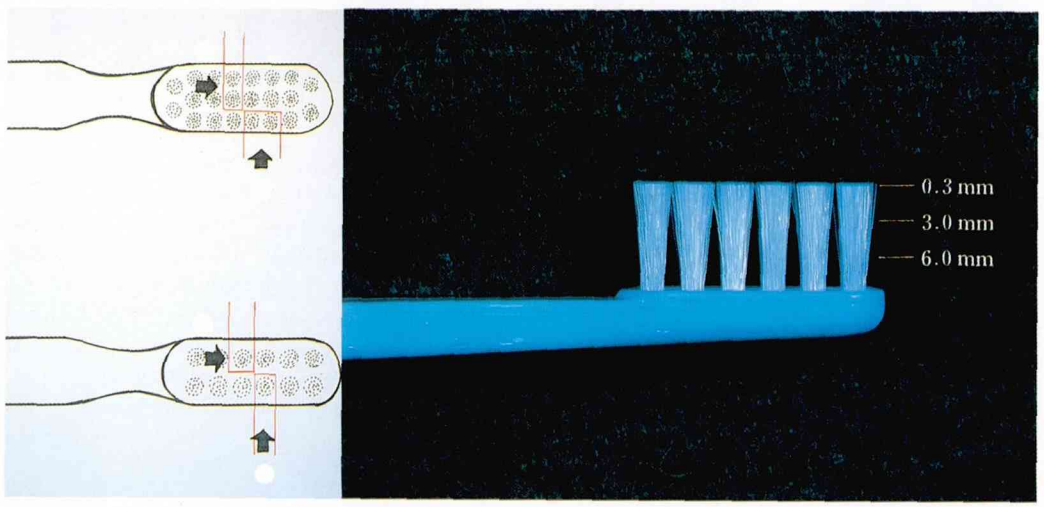

Fig. 2. The areas of brush filament for microscopical observation

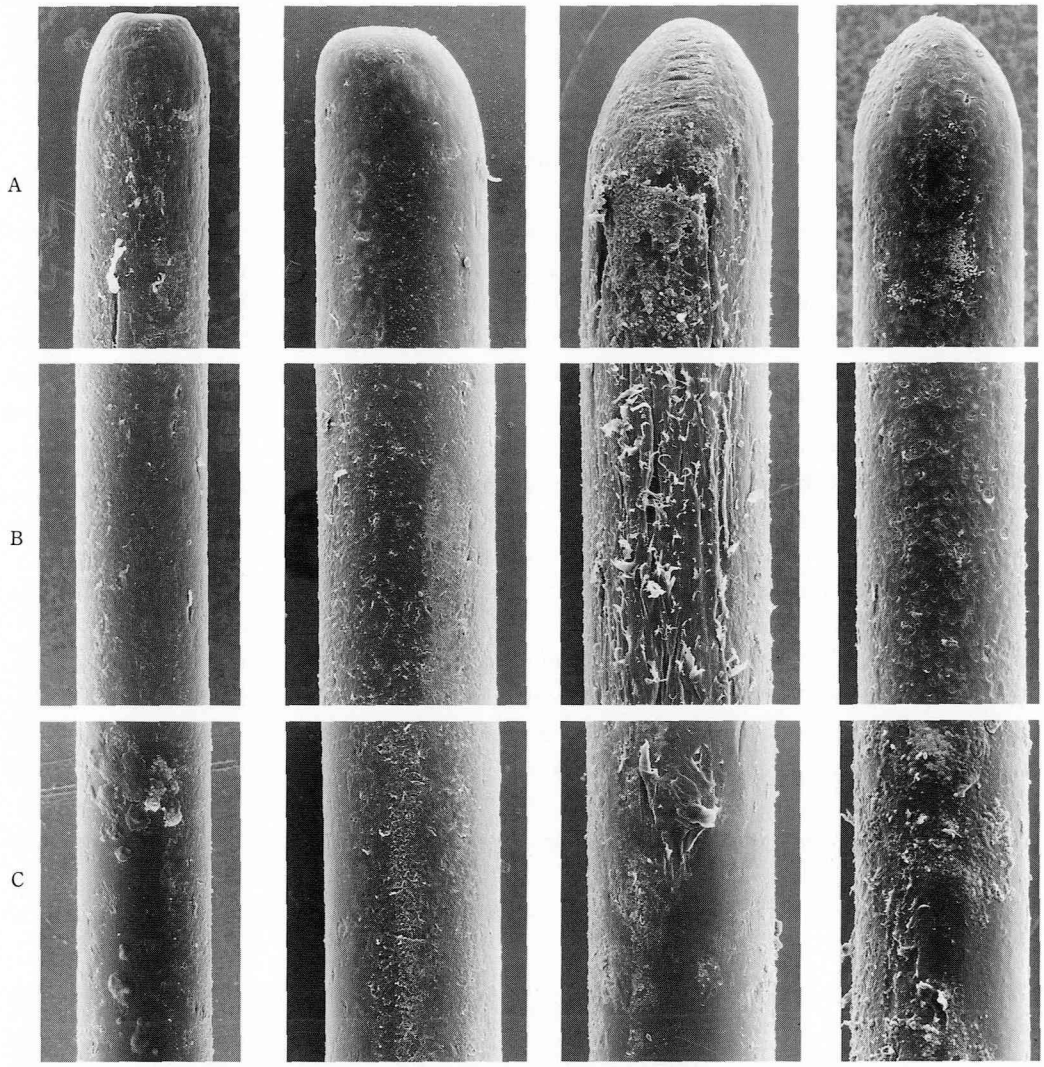

Fig. 3.
The edge (A) of brush filament worn rectangulaaly after two weeks of using the Bass techniques. (SEM×150 magnification)
① Tooth brush : S : Diameter 6 mil
② Plaque removal rate : 96%

Fig. 4.
The edge of the tooth brush filament worn rectangularly to the axis after two weeks of using the Scrub techniques. (SEM×150 magnification)
① Tooth brush : Open-tufted : 8mil
② Plaque removal rate : 98.5%

Fig. 5.
The round cut area (A) and the moving area (B) of brush body worn : Deep ditches, naps and peeling-off were observed with the Roll techniques. (SEM×150 magnification)
① Tooth brush : M : 8mil
② Plaque removal rate : 92.5%

Fig. 6.
The round cut area (A) and the moving area (B) of brush body worn. Deep ditches, naps and peeling-off were observed with the modified stillman techniques. (SEM×150 magnification)
① Tooth brush : M : 8mil
② Plaque removal rate : 92.5%

References

1) Maizumi, H., Omori, Y., Yamamoto, S., Kondo, K., Otsuka, K. and Miyazawa, K. (1974) Observations of the toothbrush bristles by means of scanning electron microscopy observation of polished rounded bristles. Sigaku, **62**: 824—828.

2) Ueda, M., Mise, H., Morikuni, T., Iida, M., Takado, K., Hatakeyama, Y., Inoue, Y. and Terasaka, A. (1977) Morphological studies of the un-used toothbrush bristles. J. Jap. Ass. Periodont. **19**: 53—61.

3) Suda, Y., Suzuki, S., Miyashita, H. and Hasegawa, K. (1980) Dimensional changes of filament taken from the worn-out toothbrush. J. Jap. Ass. Periodont, **22**: 122—129, 1980.

4) Ueda, M., Inada, Y., Terasaki, A., Nishigaki, T., Terano, H. and Yamaoka, A. (1981) A wear of the toothbrush bristles under bass techniques with special reference to the toothbrushing force. J. Jap. Ass. Periodont. **23**: 367—377.

5) Miyashita, H., Tamaki, N., Akiyoshi, O., Suzuki, M. and Suzuki, M. (1980) The observations of the used toothbrush. J. Jap. Ass. Periodont. **22**: 465—475.