Dimensional changes in stone casts resulting from long-term immersion of addition-type silicone rubber impressions in disinfectant solutions

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There is a concern that long-term immersion of impressions in disinfectant solutions may cause changes in the dimensions of the resulting stone casts. This study investigated the dimensional changes in stone casts resulting from immersion of five brands of addition-type silicone rubber impressions in disinfectant solutions for 30 min and 24 h. Impressions of a master cast designed to simulate an abutment tooth were immersed in 2% glutaraldehyde and 0.55% ortho-phthalaldehyde. The diameter of the stone cast was measured using a laser scan micrometer. For four brands of impression materials, 30-min immersion in disinfectant solutions produced no dimensional changes in the stone casts. For four brands of impression materials, 24-h immersion caused a significant decrease in the stone cast dimensions.

Keywords: Addition-type silicone rubber impression materials, Disinfection, Dimensional accuracy

INTRODUCTION

In dental practice, disinfection of impression materials is required in order to prevent the transmission of infectious diseases1-4. Addition-type silicone rubber impression materials can be immersed in disinfectant solutions for short periods without affecting the accuracy or detail of reproduction5-7, and the recommended immersion period is less than 30 min2. In some cases, however, it is difficult to adhere to the recommended disinfection period. If impression materials could be immersed for a longer period, for example overnight, then this form of disinfection would be easier to incorporate into dental preparation procedures. However, few reports8-10 have examined the effects of long-term immersion of impression materials in disinfectant solutions on the surface properties and dimensional accuracy of the resulting stone casts.

Hydrophilic addition-type silicone rubber impression materials contain surfactant to make them hydrophilic. Long-term immersion in disinfectant solutions causes the surfactant in an impression to leach out, rendering the impression less hydrophilic9, and imbibition may also cause alterations in the impression dimensions. It has been reported that immersion in 2% glutaraldehyde solution for up to 18 h does not affect the wettability of hydrophilic addition-type silicone rubber impression materials8. However, the dimensional accuracy of the resulting stone casts has not been examined sufficiently. In recent years, addition-type silicone rubber impression materials with enhanced hydrophilic properties have been used clinically. These materials contain larger quantities of surfactant than conventional hydrophilic addition-type silicone rubber impression materials, or have added polyether in their structure11. Although such materials would have the potential to show larger dimensional changes upon immersion in disinfectant solutions than conventional impression materials, no previous studies have examined the dimensional changes in the stone casts resulting from such immersion. In addition, ortho-phthalaldehyde solution has become attention for the toxicity of glutaraldehyde solution. However no studies have examined the effects of immersion of addition-type silicone rubber impression materials in ortho-phthalaldehyde solution on the dimensional accuracy of the resulting stone casts. The present study investigated the effects of long-term immersion of hydrophilic addition-type silicone rubber impression materials in ortho-phthalaldehyde solution on the dimensional accuracy of the resulting stone casts.

MATERIALS AND METHODS

Materials used

The materials listed in Table 1 were used in accordance with the instructions of the respective manufacturers. Five brands of type 3 hydrophilic addition-type silicone rubber impression materials (ASU: Aquasil Ultra, Dentsply Caulk, Milford, MA, USA; EMF: Examixfine, GC, Tokyo, Japan; FUII: Fusion II, GC, Tokyo, Japan; IPII: Imprint II, 3M ESPE, St. Paul, MN, USA; IP3: Imprint 3, 3M ESPE, Seefeld, Germany) and type 4 dental stone (New Fujirock, GC, Tokyo, Japan) were used. FUII and IP3 have enhanced hydrophilicity, in 2% glutaraldehyde or 0.55% ortho-phthalaldehyde solution on dimensional changes in the resulting stone casts.
Table 1 Materials used in this study

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<td>PA</td>
<td>Disopa</td>
<td>Johnson &amp; Johnson, Tokyo, Japan</td>
<td>355HL</td>
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Two brands of disinfectant product were used as test materials: Denthody (20% glutaraldehyde, Nippon Shika Yakuhin, Shimonoseki, Japan) and Disopa (0.55% ortho-phthalaldehyde, Johnson & Johnson, Tokyo, Japan). The glutaraldehyde was diluted with deionized water to a concentration of 2%.

Fabrication of stone casts

Figure 1 shows a stainless steel master cast designed to simulate an abutment tooth and a perforated metal tray adjusted to an impression thickness of 5 mm. The master cast had an 8° taper to the vertical axis and a 1-mm-wide shoulder at the margin. The distance from the occlusal surface to the shoulder was 5 mm. The diameter of the upper surface was 8.3 mm and that of the lower portion was 9.0 mm.

The procedure for making the stone cast was as follows. The tray overfilled with mixed hydrophilic addition-type silicone rubber impression material was seated on the master cast, which was overlaid with the impression material. The mixed impression materials were extruded through the static mixing tip fitted to cartridge materials. Two minutes and 30 s after the start of silicone rubber mixing, the assembly was placed in a water bath maintained at 35±1°C for the respective manufacturer’s recommended setting time. After removal from the water bath, the impression was taken from the master cast and rinsed for 30 s under tap water.

After rinsing, the impressions were assigned to three groups. The first (control) group was stored in air at room temperature (23±1°C) for 30 min (C30M) or 24 h (C24H). The second group was immersed in 2% glutaraldehyde solution for 30 min (GA30M) or 24 h (GA24H). The third group was immersed in 0.55% ortho-phthalaldehyde solution for 30 min (PA30M) or 24 h (PA24H). After the four modes of immersion disinfection, the impressions were rinsed again for 30 s under tap water to remove any traces of the disinfectant solution.

Mixed stone was poured onto the surface of the impression mounted in a circular rubber mold 7 mm in height with vibration, 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 of dimensional changes. Five stone casts were prepared for each disinfection condition. The temperature of the water used was 23±1°C.

Measurement procedure

As shown in Fig. 2, three measurement positions were set on the stone cast. The diameter of the cast was measured using a laser scan micrometer (LS-3060, Keyence, Tokyo, Japan) at each position —namely, Position I: 1.0 mm below, II: 2.5 mm below, and III: 4.0 mm below the upper surface of the cast[12,13]. The mean of six measurements at each position was adopted as the representative value. The difference in diameter between the stone and the master cast at each position was calculated as the dimensional change.

The data were analyzed using Tukey’s multiple comparison test (α=0.05). The entire experiment was conducted at a room temperature of 23±1°C and a relative humidity of 50±10%.
RESULTS

The changes in the dimensions of stone casts obtained from ASU, EMF, FUII, IPII and IP3 are shown in Figs. 3, 4, 5, 6 and 7, respectively.

For ASU, FUII, IPII and IP3 impressions, stone casts obtained from impressions treated by immersion disinfection or storage in air for 30 min (GA30M, PA30M and C30M) showed no significant differences in dimensional changes at any of the measurement points. For EMF impressions, dimensional changes in GA30M and PA30M were significantly larger than those in C30M at all measurement points. There were no significant differences in dimensional changes between GA30M and PA30M at all positions for the five impression materials. For 30-min immersion, the type of disinfectant did not affect the dimensional changes in the resulting stone casts.

For the five impression materials, dimensional changes in stone casts obtained from the impressions immersed in disinfectants for 24 h (GA24H and PA24H) were significantly smaller than those after 24 h of storage in air (C24H), except for GA24H of ASU at positions I and II. ASU and EMF impressions at all measurement points, IPII impression at positions II and III, the dimensional changes in PA24H were significantly smaller than those for GA24H.

There were no significant differences between C30M and C24H at any of the positions for the five impression materials except for ASU at position III, where the difference in dimensional change between C30M and C24H was 0.11%. In either type of disinfectant, dimensional changes after 24-h immersion were significantly smaller than those after 30-min immersion.

For the five impression materials, the effects of immersion disinfection of impression materials in dimensional changes of resultant stone casts indicated similar tendency at any of the measurement points, except for position III of ASU and position I of IPII.
DISCUSSION

Changes in the dimensions of hydrophilic addition-type silicone rubber impression materials occur mainly through polymerization shrinkage, thermal contraction upon transfer from oral temperature to room temperature, and imbibition of surrounding solution\(^2\). The thermal contraction of addition-type silicone rubber impression materials that occurs from 32°C to 23°C (a 9°C temperature change) causes a dimensional change of about 10–12 μm for cylindrical stone casts for every 1 mm increase in impression thickness\(^1\). In the present study, the change in temperature of impression materials was 12°C and the impression thickness was 5 mm, and thus the dimensional change in stone casts caused by thermal contraction was estimated to be 67–80 μm. This value corresponds to a 0.76–0.95% dimensional change in the stone casts. The polymerization shrinkage of addition-type silicone rubber impression materials during 30 min is 0.1–0.15%\(^5\). The setting expansion for type 4 dental stone is 0–0.15%. In the present study, the dimensional changes of the stone casts obtained from the five brands of addition-type silicone rubber impression material in C30M were 0.80–1.16%. Considering the thermal contraction and polymerization shrinkages of impression materials and the setting expansion of dental stone, these results seem to be appropriate.

It has also been reported that stone casts showed no
that the period of storage of the impression materials in air had little effect on the dimensional changes in the resulting stone casts. It has also been reported that long-term storage in air does not affect hydrophilic addition-type silicone rubber impression materials. These results suggest that hydrophilic addition-type silicone rubber impression materials can be stored in air for up to 24 h without any significant dimensional changes.

With regard to the effects of long-term immersion of impressions, it has been reported that the accuracy of hydrophilic addition-type silicone rubber impression materials is adversely affected after 18 h of immersion in 2% glutaraldehyde solution, and also that the mesiodistal and buccolingual dimensions of crown preparation dies are decreased after immersion of the impressions. In the present study of five impression materials, the dimensional changes in the stone casts obtained from GA24H and PA24H were significantly smaller than those of C24H, except for GA24H of ASU. It seems that more accurate stone casts are obtained from the impression materials treated with long-term immersion compared to those from no immersion. However, the decrease in the dimensions of stone casts may be caused by imbibition into the impression materials. The large expansion of impression materials with imbibition may cause the deformation of stone casts.

The type of disinfectant did not affect the dimensional changes in the resulting stone casts for 30-min immersion. For long-term immersion, ASU and EMF impressions at all measurement points, IPII impression at positions II and III, the dimensional changes in PA24H were significantly smaller than those for GA24H. These results might be caused by larger expansion of impression materials due to long-term immersion in ortho-phthalaldehyde solution compared to that of immersion in glutaraldehyde solution, which were resulted from the chemical effects and the low concentration of ortho-phthalaldehyde solution.

In addition, for ASU impression there were no significant differences in dimensional changes of resultant stone casts between C24H and GA24H at position I and II, and dimensional changes in IPII showed no significant differences between GA24H and PA24H at position I. These results suggested that position I, distant from the margin, was not sensitive for the effects of long-term immersion compared to the other positions. The differences of the effects of immersion among position I, II and III may cause the deformation of stone casts.

**CONCLUSION**

Long-term immersion of hydrophilic addition-type silicone rubber impression materials in 2% glutaraldehyde or 0.55% ortho-phthalaldehyde solution affected the dimensional changes in the resulting stone casts, and the effects varied according to the brand of the impression material and the disinfectant solution.
ACKNOWLEDGMENTS
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REFERENCES