Comparative evaluation of accuracy and surface roughness of two different elastomeric impression materials before and after autoclaving an in vitro study

Kommala Sowjanya Devi*, Hanuman Chalapathi Kumar, Srinivasa Rao Pottem, Pesaragayala Sneha

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Abstract

Aim of the Study: The purpose of the study was to determine the effect of autoclaving on the dimensional accuracy and surface roughness of two different elastomeric impression materials. Materials and Methods: A standardized stainless steel master die, as per ADA specification number 19, was fabricated. The impression materials used for the study were VPS (group A), VPES (group B); each group divided into two subgroups. A total of 40 samples of the stainless steel die were made (n = 40), 20 samples of each group subgroup A (VPS without autoclave n=10) and subgroup A1 (VPS with autoclave n=10), and subgroup B (VPES without autoclave n=10) and subgroup B1 (VPES with autoclave n=10). Impression materials were mixed according to the manufacturer’s instructions and then loaded into the mold to make an impression of the die. Measurements were made using stereomicroscope (MAGNUS MSZ-Bi) of 0.65x magnification and spirometer. The results were subjected to statistical analysis using student t test and paired t test for comparison between the groups. Results: Using paired t test and independent t test, statistically significant changes were observed for two impression materials before and after autoclaving. Conclusion: Within the limitation of this study, autoclaving was one of the most effective sterilization procedures and did not significantly affect the surface roughness and dimensional accuracy of both VPS and VPES impression material. Key words: Elastomeric impression material, Surface roughness, Autoclave, sterilization, VPS, VPES, PE

Introduction

Dental impression is a negative imprint of orofacial structures. It is usually the first step during the fabrication of indirect restorations that have to be seated in or on the prepared teeth.1 An exact impression is dependent on the proper technique and optimal impression material characteristics. Clinically elastic impression materials can be divided into two large groups 1) hydrocolloid impression materials that include agar-agar and alginate impression materials; 2) synthetic elastomeric impression materials that include polyether, polysulfide, condensation silicone, addition silicone, and vinyl polyether hybrids.2 In the past, impressions were made using reversible hydrocolloid (agar-agar) and irreversible hydrocolloid (alginate) impression materials. Agar is capable of reproducing good surface detail, but the disadvantages are having a poor tear resistance, cannot be electroplated, and is dimensionally unstable due to syneresis and imbibition. Alginate impression material is more economical and easy to use, but it is poor in dimensional stability and surface detail reproduction.3 Poly ether impression materials were introduced in the late 1960s. This material was the first elastomer to be developed primarily to function as an impression material. All the other materials were adapted from other uses.

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These are relatively rigid and therefore difficult to remove from the mouth, especially from undercuts, and cause allergic reactions due to sulphuric acid ester.

Polyvinyl siloxane impression materials were introduced in 1970s. Polyvinyl siloxane impression materials exhibit superior dimensional stability and surface detail reproduction with low polymerization shrinkage and creep, when compared to the other impression materials, as these materials do not yield any by-products. Although polyvinyl siloxanes meet many of the criteria for an ideal impression material, its greatest drawback is its hydrophobicity. This hydrophobicity is because of its chemical structure, which contains hydrophobic and aliphatic hydrocarbon groups surrounding the siloxane bond. To overcome this limitation, cosmetic grade intrinsic surfactants (nonylphenoxypolyethanol homologues) are incorporated and marketed as hydrophilic VPS. These hydrophilic VPS impression materials have exhibited an increased wettability of the polymerized impression with gypsum slurries.

The newest class of impression material is the vinyl-polyether hybrids introduced in the year 2009, which combine properties from an addition of silicone and polyether impression materials. It contains a polymer with polyether and siloxane (e., addition silicone) groups that will combine elements and benefits of both impression materials. These hybrid materials may represent the blend of hydrophilicity and hydrophobicity necessary to improve impression making by wetting the tooth well and easy pouring for cast fabrication. Enhancement of hydrophilicity may influence the accuracy of impressions and can result in improved flow and a finer detail of impressions made on moist dental surfaces and in the area of the gingival sulcus.

Set impressions are a source of reservoir for pathogens which contain microorganisms – bacteria, fungi and viruses – following their removal from the patient’s mouth. These microorganisms are transmitted into plaster and stone while models are poured. These models represent a risk of disease transmission to dental healthcare workers, transporting personnel, and laboratory personnel through indirect contact.

Therefore, an appropriate infection control protocol must be followed before, during, and after impression making to avoid cross-contamination and the risk of disease transmission. As a part of the infection control, impressions have to be rinsed thoroughly with water or disinfected or sterilized before handled in a dental lab. Any surface defects or irregularities in the impression may result in an irregular and ill-fitting prosthesis. Furthermore, surface roughness (Ra) on the tissue surface of the prosthesis may affect the fit and acceptance of the prosthesis. Surface defects or irregularities may be caused by the use of an improper technique, and are most commonly the result of changes in the material’s properties during the procedure. Autoclaving is considered to be the most effective method of sterilization. However, the accuracy of different elastomeric impression materials before and after autoclaving have not been extensively studied. The purpose of this study was to determine the effect of autoclaving on the dimensional accuracy and surface roughness of different elastomeric impression materials.

Materials and Methods

The impression materials used for the study were VPS (Dentsply/Caulk, Milford, DE) and VPES (GC America Inc, Illinois, USA) light body consistency. These two impression materials were named as group A and group B, respectively. Each group was again divided into two subgroups, subgroup A (VPS without autoclave) and subgroup A1 (VPS with autoclave), subgroup B (VPES without autoclave) and subgroup B1 (VPES with autoclave).

Figure 1: Custom made metal die

Standardized stainless steel master die as per ADA specification number 19 was fabricated (figure 1). The master die consists of a ruled block and a mold ring with dimensions of 31 mm height and 38 mm.
width (ruled block). A 3 mm height and 29.97 mm diameter step has been made on the sides of the die to which the metal mold ring fits. The die consists of three parallel lines inscribed on the surface of the die named as X, Y, and Z. The dimensions of the mold ring are 98 mm (outer ring), 30 mm (inner ring), and 6 mm (height), which fits around the borders as a mold for the impression material.

The distance between the three parallel lines is measured in the microscope at four specific points referred to as C, D (control group) and C’, D’ (testing group) which was approximately 5 mm. A total of 40 specimens were obtained on the stainless steel die (n=40), which were divided into two groups of 20 for each material. A stainless steel ring was to be used to hold the impression on die.

The impression material was mixed according to the manufacturer’s instructions and loaded into the mold to make an impression of the die (figure 2). After that, the impression material was immediately covered by a thin polyethylene sheet followed by a flat glass plate being placed on top of the mold to keep the material within the mold. To avoid any displacement of the material, 500 gm weight was placed on top of the flat glass plate (figure 3).

To compensate for the polymerization of the material at room temperature rather than at mouth temperature, the impressions were allowed to set for twice the manufacturer’s recommended setting time.

The impression was then recovered from the mold, and a numeric coding system (1-10) was used to identify the samples. In each group, half of the impressions (VPS =10) (figure 4) and (VPES =10) (figure 5) samples were packed in 57x130 mm self-sealing sterilization pouches, and were steam sterilized in an autoclave at 134°C and 20 psi for 20 min (figure 6).
The distance between the cross lines CD and C’D’ were measured in the die, and the measurement was recorded.

![Stereomicroscope](image)

**Figure 7: Stereomicroscope**

Distance between the cross lines CD and C’D’ reproduced in the impression were measured before and after autoclaving.

The accuracy was measured using stereomicroscope (MAGNUSMSZBi) of 0.65x magnification (figure 7), and the surface roughness was measured using spirometer.(figure 8).

![Spirometer](image)

**Figure 8: Spirometer**

**Results**

Dimensional accuracy and surface roughness was compared before autoclaving and after autoclaving in two groups. The average surface roughness (Ra) mean value for group A (VPS), in subgroup A (without autoclave) was 12.30, in subgroup A1 (with autoclave) was 12.40. The mean difference was 0.10%. Paired t test was applied for an intra group comparison. The p value was <0.014. A significant difference was found between subgroup A, subgroup A1(table 1, graph 1).

The average surface roughness (Ra) mean value for group B (VPES), in subgroup B (without autoclaving) was 12.69, in subgroup B1 (with autoclave) was 12.82, the mean difference was 0.13%. The p value was <0.008. A statistically significant difference was found between subgroup B and subgroup B1 (table 2, graph 2). Independent sample t test was applied for an inter group comparison.

**Table 1:** Intra-group comparisons between vinyl poly siloxane (VPS), subgroup A and subgroup A1 in Ra(µm), Rz(µm) and Rq(µm)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sub groups</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>% of mean change</th>
<th>t value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ra (µm)</td>
<td>A</td>
<td>12.30</td>
<td>0.32</td>
<td>0.10</td>
<td>0.81</td>
<td>101.000</td>
<td>&lt;0.001</td>
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<td></td>
<td>A1</td>
<td>12.40</td>
<td>0.32</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rz (µm)</td>
<td>A</td>
<td>61.30</td>
<td>1.59</td>
<td>0.50</td>
<td>0.82</td>
<td>123.131</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>A1</td>
<td>61.80</td>
<td>1.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rq (µm)</td>
<td>A</td>
<td>15.99</td>
<td>0.41</td>
<td>0.13</td>
<td>0.81</td>
<td>99.000</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>A1</td>
<td>16.12</td>
<td>0.42</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Statistical Analysis: Paired t test. Statistically significant if P<0.05

**COMPARISON BETWEEN SUBGROUP A & SUBGROUP A1**

![Graph 1: Comparison between subgroup A and A1](image1)

**Table 2**: Intra-group comparisons in VPES between Before and Autoclaving after in Ra(µm), Rz(µm) and Rq(µm)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Subgroups</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>% of mean change</th>
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</thead>
<tbody>
<tr>
<td>Ra(µm)</td>
<td>B</td>
<td>12.69</td>
<td>0.32</td>
<td>0.13</td>
<td>1.02</td>
<td>4.902</td>
<td>0.001 S</td>
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<td></td>
<td>B1</td>
<td>12.82</td>
<td>0.30</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Rz(µm)</td>
<td>B</td>
<td>63.21</td>
<td>1.57</td>
<td>0.07</td>
<td>0.11</td>
<td>0.147</td>
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<td></td>
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<tr>
<td>Rq(µm)</td>
<td>B</td>
<td>16.49</td>
<td>0.41</td>
<td>0.16</td>
<td>0.97</td>
<td>5.050</td>
<td>0.001 S</td>
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<tr>
<td></td>
<td>B1</td>
<td>16.65</td>
<td>0.39</td>
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Statistical Analysis: Paired t test. Statistically significant if P<0.05

**Comparison between subgroup B and subgroup B1**

![Graph 2: Comparison between subgroup B and B1](image2)

**Table 3:** Inter group comparison between Before Autoclaving VPS and Before Autoclaving VPES

<table>
<thead>
<tr>
<th>Variables</th>
<th>Subgroups</th>
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<th>SD</th>
<th>Mean difference</th>
<th>t value</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>Ra(µm)</td>
<td>A</td>
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<td>0.39</td>
<td>2.712</td>
<td>0.014 S</td>
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<td></td>
<td>B</td>
<td>12.69</td>
<td>0.32</td>
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</tr>
<tr>
<td>Rz(µm)</td>
<td>A</td>
<td>61.30</td>
<td>1.59</td>
<td>1.91</td>
<td>2.697</td>
<td>0.015 S</td>
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<td>B</td>
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<td>1.57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rq(µm)</td>
<td>A</td>
<td>15.99</td>
<td>0.41</td>
<td>0.50</td>
<td>2.710</td>
<td>0.014 S</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>16.49</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Statistical Analysis: Independent sample t test. Statistically significant if P<0.05

**Graph 3:** Inter group comparison between Before Autoclaving VPS and Before Autoclaving VPES

**Table 4:** Inter group comparison between After Autoclaving Addition silicon and After Autoclaving VPES

<table>
<thead>
<tr>
<th>Variables</th>
<th>Subgroups</th>
<th>Mean</th>
<th>SD</th>
<th>Mean difference</th>
<th>t value</th>
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<tbody>
<tr>
<td>Ra(µm)</td>
<td>A1</td>
<td>12.40</td>
<td>0.32</td>
<td>0.42</td>
<td>2.984</td>
<td>0.008 S</td>
</tr>
<tr>
<td></td>
<td>B1</td>
<td>12.82</td>
<td>0.30</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Rz(µm)</td>
<td>A1</td>
<td>61.80</td>
<td>1.60</td>
<td>1.48</td>
<td>2.165</td>
<td>0.044 S</td>
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<td>B1</td>
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</tr>
<tr>
<td>Rq(µm)</td>
<td>A1</td>
<td>16.12</td>
<td>0.42</td>
<td>0.53</td>
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<td>0.008 S</td>
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<td>B1</td>
<td>16.65</td>
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</table>

Statistical Analysis: Independent sample t test. Statistically significant if P<0.05
The average surface roughness (Ra) between subgroup A (VPS without autoclave) was 12.30 and subgroup B (VPES without autoclave) was 12.69. The mean difference was 0.13% and the p value was 0.014. There was a statistical significant difference present (table 3, graph 3).

In subgroup A1 (VPS with autoclaving) and subgroup B1 (VPES with autoclaving), average surface roughness values were 12.40 and 12.82, respectively. The mean difference was 0.42, the p value was 0.008. Therefore, a significant difference was found (table 4, graph 4).

In subgroup A (VPS without autoclave) and subgroup A1 (VPS with autoclave) the mean dimensional change was 0.82%. There was a significant difference observed, whereas in subgroup B (VPES without autoclave) and subgroup B1 (VPES with autoclave), there was a mean dimensional change of 0.11%. There is no statistical significant difference found. The mean dimensional change was increased in group A when compared to group B.

Discussion
Accurate reproduction of surface details of the oral structure is essential for a proper restoration. Elastomeric impression materials may exhibit dimensional instability due to polymerization shrinkage, release of bye products due to chemical reactions, thermal changes or an incomplete elastic recovery from deformation.13 In the present study, in both impression materials a light body consistency was used. According to Robert et al., light body showed a high level of accuracy and precision.14 Saliva and blood contaminated impressions are often the source of contamination between the clinic and the dental lab personnel. As part of infection control protocol, proper handling of dental impressions must exist among the office staff as well as between office and dental laboratories. Sterilization results in the destruction of all forms of microbial life, whereas disinfection results in the destruction of specific pathogenic microorganisms.15 Sterilization is best achieved by physical methods such as autoclaving, which is less time consuming and more reliable than chemical disinfection. Autoclave at a high temperature is necessary to kill microbes and their spores. This study evaluates and compares the accuracy and surface roughness of elastomeric impressions before and after autoclaving at 121°C for 20 minutes. Corso et al. suggested that the effect of temperature changes on the dimensional stability of polyvinyl siloxane, with a mean dimensional change of 1 to 18µm.16 Polyvinyl siloxane impression materials are the most commonly used impression materials because of their superior surface detail reproduction and long-term dimensional stability. However, they may undergo chemical deterioration when exposed to high temperatures. Based on the results, a significant difference was observed in the (Ra)
surface roughness of subgroup A and subgroup A1. Petrie CS reported that the surface detail of the VPS impression material was affected under moist and wet conditions. Similar results were found in a study conducted by Johnson G H, where he concluded that the PE produced a better surface detail than VPS. A significant difference was observed in the mean dimension changes in group A, between subgroup A and subgroup A1. Shifra L et al., reported that the elastomeric impression materials may exhibit dimensional instability due to polymerization shrinkage, release of by products due to chemical reactions, thermal changes or incomplete elastic recovery from deformation. G P Surendra et al., concluded that there was a mean dimensional change immediately after autoclaving, which decreased considerably after 24 hours. This implies that it is desirable to delay the casting of an autoclavable elastomeric impression material by about 24 hours when compared to the other two time intervals, that is before autoclaving and after 24 hours of autoclaving. A significant difference in the Ra (surface roughness) was observed in group B, between subgroup B and subgroup B1. This is because the VPES impression material consists of a co-polymer of divinyl polydimethylsiloxane and dimethylsiloxane, it possesses different surface properties, polyether showed a high degree of wettability, and vinyl polysiloxane is hydrophobic due to its molecular chemistry. The mean dimensional change in group B, between subgroup B and subgroup B1, no statistically significant difference was found. These results coincide with a study conducted by Aiman Khan et al. According to their study, the VPES impression material remained dimensionally stable before and after autoclaving.

In our study, based on the results in Table 3, a significant difference in the Ra was observed between the subgroup A (VPS without autoclave) and subgroup B (VPES without autoclave). The VPES impression material showed more surface roughness than the VPS impression material. This difference can be explained by the variation in the colour and chemical composition of the material as well as the amount, size, and shape of the filler particles, which varies among the manufacturers, since a higher filler concentration increases the surface roughness. This finding was in agreement with the results of Goiato et al., who found that MDX 4-4210 had higher surface roughness values than Silastic 732 RTV because of its higher filler concentration.

In table 4, a significant difference was observed in subgroup A1 (VPS with autoclave) and subgroup B1 (VPES with autoclave). The surface roughness increased in the VPES impression material after autoclaving. This result was consistent with the study of Ramakrishnaiah et al., in which the polyvinyl siloxane showed a contraction after autoclave sterilization. According to their study, the shrinkage was attributed to the loss of chemical constituents from the elastomers when subjected to a high temperature of autoclave, which may cause improper surface detail reproduction. Al Kheraif AA reported that the difference in surface roughness resulted from the colour of the impression material, where darker impression materials had higher roughness values when tested using noncontact optical profilometry. The putty and light-body impressions were also found to have statistically significant higher roughness values than the heavy- and medium-body materials.

**Conclusion**

Within the limitation of this study, autoclaving is considered to be the most effective procedure, and it does not significantly affect the dimensional accuracy and surface roughness of both VPS and VPES impression materials. Autoclaving of the elastomeric impressions (VPS, VPES) can be used to prevent cross-contamination between patients and laboratories.

**References**


4. Idris B, Houston F, Claffey N. Comparison of


