Effectiveness of Disinfectants on Antimicrobial and Physical Properties of Dental Impression Materials

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Purpose: The aim of this study was to assess the antimicrobial activity of chemical disinfectants on alginate and silicone impression materials. The effect of chemical disinfectants on the dimensional stability of the impression materials was also assessed. Materials and Methods: For the microbiologic assessment, impressions of the maxillary arch were taken from 14 participants, 7 using alginate and 7 using an addition silicone. The impressions were divided into three sections. Each section was subjected to spraying with MD 520 or Minuten or no disinfection (control), respectively. Antimicrobial action of the chemical disinfectants was assessed by measuring microbial counts in trypticase soy agar (TSA) media and expressing the results in colony-forming units/cm². The surface area of the dental impressions was calculated by scanning a stone cast using computer-aided design/computer-assisted manufacture and analyzing the data using a custom computer program. The dimensional stability of the impression materials after immersion in disinfectants was assessed by measuring the linear displacement of horizontally restrained materials using a traveling microscope. The percent change in length over 3 hours was thus determined. Results: Alginate exhibited a higher microbial count than silicone. MD 520 eliminated all microbes as opposed to Minuten. The bacterial growth after Minuten disinfection was almost twice as much for alginate than for addition silicone impressions. The chemical disinfectants affected the alginate dimensional stability. Minuten reduced the shrinkage sustained by alginate during the first hour of storage. Conclusions: Alginate harbors three times more microorganisms than silicone impression material. Chemical disinfection by glutaraldehyde-based disinfectant was effective in eliminating all microbial forms for both alginate and silicone without modifying the dimensional stability. Alcohol-based disinfectants, however, reduced the alginate shrinkage during the first 90 minutes of setting. The current studies also propose another method to report the surface area based on accurate estimation by 3D image analysis. Int J Prosthodont 2016;29:63–67. doi: 10.11607/ijp.4358

In dentistry, disinfection is of the utmost importance to avoid cross contamination between the laboratory and the clinic and cross infection between dental professionals. Failure to comply with protocols and improper disinfection will result in an unsafe environment.1–5 Staphylococcus aureus, Micrococcus, Pseudomonas, Bacillus, Acinetobacter, Streptococcus, and Candida albicans are common occurrences in patients wearing removable orthodontic or prosthetic dental appliances.6–8 Some of these microorganisms can survive outside the oral cavity and, when not in contact with oral fluids for a long period, can transfer onto the dental models, further exposing dental laboratory personnel.8

The common practice of rinsing dental impressions with running water prior to delivery to the lab removes debris but does not decontaminate the material.9,9 This procedure is inadequate and does not suffice by today’s standards. A more effective approach to disinfection is suggested. Both the British and American Dental Associations stress the importance of chemical disinfection of dental impressions,9,10 as any bacteria left after disinfection can lead to contamination of the gypsum cast.2,3,12
The accuracy of lab-constructed appliances depends on the accuracy of the stone cast, and thus the accuracy of the clinical impression is important. Impression materials undergo dimensional changes during setting, and the use of disinfectants—particularly immersion ones—has also been reported to cause dimensional changes. In fact, aerosol disinfectants are preferred to immersion disinfection although aerosol disinfectants are less effective in eliminating living microorganisms present on the material surface.

The aim of this study was the assessment of antimicrobial activity of chemical disinfectants on alginate and silicone impression materials using in vivo microbial species. The effect of chemical disinfectants on the dimensional stability of the impression materials was also assessed.

Materials and Methods

The following impression materials were used in the study:

- Alginate (Blueprint 20+, Dentsply DeTrey)
- Polyvinylsiloxane (Affinis monobody, Coltene Whaledent)

Antimicrobial and dimensional stability assessments were carried out on both materials before and after the application of two chemical disinfectants. The disinfectants employed included MD 520 disinfectant (Durr Dental) and Minuten (Alpro Medical). Both disinfectants were applied using a spraying technique (Durr Hygojet, Durr Dental) for 10 seconds and left untouched for 10 minutes, followed by rinsing with tap water and air-drying with a stream of dry air.

Antimicrobial Assessments

Impressions with alginate and polyvinyl siloxane were obtained from 14 dentate voluntary participants aged between 20 and 38 years. The participants were advised to avoid food consumption and drink only water for 60 minutes prior to impression taking. They were also advised to avoid tooth brushing. Three impressions of the maxilla were taken from 7 of the participants with each material. The excess impression material, which flowed after placing the weight, was cut off with a fine-edged blade to produce a smooth and discernible surface edge. Each specimen was then placed in a sterile plastic bag containing 30 ml of Ringer’s solution (Oxoid). The samples were then stomached for 120 seconds using a bag mixer lab blender (Interscience) to dislodge attached surface microorganisms. Serial tenfold dilutions were then applied using sterile Ringer’s solution (9 ml). Appropriate diluted samples were plated on a Petri dish with TSA (Oxoid) and incubated at 37°C for 48 hours. Total plate counts were then reported.

Calculation of the Surface Area

An extra impression was taken from each participant during the first visit. This was cast in dental stone, and the resultant dental cast was used for surface area measurement. The casts were divided in the same way as the impression samples, and each of the parts was scanned using a computer-aided design/computer-assisted manufacture (CAD/CAM) machine (inEos Blue Cam, Sirona) using Sirona inLab 3D version 4.2. The 3D images obtained were converted into meshes using Delaunay triangulation and referenced by Illumina script files. The surface area of all the 3D meshes was computed using the area function of the predesigned program. The area function was a summation of the areas of constituent triangles (half the length of the cross product of the two edges). As a result, the surface area was found in μm² and could be converted into cm². The resulting colony-forming units (CFU) per cm² could then be calculated.

Assessment of Dimensional Stability

The materials were mixed and loaded in glass molds, which allowed horizontal restraint, and a 1-kg weight was placed on the surface of the impression material during setting to mimic the clinician’s pressure of tray against oral tissue. The whole assembly was placed in a water bath at 37°C until the end of setting for each material. The excess impression material, which flowed after placing the weight, was cut off with a fine-edged blade to produce a smooth and discernible surface edge. Each specimen was then placed at 90% relative humidity. The height of the specimen before and after spraying with disinfectants was measured using a traveling microscope (Vernier...
Microscope no.12, Instrument no.HB-957; Precision Tool & Instrument).

**Statistical Analysis**

The data were evaluated using SPSS version 18 (SPSS). Parametric tests were performed since Kolmogrov-Smirnov tests on the results indicated that the data were normally distributed. Analysis of variance (ANOVA) with $P = .05$ and Tukey test were used to perform multiple comparisons.

**Results**

**Antimicrobial Assessments**

The surface area for all surfaces used measured about 20 to 25 cm$^2$. The mean number of microorganisms over each material before and after disinfection with MD 520 and Minuten are shown in Table 1. The silicone impression material encouraged significantly less microbial recovery than alginate ($P = 0$). The untreated impression surfaces (control) showed a significantly higher growth than those that were treated with antimicrobial disinfectants. Only a negligible amount of microbial colonies that were below the detection limit could be identified growing on both impression materials treated after MD 520 disinfection ($P = 1$). However, after disinfection with Minuten, microbial presence could still be identified.

There was no significant difference in the microbial recovery on polyvinyl siloxane after disinfection with Minuten compared to MD 520 ($P = .176$). As a result, the microbial levels on silicone impression material after the application of each disinfectant was similar. On the other hand, Minuten was not effective for disinfection of alginate ($P = 0$). The results obtained per subject for alginate and polyvinyl siloxane impression materials are shown in Figs 1a and 1b. When alginate was used, the microbial counts were decreased by approximately half with Minuten on all seven participants (Fig 1a). On the other hand, Minuten was 100% effective in eliminating microbial growth on polyvinyl siloxane impression material (Fig 1b). This could be the result of certain microbes not targeted by the alcohol-based Minuten disinfectant, which will lead to their growth and therefore an increase in log(CFU/cm$^2$).

**Assessment of Dimensional Stability**

The results of the changes in height of horizontally restrained alginate and polyvinyl siloxane are shown in Figs 2a and 2b. The untreated alginate control showed a mean percentage contraction of 0.7% with the maximum contraction reached at 90 minutes, after which the material was stable. The silicone control contracted less ($P < .05$). MD 520 did not cause changes in dimensional stability for alginate or silicone when compared to the control ($P > .05$). Disinfection with Minuten resulted in a reduction of the contraction of alginate after 60 and 90 minutes following exposure to chemical disinfection ($P = .001$ and $P = .003$, respectively).

**Discussion**

The research investigated the antimicrobial activity of two chemical disinfectants on two dental impression...
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Materials. MD 520 is composed of glutaraldehyde and alkyl-benzyl-dimethyl-ammonium chloride, and Minuten is composed primarily of ethanol and also contains iso-propanol, quaternary alkylammonium-propionate, dodecydipropylenetriamine, and chlorine hexidine digluconate. The main concern with the use of Minuten as a surface disinfectant is the potential changes in dimensional stability of the impression materials on contact.

This study was done in vivo to achieve more realistic results for microbial counts. This allowed the disinfection ability of each chemical to be tested in clinically applicable situations. In vitro experiments can result in a different exposure time of the impression material and application of different pressures that may affect the adherence of the microbes to the impression. Samples were taken from participants between the ages of 20 and 38 since the microflora in the oral cavity changes with age. All participants were fully dentate and did not wear orthodontic or prosthetic appliances as this might have affected the surface area of the mouth, the microbial count, and the microbial flora present. The impressions were also taken at a 2-week interval to allow regrowth of the microbial flora.

The surface area of the substrate was calculated using a CAD/CAM imaging camera and a custom-made computer program was developed to measure this surface area. This measurement was necessary to enable calculation of the results in CFU/cm². To date, surface area measurements of a rough surface were calculated by adapting aluminium foil to the cast of the impression material. Its weight was then correlated with the surface area, or the foil was scanned and digitized. Both techniques may lead to high variation between results, considering that foil adaptation on the cast is a manual technique. This variation affects the results obtained for the microbial counts.

The results of the current study are confirmatory with respect to the high microbial counts identified on alginate when compared to silicone impression material and also for the effectiveness of glutaraldehyde as a disinfectant for impression materials. Alcohol-based disinfectants are less popular for impression disinfection; however, total disinfection was reported after 10 minutes of contact time. In contrast, other studies demonstrated a limited spectrum of effectiveness that improved with time. In the current study, an increase in contact time might have successfully eliminated more microbes. The effect of contact time on antimicrobial effectiveness and any changes in the properties of the impression materials needs to be investigated further.

The use of a traveling microscope to assess dimensional stability of impression materials has been reported previously. In these studies, reference points were used to enable measurement of the dimensional changes, rather than a horizontally restrained specimen of the same dimensions for all the materials tested as in the present study. The horizontal restraint allowed only vertical movement, thus facilitating the measurements.

Alginate is reported to contract when left untreated and when sprayed with glutaraldehyde-based disinfectants. The contraction sustained by alginate was reduced when the material was sprayed with Minuten. It is postulated that Minuten, which is alcohol-based, displaced the water molecules from the alginate surface, thus reducing water evaporation from the materials, resulting in reduced material shrinkage.

Alcohols are not ideal impression disinfectants. Their action depends on surface friction, thus the clinician needs to apply mechanical friction during disinfection. Alcohol-based disinfectants are thus mostly employed for surface disinfection. Minuten exhibited
reduced antimicrobial activity on alginate impressions, suggesting that its disinfection effect is limited.

Taking into consideration the results of the current study, silicone impression materials can be disinfected effectively with both glutaraldehyde and alcohol-based disinfectants. Glutaraldehyde-based disinfectants are more efficient with alginate, but when dimensional stability is important an alcohol-based disinfectant may be considered.

Conclusions

Alginate harbors three times more microbes than silicone impression material. Additionally, glutaraldehyde is more effective than alcohol-based chemical disinfectants, particularly when alginate is used as impression material. The dimensional stability of alginate and silicone was not affected by glutaraldehyde-based disinfectants. Alcohol-based disinfectants, however, reduced alginate shrinkage during the first 90 minutes of setting.

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References