Effect of Melamine Sponge on Tooth Stain Removal

Takero OTSUKA[1], Toshitsugu KAWATA[1]

Objectives: *To investigate the stain removal ability of melamine sponge before aesthetic tooth whitening in extracted teeth.*
Methods: *Melamine sponge of thickness 40 mm was compressed and the destruction of the partition wall structure during the compression process was examined under a stereoscopic microscope. An extracted human tooth was cleaned by normal polishing or with melamine sponge for 90 s. To evaluate the stain level, the tooth surfaces were photographed under a stereoscopic microscope at 0, 30, 60 and 90 s. The residual stained region was traced in a high-magnification photograph, and the stain intensity was presented as a change, relative to the intensity before the experiment (0 s).*
Results: *Mechanical cleaning by toothbrushing produced polishing scratches on the tooth surface, whereas use of the melamine sponge resulted in only minimal scratches. As the compression level increased, the stain-removing effect tended to become stronger.*
Conclusion: *Melamine sponge can remove stains from the tooth surface more effectively and less invasively compared to a conventional toothbrush. As no new scratches are made on the tooth surface when using a melamine sponge brush, the risk of re-staining is reduced. Cleaning using a melamine sponge brush can be easily and effectively performed at home and in a dental office.*
Key words: *melamine sponge, stain removing, toothbrush, tooth surface*
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The demand for teeth whitening treatment has grown almost exponentially in the last 20 years, and teeth-whitening products are now very popular[1,2]. To satisfy the increasing aesthetic demands of patients, we have to select a method with minimal adverse effects for patients requesting teeth whitening. In routine clinical practice, we frequently encounter patients who expect us to fully respond to their requests. During teeth whitening, external colouring substances, i.e. stains, are first removed, and, when this is not effective, whitening or bleaching is applied. When this is also ineffective, replacement treatment is performed. Patients are provided with sufficient explanation, regarding the main steps of teeth whitening (Fig 1). Patients who are concerned about stained teeth are mostly satisfied with dental cleaning. However, dental cleaning damages the teeth, regardless of the procedure, resulting in scratches of various sizes on the tooth surface, which increases the risk of re-staining. Teeth whitening using hydrogen peroxide damages the teeth due to the presence of residual hydroxide radicals, and it shortens the life-span of the tooth after replacement treatment in some cases[3,4]. Therefore, clinicians hesitate when promoting teeth whitening in dental offices. However, patients request this treatment, because the merits surpass the issues. In the present situation, clinicians employ a method that is reliable and satisfies patients, while searching for a teeth whitening system that does not adversely affect the tooth quality.

Melamine foam is a household cleaner used in the elimination of ceramic stain. Melamine foam, with a partition wall thickness of less than 0.5 μm, scrapes dirt from micro concavities of the teeth, akin to the action of scooping. Soft sponge is made to soak up tap water, acting as a lubricant. Stains can be removed sufficiently by lightly rubbing the tooth surface with the sponge several

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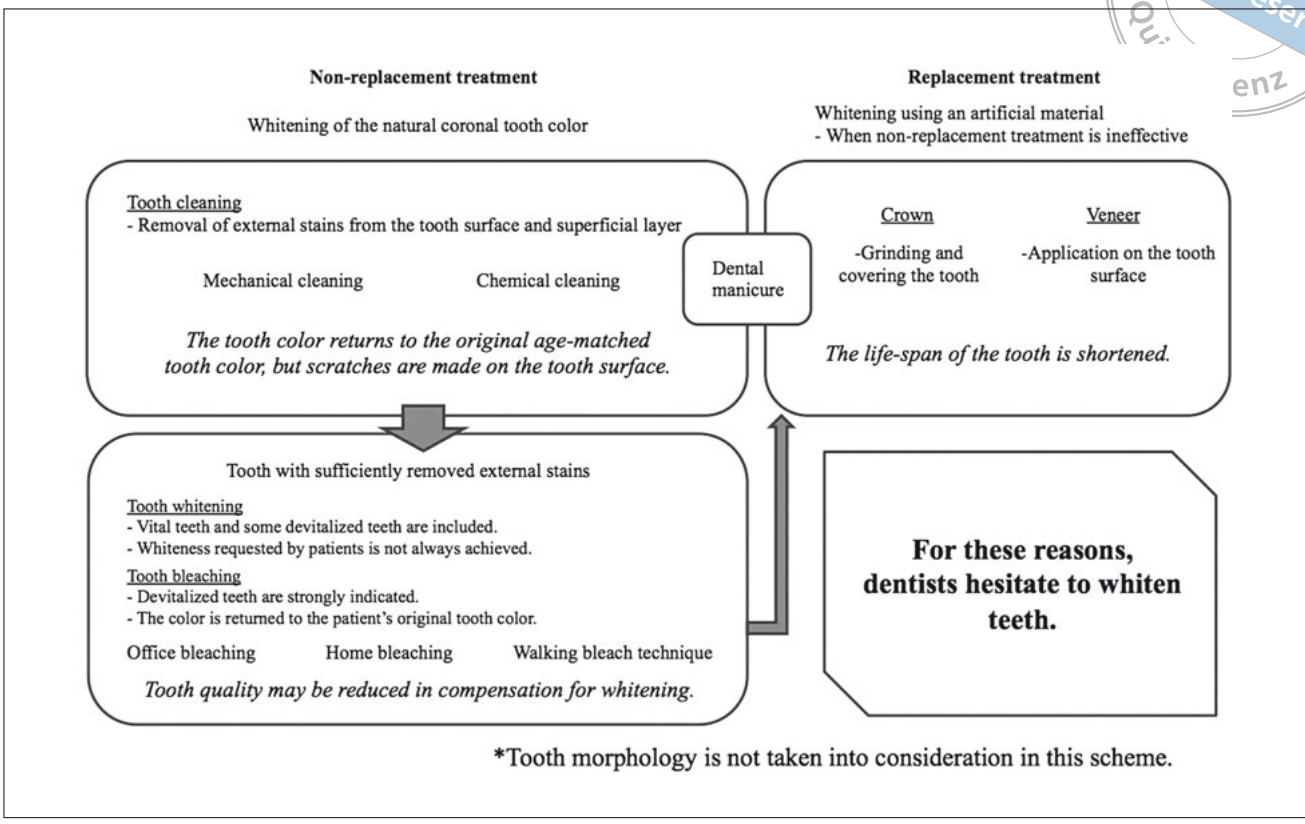

Fig 1 Scheme of teeth whitening.

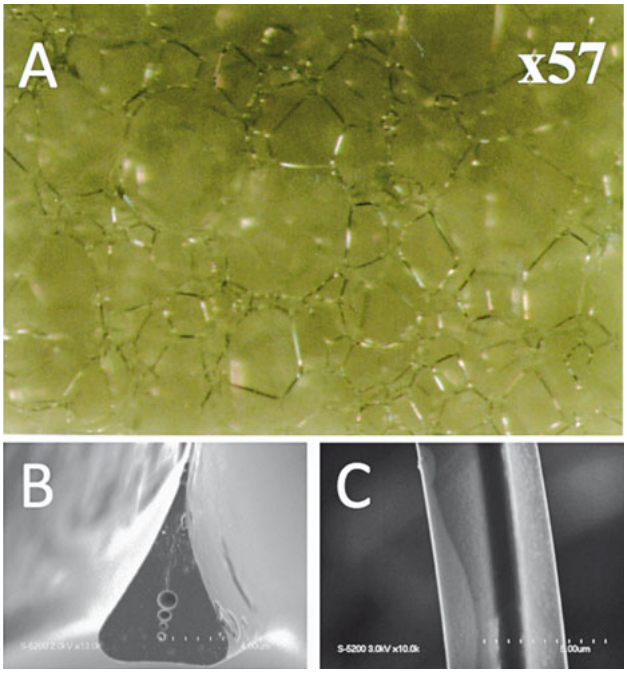

Fig 2 Skeletal structure of melamine sponge. The partition wall is 0.2 microns thick and can enter concavities; **A)** optical microscope photograph; **B and C)** scanning electron micrograph.

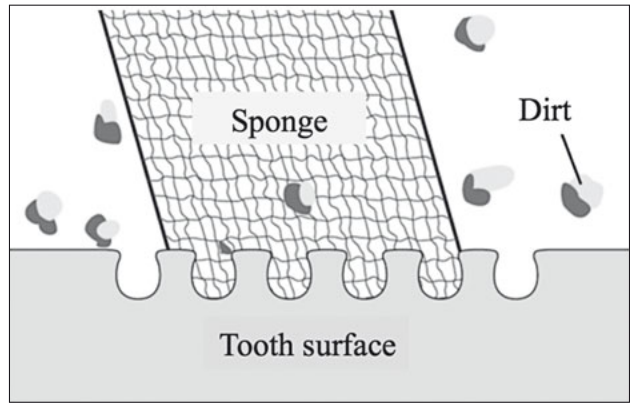

Fig 3 Stains in concavities which were unreachable by a toothbrush tip could not be removed. Since the partition wall of melamine sponge was very thin, it could remove stains, akin to the action of scooping.

Table 1 Results of formalin dissolution test of melamine sponge.

	Formalin dissolution test (Japan Chemical Analysis Center)		Quantitative dissolution test of formaldehyde (Hitachi Kyowa Engineering)	
Test outline	Formalin measurement using acetylcholine absorption spectroscopy per 1 g of sample		Hot water extraction (60°C for 30 min), LC	
Sample	Compressed melamine foam (newly developed)	Uncompressed melamine foam (commercial melamine)	Compressed melamine foam (newly developed)	Uncompressed melamine foam (commercial melamine)
Results	Not detected	Detected	4.923 to 4.959 ppb*	≥ 30 ppb*

*≤ 10 ppb was acceptable
LC: liquid chromatography; ppb: parts per billion.

times (Figs 2 and 3). In the field of dentistry, melamine foam has been shown to be effective in composite resin-teeth cleaning[5].

Prior to use in the oral cavity, the safety of melamine sponge must be checked in the human body. When using commercial melamine sponge such as Gekiochi-kun (LEC, Tokyo, Japan), Hightech-Tawashi (Suny-Clean, Fukuoka, Japan) and Beppinsan (MOCK, Tokyo, Japan), chemical injury can occur by formaldehyde eluting from the sponge, as well as mechanical damage of the skin corneum. However, the safety of our novel tooth surface cleaning tool melamine foam has been confirmed by a quantitative formaldehyde dissolution test (Table 1). From our formalin dissolution test, we did not detect any compressed melamine foam (newly developed).

The objective of this study was to investigate the effect of cleaning using melamine sponge before aesthetic tooth whitening, in terms of stain removal in extracted teeth.

Materials and methods

Melamine sponge with a thickness of 40 mm was compressed at compression ratios of 0 (no compression), 1/2.6, 1/4, 1/8 and 1/20, and destruction of the partition wall structure during the compression process was examined under a stereoscopic microscope.

Five extracted human teeth were used. Each tooth surface was cleaned by normal toothbrushing or with melamine sponge for 90 s, at a stroke force of 300 g or less. To evaluate the stain level on the tooth surface, the teeth were photographed under a stereoscopic microscope every 30 s (0, 30, 60 and 90 s). The residual stained

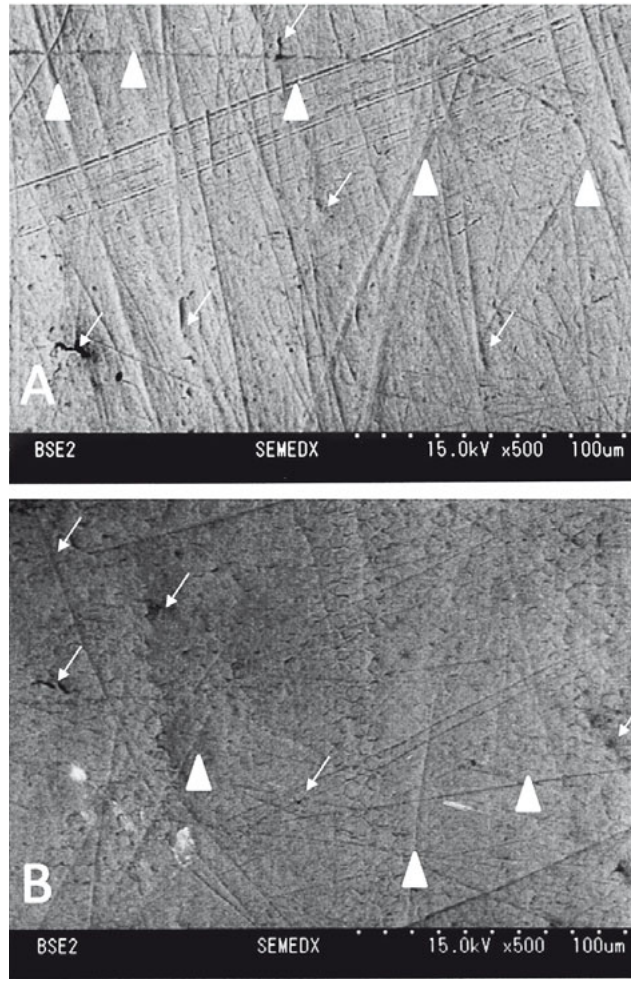

Fig 4 **A)** Normal polishing (x500). Many scratches were observed on the tooth surface. **B**) The tooth surface cleaned using the novel cleaning tool alone (x500). No scratches were produced. Arrows indicate the natural tooth surface concavities and arrowheads indicate artificial scratches.

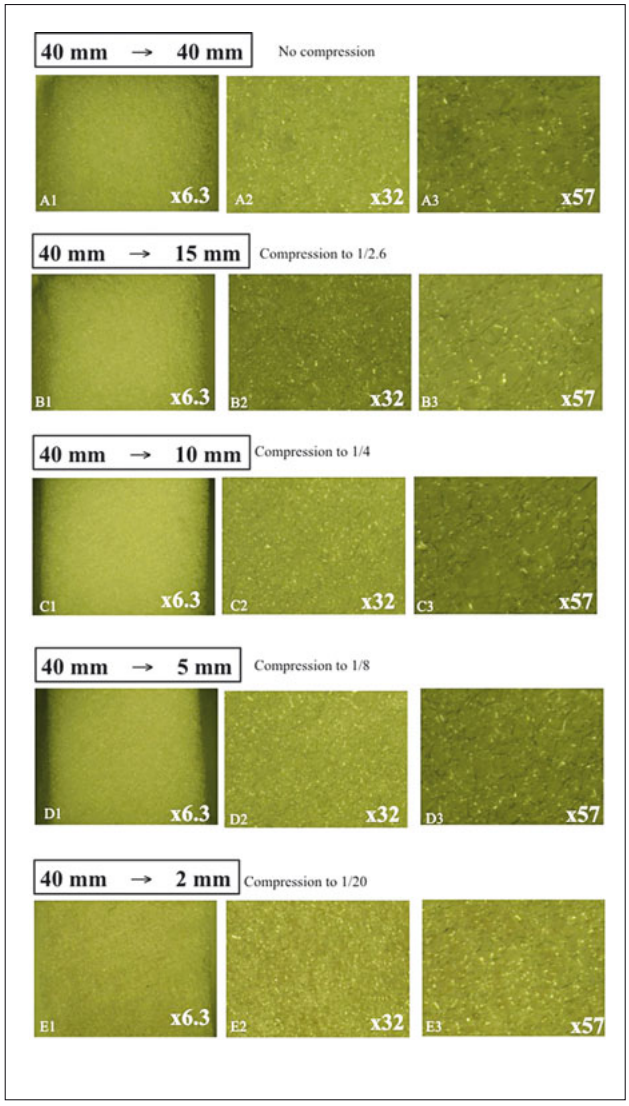

Fig 5 Magnified views of melamine sponge by thickness: **A)** no compression; **B)** a compression of 1/2.6; **C)** a compression of 1/4; **D)** a compression of 1/8; **E)** a compression of 1/20.

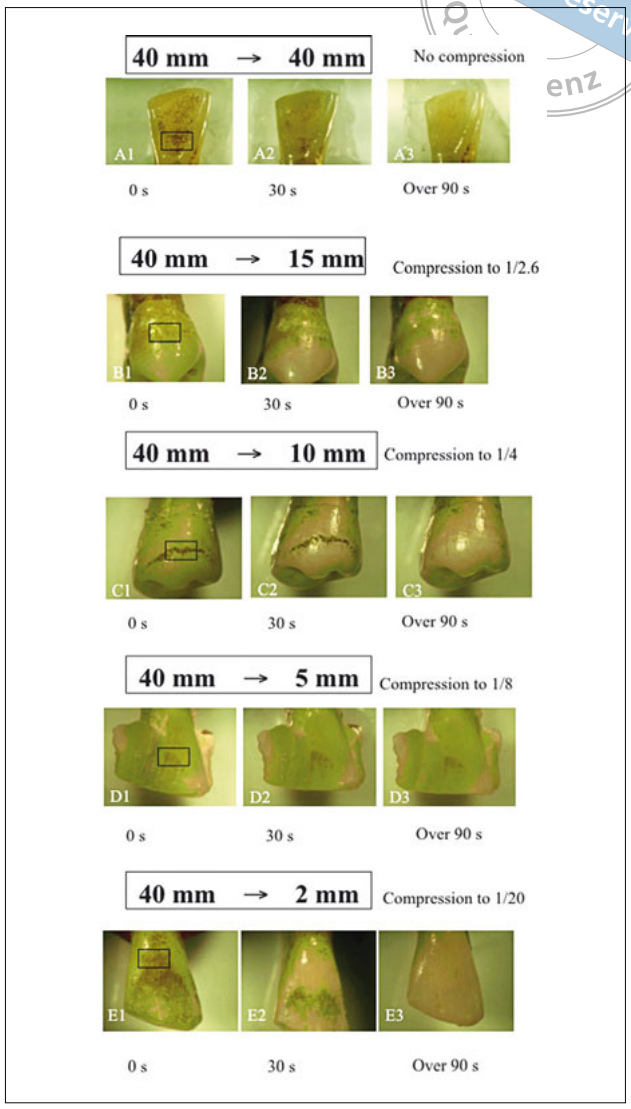

Fig 6 Stain-removing effects at 0 s, 30 s and over 90 s, for melamine sponge compressed at different levels: **A)** no compression; **B)** a compression of 1/2.6; **C)** a compression of 1/4; **D)** a compression of 1/8; **E)** a compression of 1/20.

region was traced in a high-magnification photograph, and the stain intensity was presented as a change relative to the intensity before the experiment (0 s), which was regarded as the 100th stain level, using NIH Image software (National Institutes of Health, Maryland, USA)[6].

Results

Non-replacement treatment: comparison with tooth cleaning

Mechanical cleaning by toothbrushing produced polishing scratches on the tooth surface (Fig 4A). In contrast, melamine sponge produced only minimal artificial polishing scratches, and natural concavities of the teeth were still noticeable (Fig 4B).

Safety and condition of the partition wall of compressed melamine sponge

Formalin used in the manufacturing process of commercial melamine sponge is retained in the sponge. The formalin removal method is an industrial secret of BASF (Baden Aniline and Soda Factory) (Table 1). Since melamine sponge itself is soft and not suitable for tooth surface cleaning, sponges with different heat-compression rates were prepared, to improve the physical properties whilst retaining tooth-cleaning ability (Fig 5).

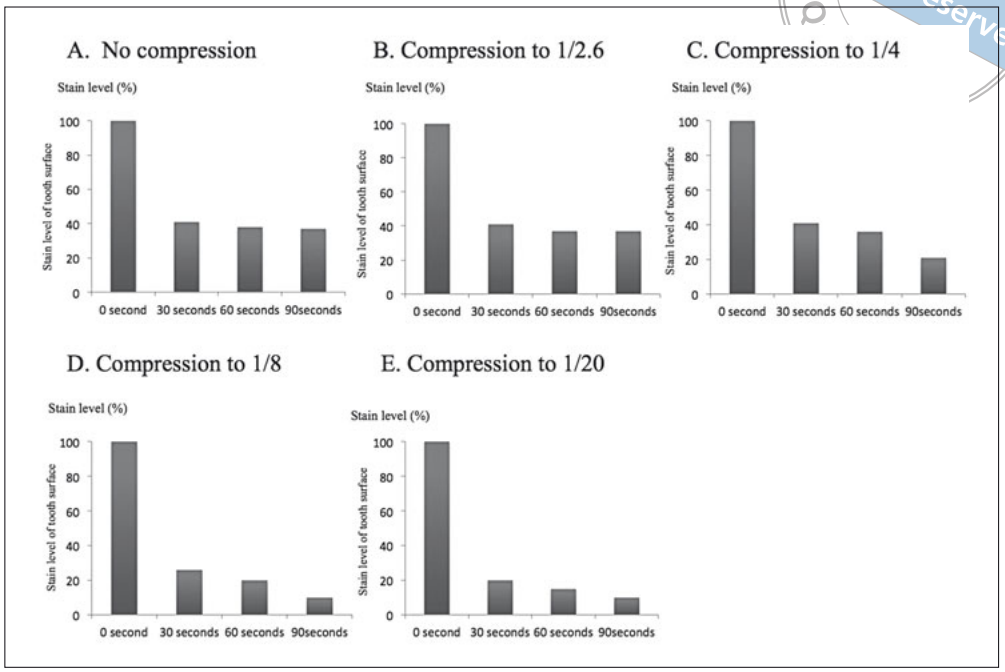

Fig 7 Graphs showing the percentage levels of stain on the tooth surface at 0, 30, 60 and 90 s, for melamine sponge compressed at different levels. Graphs A to E correspond with parts A to E of Fig 5: **A)** no compression; **B)** a compression of 1/2.6; **C)** a compression of 1/4; **D)** a compression of 1/8; **E)** a compression of 1/20.

Stain-removing effect of melamine sponge compressed at different levels

Stains which were difficult to remove using commercial dentifrices and toothbrushes, were removed using melamine sponge toothbrushes. All compressed melamine sponge toothbrushes showed a stain-removing effect. In particular, a marked effect was exhibited within a short period of time when the compression rate was high (Figs 6 and 7).

Discussion

In this report, we suggest that melamine sponge can remove stain from the tooth surface more effectively and less invasively compared to conventional toothbrushes. Tanaka et al reported that melamine foam would be more effective for removal of stains on composite resin artificial teeth than by toothbrushing[5]. Repeated mechanical cleaning produces concavities and convexities on the tooth surface, and these changes in surface morphology may induce the re-adhesion of stains[7,8]. Using a melamine brush instead of a conventional toothbrush could result in long-term cleanliness of the tooth surface.

All compressed melamine sponge toothbrushes showed good stain removal in this study. As the compression level increased, the stain-removing effect tended to get stronger. Tanaka et al reported that four-fold compression of melamine foam has a good dimensional stability on heating/compression molding[5]. Although the data are not shown, the frequency of irrigation increased as the compression rate rose, and the compression rate exhibiting both clinical operability and stain-removing effect was 1/4. Highly-compressed melamine would be less practical for use in a toothbrush, because it has a low water absorption rate.

Although the physical properties of melamine sponge are very similar to those of soft polyethylene foam and polyurethane, the stain-removing effect of melamine foam is superior. The main reason is the partition wall thickness being thinner than 0.5 μm, which enables it to enter small concavities on the tooth surface and allow it to scrape residual staining substances, akin to the action of scooping. The partition wall tips are always ablated and a new surface appropriately appears, retaining the cleaning function. In addition, melamine sponge is very soft and unlikely to make a new scratch on the hard tooth tissue; thus, the frequency of staining does not change.

In this experiment, we used an extracted tooth for testing the stain-removing ability of melamine foam. In terms of daily use, it is difficult to brush the posterior teeth with a large sponge, so it is necessary to make the brushing region smaller for use in the oral cavity. Given that melamine itself is very soft, greater brushing force may be required compared to the conventional method. Also, the supporting part of the toothbrush comes into direct contact with the tooth surface if the thickness is not adequate. Therefore, further research is required to determine the size and structure of the novel toothbrush.

Conclusions

Melamine sponge removed stains from the tooth surface more effectively and less invasively compared to conventional toothbrushes. No new scratches were made on the tooth surface when using a melamine sponge brush, therefore reducing the risk of re-staining. Cleaning using a melamine sponge brush can be easily and effectively performed at home and in a dental office.

Acknowledgments

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Conflict of interest

The authors reported no conflicts of interest related to this study.

Author contribution

Dr Takero Otsuka, who carried out the research and wrote the paper, and Dr Toshitsugu Kawata, who directed the research.

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