Influence of Storage Methods on the Surface Roughness of Tissue Conditioners

Guang HONG¹, YingAi LI¹, Takeshi MAEDA¹, Wataru Mizumachi¹, Shinsuke SADAMORI¹, Taizo HAMADA¹ and Hiroshi MURATA²
¹Department of Prosthetic Dentistry, Graduate School of Biomedical Sciences, Hiroshima University, 1-2-3 Kasumi, Minami-ku, Hiroshima 734-8553, Japan
²Department of Prosthetic Dentistry, Graduate School of Biomedical Sciences, Nagasaki University, 1-7-1 Sakamoto, Nagasaki 852-8588, Japan
Corresponding author, Guang HONG; E-mail: hong@hiroshima-u.ac.jp
Received June 29, 2007/Accepted September 5, 2007

The purpose of this study was to compare the influence of three kinds of storage methods on surface roughness of tissue conditioners. Four commercial tissue conditioners (GC Soft Liner, Softone, Fictioner, and Hydro-Cast) were used in this study. Five samples of each material were stored in distilled water, air, and a denture cleanser (Polident). Mean surface roughness (R₃) values of dental stone casts made from the tissue conditioners were measured after 0, 1, 3, 7, and 14 days of immersion using a profilometer. Significant differences in the R₃ values of the specimens were found among the three storage methods. The values of R₃ significantly increased with increase in immersion time for each storage method, except for the materials stored in air. It was found that the materials stored in air showed the most stable and lowest values of R₃. Results obtained suggested that a tissue conditioner exhibited smooth and minimal change in surface roughness with time when stored in air than in distilled water and denture cleanser.

Keywords: Surface roughness, Tissue conditioner, Storage method

INTRODUCTION

The clinical use of tissue conditioners as temporary lining materials for dentures was first reported in 1961¹. They are often used in a variety of applications because of their viscoelastic property, such as for the treatment of damaged alveolar mucosa due to ill-fitting dentures or after a surgery, to record dynamic functional impressions, or for temporary relining during the healing phase after implant placement²⁻⁸. In clinical situations, the surface roughness of tissue conditioners is an important factor as well as the viscoelastic properties and dimensional stability when this material is used as a dynamic impression material and tissue conditioning material¹⁻⁵. The loss of surface integrity and surface smoothness may begin three to four days after application⁹. This surface change can irritate denture-bearing areas, and at the same time create an environment for the colonization of oral microorganisms — which can accelerate the deterioration of the tissue conditioner¹⁰⁻¹¹. The latter occurs because the materials are easily colonized and deeply infected by these organisms¹⁰⁻¹². Against this background, denture cleansers are occasionally used to clean dentures lined with tissue conditioner.

Although denture cleansers have been reported to be effective in the prevention of denture plaque formation¹³, the use of cleansers will deteriorate the tissue conditioners¹⁴⁻¹⁶. To date, the mechanical properties, dimensional stability, and weight change of tissue conditioners have been widely investigated¹⁷⁻²⁴. However, few studies have examined the influence of storage methods on the surface roughness of tissue conditioners.

The purpose of this study, therefore, was to compare the influence of three kinds of storage methods on the surface roughness of tissue conditioners. We hypothesized that the influence on the surface roughness of the materials would differ according to storage methods.

MATERIALS AND METHODS

Sample preparation
Table 1 lists the four commercial tissue conditioners used in this study with details on the compositions of their powders and liquids²⁵⁻²⁶. Each material was processed according to manufacturer’s recommendations and poured into a polypropylene container (diameter: 18 mm, thickness: 2.5 mm). A glass plate was placed on top of the container and pressed onto the mass, then removed two hours later. After removal, the sample surface of Fictioner was coated with a surface treatment material which contained methyl methacrylate (top coat)²⁷. Five samples of each material were stored in distilled water, air, or a solution of denture cleanser (Polident, Neutral peroxide with enzyme, Kobayashi Block Co. Ltd., Japan). The surface roughness of each material was measured after 0, 1, 3, 7, and 14 days of immersion.

Each tissue conditioner specimen was boxed using wax, and then poured on with dental gypsum (New Fujirock, Type IV, Batch No. 0309161, GC Corp., Japan) to make gypsum specimens for indirect
Table 1  Tissue conditioners used

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>Composition</th>
<th>P/L by weight</th>
<th>Batch No. powder/liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-Cast</td>
<td>Kay-See Dental Mfg. Co. USA</td>
<td>Poly (ethyl methacrylate)</td>
<td>BBP, EtOH (12.4 wt%)</td>
<td>0.9, 14600010466, 11410010461</td>
</tr>
<tr>
<td>Fictioner</td>
<td>Nissin Dental Co. Japan</td>
<td>Poly (n-butyl methacrylate/ i-butyl methacrylate)</td>
<td>DBS, BPBG, EtOH (0 wt%)</td>
<td>2.0, BFD-G, BGB-I</td>
</tr>
<tr>
<td>Softone</td>
<td>Bosworth Co. USA</td>
<td>Poly (ethyl methacrylate)</td>
<td>DBP, BB EtOH (8.3 wt%)</td>
<td>1.25, 0001, 033</td>
</tr>
<tr>
<td>Soft Liner</td>
<td>GC Corp. Japan</td>
<td>Poly (ethyl methacrylate)</td>
<td>BPBG, DBP, EtOH (14.8 wt%)</td>
<td>1.22, 0002032, 0002041</td>
</tr>
</tbody>
</table>

BBP: butyl benzyl phthalate, DBS: dibutyl sebacate, DBP: dibutyl phthalate, BPBG: butyl phthalyl butyl glycolate, BB: benzyl benzoate, EtOH: alcohol

measurement. After one hour, the tissue conditioners were removed and gypsum specimens were stored for one day at 23±2°C and 70% humidity before measurement.

Surface roughness measurement
A profilometer (Surfcomer SE-3300, Kosaka Laboratory Ltd., Tokyo, Japan) was used as a measuring instrument. Measurements were carried out for the five specimens at 23±2°C and 70% humidity. Finally, averaged roughness (Ra, ±S.D.) of each product was calculated from a total of 25 points of the five samples. Surface roughness was measured with a tracing length of 2.5 mm and a cut-off value of 0.8 mm.

Surface porosity evaluation
Surface porosity of tissue conditioners was examined according to the method described by Goll et al.15 and Harrison et al.16. Each sample was graded with one of the following five scores: 0 (no change), 1 (slight change), 2 (moderate change), 3 (marked change), or 4 (severe change).

Statistical analysis
All surface roughness data were analyzed independently by one-way analysis of variance (ANOVA) and two-way ANOVA. Three-way ANOVA was used to determine the effects of tissue conditioner type, storage method, and immersion time on the surface roughness of tissue conditioners. Differences in surface roughness values between materials were tested with SNK multiple comparison test. All data were analyzed at 0.05 level of significance. All analyses were computed with SPSS for Windows operating system (SPSS 10, SPSS Japan Inc., Tokyo, Japan).

RESULTS
Figure 1 shows the means and standard deviations (S.D.) of the surface roughness of tissue conditioners and their changes with immersion period for all the three types of storage methods. The surface roughness of all the tissue conditioners significantly increased with increase in immersion time (p<0.05, one-way ANOVA) for each storage method. However, exceptions were found for Soft Liner for all the storage methods, for Fictioner stored in air and distilled water, and Softone stored in air. On the effect of storage method, all materials stored in air showed the most stability coupled with low surface roughness values. As for the other two storage methods, high surface roughness values were found in all the materials stored in denture cleanser solution starting from day 1 of immersion, except for Soft Liner. With Softone, high surface roughness values were found for samples stored in distilled water and denture cleanser solution.

Figure 2 shows the means and standard deviations (S.D.) of surface roughness for each tissue conditioner in different storage methods after one day of immersion. Significant differences were found among different storage methods for all the materials, except with Soft Liner (p<0.05, one-way ANOVA). With Hydro-Cast and Softone, samples stored in air exhibited the lowest (p<0.05, SNK test) surface roughness values at 1.276 μm and 0.933 μm respectively. Conversely, samples stored in distilled water and denture cleanser solution exhibited high surface roughness values. With Fictioner, the sample stored in denture cleanser solution exhibited the highest surface roughness value at 2.441 μm. Conversely, samples stored in distilled water and air exhibited low surface roughness values. For samples stored in air, no significant differences were found among Soft Liner, Fictioner, and Softone in terms of surface roughness (SNK, p=0.146). By contrast, Hydro-Cast sample exhibited the highest surface roughness value at 1.539 μm. For samples stored in distilled water, Hydro-Cast sample exhibited the highest surface roughness value at 1.964 μm. For samples stored in denture cleanser solution, Fictioner exhibited the
highest surface roughness value.

Figure 3 shows the means and standard deviations (S.D.) of surface roughness for each tissue conditioner in different storage methods after three days of immersion. Significant differences were found among different storage methods for all the materials except with Soft Liner (p<0.05, one-way ANOVA). With Hydro-Cast and Softone, samples stored in air exhibited the lowest (p<0.05, SNK test) surface roughness values at 1.712 \( \mu m \) and 1.013 \( \mu m \) respectively. With Fictioner, the sample stored in denture cleanser solution exhibited the highest surface roughness value at 3.068 \( \mu m \). For storage in air and distilled water, inter-product comparison showed that the Hydro-Cast sample exhibited the highest surface roughness value. For storage in denture cleanser solution, the Hydro-Cast and Fictioner samples exhibited high surface roughness values.

Then, according to three-way ANOVA, significant differences were found among materials, storage methods, and immersion time (p<0.05).
Figure 4 shows the surface porosity evaluation results of tissue conditioners at 1, 3, 7, and 14 days, where SL: Soft Liner, HC: Hydro-Cast, FT: Fictioner, and ST: Softone.

<table>
<thead>
<tr>
<th></th>
<th>Distilled Water</th>
<th>Air</th>
<th>Denture Cleanser</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SL</td>
<td>HC</td>
<td>FT</td>
</tr>
<tr>
<td>1 day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 days</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No change
- Slight
- Moderate
- Marked
- Severe

**Fig. 4** Surface porosity evaluation results of tissue conditioners at 1, 3, 7, and 14 days, where SL: Soft Liner, HC: Hydro-Cast, FT: Fictioner, and ST: Softone.

**DISCUSSION**

When used as a dynamic impression material and tissue conditioning material, the surface roughness of tissue conditioners is an important factor as well as the viscoelastic properties and dimensional stability. In clinical situations, dentures lined with tissue conditioner are often stored in water, whereby denture cleansers are occasionally used to clean the infected dentures. However, presently, no information is available on the effect of storage methods on tissue conditioners. Therefore, apart from the influences of storage methods on the mechanical properties and dimensional stability of tissue conditioners, this study set out to investigate the influence on the surface roughness of tissue conditioners. The hypothesis that the influence on the surface roughness of tissue conditioners would differ according to storage methods was proven to be true and accepted.

In clinical situations, tissue conditioners are often replaced every three to four days. Their usage does not entail a long period such as two weeks. Therefore, in this study, we tested the samples for two weeks. In terms of choice of denture cleanser, a cleanser containing neutral peroxide with enzyme (Polident) was used in this study. This was based on a report by Nikawa et al., wherein it was reported that this type of cleanser exhibited the most outstanding efficacy against fungal biofilm formation.

As for the tissue conditioners used in this study, it could be seen from Table 1 that their compositions differed. Furthermore, the mean particle sizes of polymers, alcohol contents, and powder/liquid ratios were different too (Table 1). On the mean particle size of polymer, Hydro-Cast was 100 µm, Softone was 60 µm, and Soft Liner was 37 µm. On alcohol content, Hydro-Cast was 12.4 wt%, Fictioner was 0 wt%, Softone was 8.3 wt%, and Soft Liner was 14.8 wt%. On powder/liquid ratio, Hydro-Cast was smallest at 0.9 while Fictioner was largest at 2.0. Taken together, it was speculated that these differences accounted for the differences in the overall surface roughness of the materials.

With Fictioner, surface roughness significantly increased with increase in immersion time, except for samples stored in air and distilled water. On this note, the sample stored in denture cleanser solution exhibited the highest surface roughness value. Davenport et al.14, Goll et al.15, and Harrison et al.16 have reported that the use of cleansers caused the tissue conditioners to deteriorate. Based on these reports, this might be the reason why surface roughness increased. Indeed, samples stored in air and distilled water showed stability in surface roughness coupled with low surface roughness values. It should be highlighted that a surface treatment material was
applied to Fitioneer, which was an alcohol-free tissue conditioner with a high powder/liquid ratio of 2.0. Murata et al. reported that the surface roughness change of coated Fitioneer after immersion in water was smaller than that which was non-coated. Therefore, it seemed that use of a surface treatment material in conjunction with an alcohol-free tissue conditioner with a high powder/liquid ratio were the means to ensuring stability in surface roughness change. This could be due to minimal loss of plasticizer and alcohol, as well as water absorption.

With Softone, surface roughness significantly increased with increase in immersion time, except for the sample stored in air. On this note, the samples stored in distilled water and denture cleanser solution exhibited high surface roughness values. Jones et al. and Wilson reported that after gelation of tissue conditioner, the following phenomena occurred: absorption of water, and loss of plasticizer and alcohol. Indeed, absorption of water and loss of plasticizer and alcohol were likely to happen after immersion in distilled water and denture cleanser solution. This could be the reason why surface roughness increased. By contrast, the sample stored in air showed stability in surface roughness change coupled with the lowest surface roughness value. It was thought that storage in air produced the minimum loss of plasticizer and alcohol, thus accounting for the least change in surface roughness.

With Hydro-Cast, surface roughness significantly increased with an increase in immersion time for each storage method. In particular, the sample stored in denture cleanser solution showed the highest surface roughness value — thus confirming that the use of cleansers could cause tissue conditioners to deteriorate. It was speculated that the higher absorption of water as well as loss of plasticizer and alcohol during storage in denture cleanser solution accounted for this result. By contrast, the sample stored in air showed the most stability with lower surface roughness value. The reason for this might be due to the minimum loss of plasticizer and alcohol in air. BBP (butyl benzyl phthalate) was used as a plasticizer in the liquid of Hydro-Cast. As this plasticizer had a large molecular weight, it was thought that this could have accounted for the minimal loss of the plasticizer. However, when compared to the other materials, Hydro-Cast exhibited the highest surface roughness values for all storage methods and at almost all immersion periods. At this juncture, it must be highlighted that Hydro-Cast had the lowest powder/liquid ratio of 0.9, thereby increasing the loss of plasticizer. Moreover, the mean particle size of polymer was largest at 100 μm, thereby increasing the surface roughness.

With Soft Liner, no significant changes in surface roughness with immersion time nor storage method were found. In other words, this material showed strong stability in surface roughness change. In terms of plasticizer leachability, Jones et al. reported that BB (benzyl benzoate), of which the molecular weight is the smallest (212.24), ranked the highest. On the contrary, BPBG (butyl phthalyl butyl glycolate) which has the largest molecular weight, was used as a plasticizer in the liquid of Soft Liner. Therefore, it was thought that there was minimal loss of plasticizer. Similarly, the molecular structure could have accounted for the decreased absorption of water. As for the mean particle size of Soft Liner, it was the smallest, hence accounting for the lowest surface roughness values when compared to the other materials.

Changes in surface roughness were the most remarkable from day 1 to day 7 after immersion. Pertaining to this result, Ellis et al. has reported on two-third loss of alcohol content within the first week. Further on this, Wilson reported that most alcohol was lost within the first 12 hours.

In terms of surface porosity, the most drastic changes were observed in samples stored in denture cleanser solution, followed by distilled water and then air. Klinger and Lord reported that temporary soft reline materials exposed to Polident sustained considerable internal porosity within a short period of time. High osmotic pressure and pH of denture cleanser solution might have increased the absorption of water and the loss of plasticizer and alcohol. These phenomena then led to the increased surface porosity of samples immersed in denture cleanser solution. These surface porosity results coincided with the results of surface roughness test. Results of this study indicated that the surface roughness of tissue conditioners was greatly influenced by storage method. However, the influence of storage method varied according to the material. Differences in composition components might be the reason for this variation in influence. Furthermore, the surface roughness of tissue conditioners tended to increase with increase in immersion time.

CONCLUSIONS

Results of this study are summarized as follows:

1. Significant differences in surface roughness of tissue conditioners were found for different storage methods.
2. Surface roughness significantly increased with increase in immersion time for each storage method, except for samples stored in air.
3. Samples stored in air showed the most stability in surface roughness change, thereby yielding the lowest surface roughness values.
(4) It is recommended to store tissue conditioners in air during dynamic impression taking.

ACKNOWLEDGEMENTS

This research was supported in part by a Grant-in-aid (Nos. 18592126 and 19592238) for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

REFERENCES