INTRODUCTION

Agar-alginate combined impressions are commonly used in dental clinics because this system offers accurate reproducibility, easy manipulation, and lower cost than agar-alone procedures1-4). It has been reported that the edge sharpness of stone casts made from agar-alginate combined impressions is better than that obtained with alginate impressions2), and that the dimensional accuracy of the stone casts is clinically acceptable1,3). In order to prevent transmission of infectious diseases during dental treatment, impressions need to be disinfected4-9). Agar-alginate combined impressions also need to be disinfected without any resulting adverse effects on the casts obtained. Although guidelines for the selection of appropriate methods for disinfection of impressions indicate that immersion disinfection of alginate impression materials should not exceed 10 min, and that agar impressions should not be immersed in alkaline glutaraldehyde solution4), no appropriate disinfection methods for agar-alginate combined impressions have been suggested.

A few studies have investigated the effects of disinfection of agar-alginate combined impressions on the surface roughness of the resulting stone casts; immersion in glutaraldehyde solution was found to lead to deterioration of the surface properties of the casts10,11). However, the effects of immersion in ortho-phthalaldehyde solution in place of glutaraldehyde, which is toxic, have not been examined, and so far such effects have been reported only for alginate impressions12).

It has been reported that the surface roughness of stone casts produced from agar-alginate combined impressions immersed in sodium hypochlorite solution for 10–15 min was greater than that without immersion for some products10,13), whereas the effects of short-term immersion have not been investigated.

Keywords: Agar impression materials, Alginate impression materials, Disinfection, Surface roughness, Scanning electron microscope

MATERIALS AND METHODS

Table 1 lists the materials that were used in accordance
Table 1  Materials used in this study

<table>
<thead>
<tr>
<th>Code</th>
<th>Brand name</th>
<th>Manufacturer</th>
<th>Lot No.</th>
<th>W/P (mL/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agar impression material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARO</td>
<td>Aromloid</td>
<td>Omnico, Tokyo, Japan</td>
<td>1304221</td>
<td>—</td>
</tr>
<tr>
<td>DAN</td>
<td>Danloid J-Spec</td>
<td>Clark, Saitama, Japan</td>
<td>13040110</td>
<td>—</td>
</tr>
<tr>
<td>Alginate impression material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFP</td>
<td>Aroma Fine Plus</td>
<td>GC, Tokyo, Japan</td>
<td>1307011</td>
<td>2.38</td>
</tr>
<tr>
<td>Dental stone</td>
<td>New Plastone II</td>
<td>GC</td>
<td>1307151</td>
<td>0.23</td>
</tr>
<tr>
<td>Ortho-phthalaldehyde</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA</td>
<td>Disopa</td>
<td>Johnson &amp; Johnson, Tokyo, Japan</td>
<td>003CA</td>
<td>—</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>Pureox</td>
<td>Oyalox, Tokyo, Japan</td>
<td>1051</td>
<td>—</td>
</tr>
</tbody>
</table>

Fig. 1  Apparatus used in this study.
a: Perforated ring tray on the glass plate. b: Plastic plate. c: Rubber mold.

with the instructions of the respective manufacturers. Two brands of cartridge-form agar impression material (ARO: Aromaloid, Omnico, Tokyo, Japan; DAN: Danloid J-Spec, Clark, Saitama, Japan) were boiled for 10 min and then stored in a dry conditioner (Melty, Morita, Tokyo, Japan). The storage temperatures for ARO and DAN were 63°C and 65°C, respectively. Using an automatic mixer (Rakuneru, GC), alginate impression material (AFP: Aroma Fine Plus, GC) and type V dental stone (New Plastone II, GC, Tokyo, Japan) were mixed at W/P ratios of 2.38 and 0.23, respectively. The disinfectants used were 0.55% ortho-phthalaldehyde solution (PA) and 0.5% sodium hypochlorite solution (SH). Two brands of disinfectant product were used as test materials: Disopa (0.55% ortho-phthalaldehyde, Johnson & Johnson, Tokyo, Japan) and Purelox (6% sodium hypochlorite, Oyalox, Tokyo, Japan). The sodium hypochlorite was diluted with deionized water to a concentration of 0.5%.

The procedure for making the stone casts was as follows. Half a stick of agar sol was poured into a perforated ring tray (20 mm internal diameter, 5 mm height) on a clean, smooth glass plate (50 mm square, 2 mm thickness, Hayashi Rikagaku, Tokyo, Japan). Mixed alginate impression material was then immediately seated on the agar sol with a spatula. A plastic plate was placed on top of the alginate mixture with soft pressure and held in place to make an impression of the glass plate. The agar-alginate combined impression was then removed from the glass plate and the plastic plate five min after the start of alginate mixing, and the surface of the agar impression was mounted in a circular rubber mold with a height of 10 mm. Each impression was rinsed for 60 s under tap water.

After rinsing, the impressions were assigned to two groups. The first group was immersed in 0.55% ortho-phthalaldehyde solution for 1, 3, 5 and 10 min (PA1, PA3, PA5 and PA10), and the second group was immersed in 0.5% sodium hypochlorite solution for 1, 3, 5 and 10 min (SH1, SH3, SH5 and SH10). After both modes of immersion disinfection, the impressions were rinsed again for 60 s under tap water to remove any traces of the disinfectant solutions.

Mixed stone was poured onto the surface of the impression and allowed to set at room temperature. One hour after stone mixing, the stone cast was removed from the impression and stored at room temperature for 24 h before measurement. A stone cast obtained from an impression that had not been treated after the first rinsing was prepared as a control (C). Five stone casts were prepared for each condition.

Using a surface roughness measuring instrument (Surfcom 1400A, Tokyo Seimitsu, Tokyo, Japan), the roughness (Ra) of the stone casts was measured in accordance with ISO 4288:1996. Six measurements were
obtained for each stone cast at six different positions, and the mean value was defined as the surface roughness.

The surfaces of the stone casts were observed using a scanning electron microscope (SEM) (S-4300SE, Hitachi, Tokyo, Japan) at a magnification of ×1,000.

The roughness data were subjected to Dunnett’s multiple comparison test (α=0.05) to allow comparison between control and other conditions. When heteroscedasticity was indicated by Bartlett’s test, data were subjected to Welch’s t test.

The entire experiment was conducted at a room temperature of 23±1°C and a relative humidity of 50±5%. The impression taking was done in an incubator (V-850, Atom, Tokyo, Japan) adjusted to a temperature of 35±1°C and a relative humidity of 95±5%. The temperature of the water used was 23±1°C.

RESULTS

Figures 2 and 3 show the surface roughness (Ra) of the stone casts obtained from the combined Aromaloid and Aroma Fine Plus impressions (ARO-AFP) and the combined Danloid J-Spec and Aroma Fine Plus impressions (DAN-AFP), respectively.

For ARO-AFP impressions, the Ra of stone casts obtained from the untreated impression (C) was 0.258 μm. The Ra values of the stone casts obtained from impressions that had been immersed in 0.55% ortho-phthalaldehyde solution for 3, 5 and 10 min (PA3, PA5 and PA10) were too large to measure in accordance with ISO 4288:1996. The Ra for PA1 was 3.698 μm. The Ra values of the stone casts obtained from impressions that had been immersed in 0.5% sodium hypochlorite solution for 1, 3, 5 and 10 min (SH1, SH3, SH5 and SH10) were 0.332–0.408 μm. The Ra values for SH1, SH3, SH5 and SH10 were significantly larger than for the control (C). For DAN-AFP impressions, the Ra for C was 0.275 μm. The Ra values for PA1, PA3, PA5 and PA10 were 2.735–6.539 μm, and those for SH1, SH3, SH5 and SH10 were 0.389–0.513 μm. The Ra values of stone casts obtained from impressions that had been immersed in disinfectant solutions were significantly larger than the value for C.

Figures 4 and 5 show typical SEM observations of the surfaces of the stone casts obtained from ARO-AFP and DAN-AFP impressions. Both sets of casts obtained from impressions that had been treated with ortho-phthalaldehyde solution (PA1, PA3, PA5 and PA10) had larger crystals than those of C, and the crystals were not arranged closely. In addition, dental stone powder was observed on the surfaces of the impressions after separation from the casts (Fig. 6).

On the other hand, SEM observations of the stone casts obtained from impressions that had been treated with sodium hypochlorite solution (SH1, SH3, SH5 and SH 10) revealed no differences from those of C.
Fig. 4  SEM observations of the surface of the stone casts obtained from ARO-AFP impressions.
C: Control; first rinsing only, PA1: Immersed in 0.55% ortho-phthalaldehyde solution for 1 min, PA3: Immersed in 0.55% ortho-phthalaldehyde solution for 3 min, PA5: Immersed in 0.55% ortho-phthalaldehyde solution for 5 min, PA10: Immersed in 0.55% ortho-phthalaldehyde solution for 10 min, SH1: Immersion in 0.5% sodium hypochlorite for 1 min, SH3: Immersion in 0.5% sodium hypochlorite for 3 min, SH5: Immersion in 0.5% sodium hypochlorite for 5 min, SH10: Immersion in 0.5% sodium hypochlorite for 10 min.

Fig. 5  SEM observations of the surface of the stone casts obtained from DAN-AFP impressions.
C: Control; first rinsing only, PA1: Immersed in 0.55% ortho-phthalaldehyde solution for 1 min, PA3: Immersed in 0.55% ortho-phthalaldehyde solution for 3 min, PA5: Immersed in 0.55% ortho-phthalaldehyde solution for 5 min, PA10: Immersed in 0.55% ortho-phthalaldehyde solution for 10 min, SH1: Immersion in 0.5% sodium hypochlorite for 1 min, SH3: Immersion in 0.5% sodium hypochlorite for 3 min, SH5: Immersion in 0.5% sodium hypochlorite for 5 min, SH10: Immersion in 0.5% sodium hypochlorite for 10 min.
DISCUSSION

Agar impression materials have hydrocolloid characteristics similar to those of alginate impression materials. It is thought that the effects of immersion disinfection on agar impressions are similar to those for alginate impressions. Since the hydrocolloid impression must be poured within a short time after removal from the mouth, the period of immersion of alginate impression materials in disinfectant solution should not exceed 10 min. As agar impression materials appear to require an immersion time of less than 10 min, agar-alginate combined impressions might have a similar requirement. The germicidal effects of short-term immersion of hydrocolloid impression materials in disinfectant solutions have been reported. Therefore the aim of this study was to examine the effects of immersion of agar-alginate combined impressions in disinfectant solutions for 1, 3, 5 and 10 min on the surface properties of the resulting stone casts.

It has been reported that stone casts obtained from agar-alginate combined impressions have a low degree of surface roughness. In this study we found that the Ra values of stone casts obtained from untreated impressions (C) were 0.258 μm and 0.275 μm, which were as low as those for addition-type silicone rubber impressions. These results indicate that stone casts obtained from agar-alginate combined impressions can have excellent surface properties.

Orthophthalaldehyde possesses several potential advantages over glutaraldehyde. However, after immersion of agar-alginate impressions in 0.55% orthophthalaldehyde solution, the Ra values of some of the resulting stone casts were too high for compliance with ISO 4288:1996. SEM observations of these casts revealed that the crystals were larger than those for C preparations, and not arranged closely. In addition, dental stone powder was observed on the surfaces of the impressions after separation from the casts.

Immersion of agar-alginate combined impressions in glutaraldehyde solution has been shown to degrade the surface of the resulting stone casts, and SEM observations of such casts revealed features similar to those for PA1, PA3, PA5 and PA10 in the present study. As was the case for immersion in orthophthalaldehyde solution, dental stone powder has also been observed on the surfaces of impressions following immersion in glutaraldehyde solution. Though immersion of alginate impressions in glutaraldehyde for 30 min greatly affected the surface quality of the resulting stone casts, the orthophthalaldehyde solution we used did not include any alkaline buffer. Further study will be required to clarify the mechanism of the chemical reaction between orthophthalaldehyde solution and dental stone.

It has been reported that immersion of alginate impressions in orthophthalaldehyde solution affected the surface roughness of the resulting stone casts. It has been considered that the effect of orthophthalaldehyde solution on stone casts is attributable to a chemical reaction between the dental stone and residual disinfectant solution remaining on the impression surface. The results of the present study suggested that orthophthalaldehyde solution remaining on the surface of the agar reacted with the dental stone. Therefore, the second rinse under tap water might have been too short to remove all traces of the disinfectant solution.

The CDC has recommended that household bleach (1:10 dilution) should be used for disinfection of hydrocolloid impressions. The effects of immersion in sodium hypochlorite solution on the surfaces of stone casts obtained from agar-alginate combined impressions appear to vary among the brands of agar impression materials: some products show an increase of surface roughness, whereas others show a decrease or no change. In the present study, immersion of agar-alginate combined impressions in 0.5% sodium hypochlorite solution yielded stone cast Ra values of 0.332–0.513 μm for SH1, SH3, SH5 and SH10, which were significantly higher than those for C. However, the Ra values for SH1, SH3, SH5 and SH10 were considered to be sufficiently low, and SEM observations of these preparations demonstrated no differences from the features evident in C. The results indicate that immersion of agar-alginate combined impressions in 0.5% sodium hypochlorite solution for up to 10 min does not adversely affect the surface properties of the resulting stone casts.

Although Ra value for SH1 appeared to be small in comparison with the other preparations, shortening of the immersion time may not improve the surface quality significantly. The Japan Prosthodontic Society
has recommended that alginate impressions should be immersed in 0.1–1.0% sodium hypochlorite solution for 15–30 min. Though some agar products were affected with the immersion in 0.5% sodium hypochlorite solution for 15 min on the surface roughness of stone casts obtained from agar-alginate combined impressions, other products were not affected. It is thought that the immersion in 0.5% sodium hypochlorite solution for 15 min is more feasible disinfection methods for agar-alginate combined impressions than 10 min immersion in terms of surface property.

However, it was reported that the immersion of agar-alginate combined impressions in 0.5% sodium hypochlorite solution for 15 min caused dimensional changes in resultant stone casts. The water absorption of the impression immersed in sodium hypochlorite solution was caused by the movement of water due to the differences in osmotic pressure between the impression and the disinfectant solution. The expansion of agar impression materials in water increased as the immersion time increased. Therefore short-term immersion of agar-alginate combined impressions in 0.5% sodium hypochlorite solution might decrease the dimensional changes of stone cast caused by immersion. It is necessary to examine the effects of immersion time in 0.5% sodium hypochlorite solution on the dimensional accuracy of the resulting stone casts.

CONCLUSION
The findings of the present study indicate that immersion of agar-alginate combined impressions in 0.5% orthophthalaldehyde solution for even 1 min degrades the surface properties of the resulting stone casts, whereas immersion in 0.5% sodium hypochlorite solution has no serious adverse effects.

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REFERENCES
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