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Original article

Disinfection Effect on Surface Properties of Prosthodontic Polymer Impression Materials: An *In Vitro* Study

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Abstract
This study was conducted to evaluate the surface roughness, shore hardness, and dimensional accuracy of commercially obtainable Prosthodontic polymer impression material in terms of imbibition after immersion in two different media and without disinfection. This in vitro study was designed to investigate the surface properties of polymer impression materials before and after disinfection by immersion. Materials with different consistencies (alginate (irreversible hydrocolloid), condensation silicone (putty), and addition silicone (putty) impression materials) were investigated. The tested null hypothesis was the fact that there would be no significant differences in surface properties among these Prosthodontic polymer impression materials. Two disinfecting agents, Zeta 7 solution and ASEPTOPRINT, were used to assess the surface roughness, hardness, and dimensional accuracy of the impression material. The weights of the discs of the Prosthodontic polymer impression material samples were measured before and immediately after immersion to determine if there was a change in the properties of the material. study was conducted at the Advanced Medical Polymer Group in the Libyan Polymer Research Center to evaluate the surface properties of prosthodontic polymer impression materials. Data analysis included mean, standard deviation, and One-way ANOVA calculations. The study showed that the surface properties of dental polymer impression materials were affected by disinfection methods. Specifically, for alginate material, there were significant differences in surface properties between the control group (before immersion) and after immersion in zeta 7 solution and ASEPTOPRINT spray. However, for addition silicone (putty), there was a significant difference in surface properties between the control group and after immersion in zeta 7 solution, while immersion in spray did not show a significant difference. For condensation silicone (putty) material, there were significant differences in surface properties between the control group and after immersion in both zeta 7 solution and ASEPTOPRINT spray. The study concluded that disinfection methods can affect the surface properties of dental polymer impression materials.
Keywords. *Polymer Impression Material, Disinfection, Zeta 7 Solution, ASEPTOPRINT Roughness, Hardness.*

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Introduction

Dental impressions are molds of a patient's teeth and oral structures used in dental procedures like prosthetics and restorations. However, they can become contaminated with microorganisms, potentially transmitting infections. Disinfection is crucial to prevent cross-contamination and ensure patient safety. Various disinfectant materials and techniques are used in dental practices [1].

Disinfection of dental impressions is crucial for a safe, hygienic practice. Understanding the impact of disinfection on surface properties and dimensional stability is essential, as surface roughness refers to irregularities [2].

Roughness, caused by chemical reactions or physical interactions, is surface irregularities during disinfection that can negatively impact the fit, acceptance, and aesthetics of dental prostheses. It can hinder cast accuracy, cause improper fit, or cause patient discomfort [3].

Dimensional accuracy is crucial for accurately capturing oral tissues. Disinfection methods can alter the dimensional stability of the impression, leading to inaccuracies in the resulting cast. This can affect the fit and functionality of the final prosthesis. If the impression material expands or contracts during disinfection, the cast may not accurately represent the patient's oral anatomy [4].

Hardness is the impression material's resistance to indentation or scratching. Maintaining it after disinfection prevents damage during procedures. Absorption of disinfection solutions can decrease

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hardness, making the impression more vulnerable. Soft or pliable impression materials may cause inaccuracies in prosthesis, affecting the accuracy of oral tissue capture [5].
This in vitro study was designed to the investigation of surface properties of Prosthodontic polymer impression materials before and after disinfection by immersion. Materials with different consistencies (alginate (irreversible hydrocolloid), condensation silicone (putty) and addition silicone (putty) impression materials) were investigated. The tested null hypothesis was the fact that there would be no significant differences in surface properties among these Prosthodontic polymer impression materials.

Materials and methods

Material

Prosthodontic polymer impression materials are produced by various companies and come in three forms: alginate (irreversible hydrocolloid), condensation silicone (putty), and addition silicone (putty)

Samples Preparation

These Prosthodontic polymer impression materials were made in three different routes (Alginate, condensation silicone (putty) and addition silicone (putty)) according to the manufacturer's instructions.
One hundred Thirty-five (135) samples were divided into three groups based on their manufacturing techniques: (Alginate (tropical), Zeta plus condensation silicone (putty) (Zhermack indurent gel “catalyst) and addition silicone (putty) (Zhermack Hydrorise Putty (base) and catalyst), Surface properties were tested using roughness, shore hardness, and dimensional accuracy tests. Samples were made with cylinder diameters of 2 x 0.7 mm.

Disinfection Immersion Protocol

Prepared forty-five samples for each test (surface roughness, shore hardness, dimensional accuracy) from several types of Prosthodontic impression material. Each test has three groups (consisting of 5 samples from each material). The study groups were as follows: Immersed in disinfection Zeta 7 solution for 3 minutes and immersed in disinfection ASEPTOPRINT spray for 3 minutes.

Testing procedure

Surface roughness test

The Surface Roughness Test (SR) was conducted using a Surface Roughness Meter (STR-6210). The stylus moved across the specimen's surface, converting it into electrical signals. Three measurements were taken for each specimen, and mean average values were used for statistical analysis. Five readings were taken on different surfaces, and the mean was calculated.

Shore hardness test

Shore Hardening A was used to measure surface hardness, with an indenter attached to a digital scale. The indenter was pressed down firmly and recorded, and the Shore A hardness measurement was taken directly from the scale. The results were averaged for each sample out of 15 for alginate, condensation silicone, and addition silicone. Measurements were taken from different batches using a Durometer, and the test was conducted at room temperature. Five replicates were tested for each sample, and the average hardness was calculated using the formula:

Average Hardness = 1St+2Nd +3Rd+4Fr+5Fif / 5(Shores).

Dimensional accuracy test

Samples were constructed, initial weight measured using an electronic balance (OHAUS, PIONEER), then weighed for zero-hour, one hour, and 24 hours after immersion. then all samples were kept in a tissue moistened with distilled water at room temperature. Change in percentage weight for each specimen calculated.

Statistical Analysis

The study employs parametric tests like ANOVA to analyze the influence of an independent variable on selected dependable variables, a one-way analysis of variance similar to the t-test, and the Siegel-Tukey test to determine if one group of data has more widely dispersed values.

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Results

The study found that Prosthodontic polymer impression materials showed significant differences in surface roughness values before and after immersion in Zeta 7 solution disinfectant, but no significant difference after immersion in ASEPTOPRINT spray disinfectant.

The mean values and standard deviation of the impact of disinfectant levels on surface roughness in Prosthodontic polymer impression materials, comparing alginate, condensation silicone (putty) and addition silicone (putty). Results showed no significant difference in values at the p <.05 level, but post-hoc comparisons showed a significant difference in deviation scores for different impression materials alginate, condensation silicone (putty) and addition silicone (putty) impression material before immersion F (2, 12) = 4.975, p = 0.027, After immersion in Zeta 7 solution F (2, 12) = 3.737, p = 0.055, and After immersion in ASEPTOPRINT spray disinfectant F (2, 12) = 18.020, p = 0.000, compared different Prosthodontic polymer impression materials.

Figure (1) shows the mean and standard deviation of the addition silicone (putty) material has higher surface roughness compared to alginate and condensation silicone (putty), and the maximum dimensional accuracy zero hour after immersion in ASEPTOPRINT spray disinfectant (maximum mean = 3.35) is still higher than before immersion.

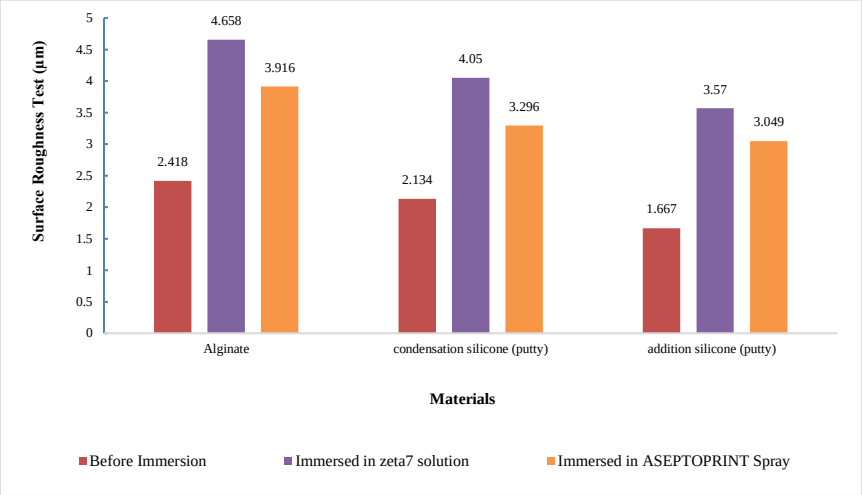

Figure 1. Line graph showing One-way ANOVA comparison of Surface Roughness Test (µm) of the tested disinfection polymer impression materials

The study found that the shore hardness values of Prosthodontic polymer impression materials varied significantly before and after immersion in Zeta 7 solution disinfectant, but no significant difference was observed after immersion in ASEPTOPRINT spray disinfectant.

The mean values and standard deviation of the impact of disinfectant levels on shore hardness in Prosthodontic polymer impression materials, comparing alginate, condensation silicone (putty), and addition silicone (putty).

Results showed no significant difference in values at the p <.05 level, but post-hoc comparisons showed a significant difference in deviation scores for different impression materials: alginate, condensation silicone (putty) and addition silicone (putty). impression material before immersion F (2, 12) = 95.966, p = 0.000, After immersion in Zeta 7 solution F (2, 12) = 158.265, p = 0.000, and After immersion in ASEPTOPRINT spray disinfectant F (2, 12) = 140.936, p = 0.000, compared different Prosthodontic polymer impression materials.

Figure (2) shows the mean and standard deviation of the addition silicone (putty) material has higher shore hardness compared to alginate and condensation silicone (putty), and the maximum dimensional accuracy zero hour after immersion in ASEPTOPRINT spray disinfectant (maximum mean = 7.36) is still higher than before immersion.

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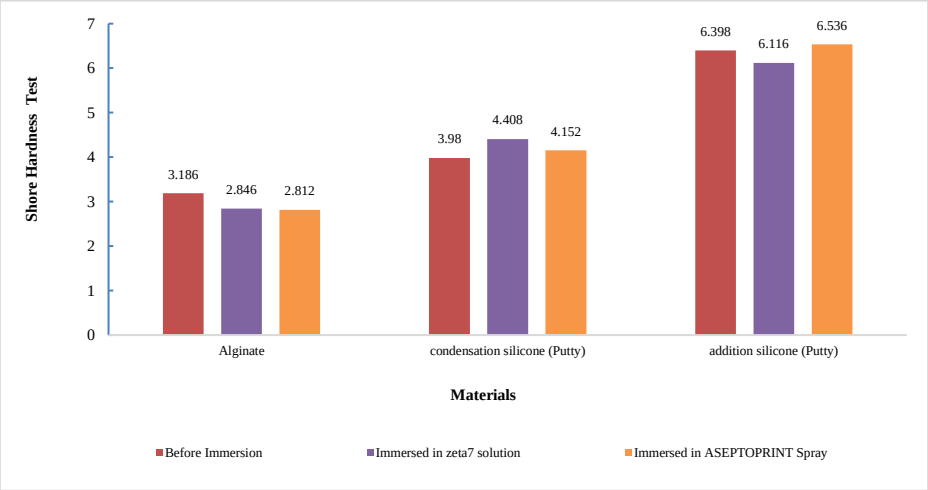

Figure 2. Line graph showing One-way ANOVA comparison of Shore Hardness Test of the tested disinfection polymer impression materials

The study found significant differences in dimensional accuracy at zero hour, after 1 hour, and after 24 hours values of Prosthodontic polymer impression materials samples before and after immersion in Zeta 7 solution disinfectant, but no significant difference after immersion in ASEPTOPRINT spray disinfectant.
The mean values and standard deviation of the impact of disinfectant levels on dimensional accuracy at zero hour in dental polymer impression materials, comparing alginate, condensation silicone (putty) and addition silicone (putty). Results showed no significant difference in values at the $p < .05$ level, but post-hoc comparisons showed a significant difference in deviation scores for different impression materials alginate, condensation silicone (putty) and addition silicone (putty) impression material before immersion $F(2, 12) = 24.431$, $p = 0.000$, After immersion in Zeta 7 solution $F(2, 12) = 4.752$, $p = 0.030$, and After immersion in ASEPTOPRINT spray disinfectant $F(2, 12) = 2.502$, $p = 0.123$, compared different Prosthodontic polymer impression materials.
During for a show the mean values and standard deviation of the impact of disinfectant levels on dimensional accuracy after 1 hour in Prosthodontic polymer impression materials, comparing alginate, putty, and silicone. Results showed no significant difference in values at the $p < .05$ level, but post-hoc comparisons showed a significant difference in deviation scores for different impression materials alginate, condensation silicone (putty) and addition silicone (putty) impression material before immersion $F(2, 12) = 56.723$, $p = 0.000$, After immersion in Zeta 7 solution $F(2, 12) = 31.821$, $p = 0.000$, and After immersion in ASEPTOPRINT spray disinfectant $F(2, 12) = 29.377$, $p = 0.000$, compared different Prosthodontic polymer impression materials.
During for a show the mean values and standard deviation of the impact of disinfectant levels on dimensional accuracy after 24 hours in Prosthodontic polymer impression materials, comparing alginate, putty, and silicone. Results showed no significant difference in values at the $p < .05$ level, but post-hoc comparisons showed a significant difference in deviation scores for different impression materials alginate, condensation silicone (putty) and addition silicone (putty) impression material before immersion $F(2, 12) = 15.855$, $p = 0.000$, After immersion in Zeta 7 solution $F(2, 12) = 12.261$, $p = 0.001$, and After immersion in ASEPTOPRINT spray disinfectant $F(2, 12) = 6.547$, $p = 0.012$, compared different Prosthodontic polymer impression materials.
Figure (3, a) shows the mean and standard deviation of the Addition silicone (putty) material has higher dimensional accuracy zero hour compared to alginate and condensation silicone (putty), and the maximum dimensional accuracy zero hour after immersion in ASEPTOPRINT spray disinfectant (maximum mean = 3.77) is still higher than before immersion.
Figure (3, b) shows the mean and standard deviation of the addition silicone (putty) material has higher dimensional accuracy 1 hour compared to alginate and condensation silicone (putty), and the maximum dimensional accuracy 1 hour after immersion in ASEPTOPRINT spray disinfectant (maximum mean = 3.70) is still higher than before immersion.
Figure (3, c) shows the mean and standard deviation of the addition silicone (putty) material has higher dimensional accuracy 24 hour compared to alginate and condensation silicone (putty), and the maximum dimensional accuracy 24 hour after immersion in ASEPTOPRINT spray disinfectant (maximum mean = 3.51) is still higher than before immersion.

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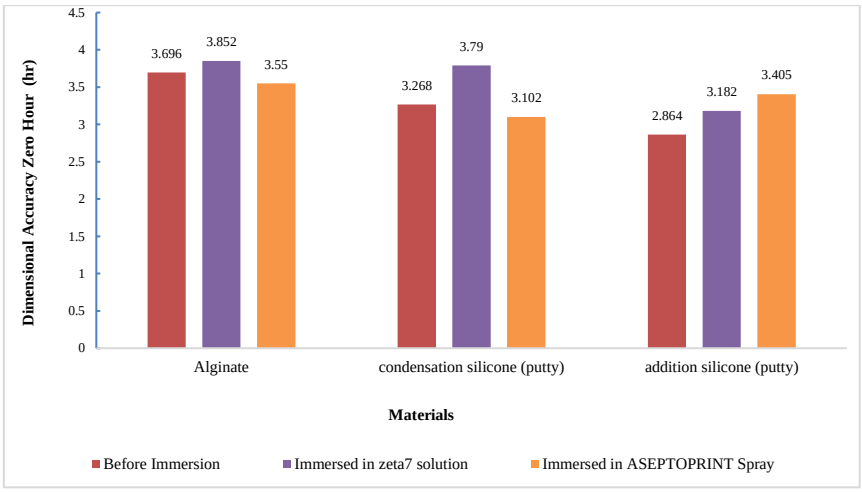

Figure 3a. Line graph showing One-way ANOVA comparison of Dimensional Accuracy at Zero Hour (hr) Test of the tested disinfection polymer impression materials

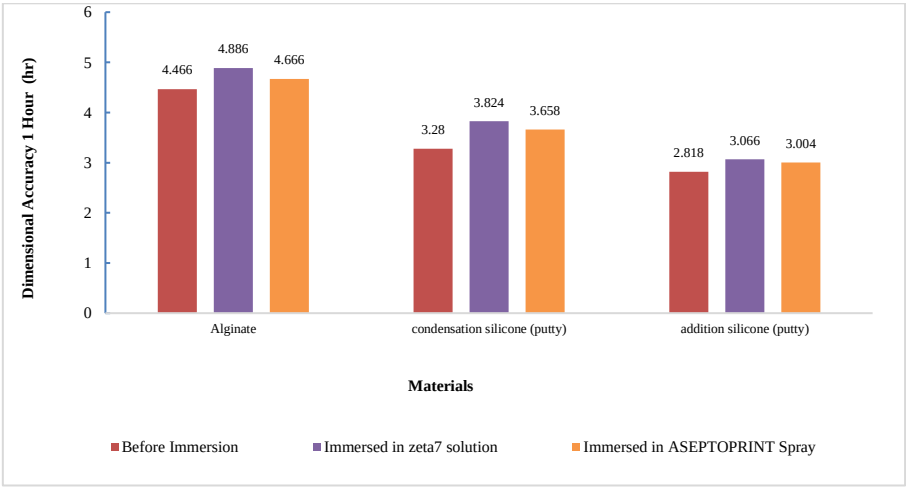

Figure 3b. Line graph showing One-way ANOVA comparison of Dimensional Accuracy after 1 Hour (hr) Test of the tested disinfection polymer impression materials

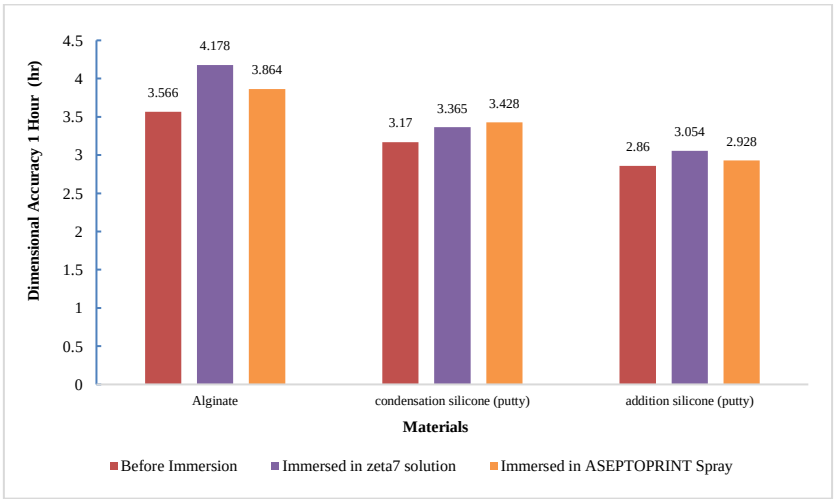

Figure 3c. Line graph showing One-way ANOVA comparison of Dimensional Accuracy after 24 Hours (hr) Test of the tested disinfection polymer impression materials.

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Discussion

In the current study, the researchers aimed to compare the surface properties of different polymer impression materials before and after disinfection using zeta7 solution and ASEPTOPRINT spray. They also evaluated the dimensional accuracy of the materials after disinfection. The null hypothesis for all tests was that there would be no significant differences in surface properties or dimensional accuracy among the Prosthodontic polymer impression materials.

Alginate, an irreversible hydrocolloid, is a cost-effective and easy-to-use impression material used for creating diagnostic models, temporary restorations, and orthodontic appliances. Its hydrophilic nature allows it to absorb water, but it can undergo dimensional changes if not handled properly. Dentists must disinfect alginate impressions to prevent distortion [6].

In contrast, for the alginate material, the results indicated a significant difference in surface properties after immersion in zeta7 solution, but not after immersion in ASEPTOPRINT spray. This is consistent with the findings of the previous study by Iwasaki et al (2016), which showed that immersion of agar-alginate combined impressions in sodium hypochlorite caused deterioration of the cast surface properties [7].

Putty impression materials, also known as silicone putties or addition silicone putties, are used for preliminary impressions due to their medium to high viscosity and good flow properties. They are easy to handle, set quickly, and provide good dimensional stability, ensuring impressions retain their shape over time. However, they may have slightly less detail reproduction compared to other impression materials [8].

For the condensation silicone (putty) material, significant differences in surface properties were observed after immersion in both zeta7 solution and ASEPTOPRINT spray. This is consistent with the results of the previous study by Wezgowiec et al (2022), which found that both traditional and alternative methods of disinfection had a significant impact on the hardness of silicones [9].

For the addition silicone (putty) material, the results showed no significant differences in surface properties between the control group (before immersion) and after immersion in zeta7 solution or ASEPTOPRINT spray. The same was observed for the dimensional accuracy test. These results are consistent with the previous study by Hummudi Mansoor (2022), which found no significant effects on dimensional accuracy and surface roughness of alginate impression material after disinfection with ethanol [10].

Overall, the results of the current study were consistent with previous research in some aspects, such as the effect of ethanol disinfection on alginate material and the impact of disinfection on addition silicone (putty) hardness. However, there were some discrepancies, particularly in the results of the dimensional accuracy test, which may be attributed to differences in the methodology and materials used in the different studies.

Conclusion

Based on these findings, the study concludes that disinfection methods can affect the surface properties of Prosthodontic polymer impression materials. Alginate and condensation silicone (putty) materials showed significant differences in surface properties after immersion in disinfecting solutions, while addition silicone (putty) materials did not show significant differences. The dimensional accuracy of the impression materials was not significantly affected by the disinfection methods. Therefore, the null hypothesis that there would be no significant differences in surface properties among these impression materials is partially rejected, as some materials showed significant differences in surface properties after disinfection. Dentists should consider the effects of disinfection on impression materials when selecting the appropriate disinfection method for their dental practice

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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المستخلص

أُجريت هذه الدراسة لتقييم خشونة السطح، والصلابة، ودقة أبعاد مواد الطباعة البوليمرية المتوفرة تجاريًا، وذالك من حيث الامتصاص بعد الغمر في وسطين مختلفين ودون تعقيم. صُممت هذه الدراسة المختبرية لدراسة خصائص أسطح مواد الطبعات البوليمرية قبل وبعد التعقيم بالغمر. تم فحص مواد ذات قوام مختلف (الالجينت (غرواني مائي غير قابل للانعكاس)، وسيليكون التكثيف (معجون)، ومواد طباعة سيليكون إضافية (معجون). كانت الفرضية الصفرية التي تم اختبارها هي عدم وجود فروق جوهرية في خصائص الأسطح بين مواد الطبعات البوليمرية. هنا ثم استُخدام عاملان مطهران، هما محلول زيتا 7 ومادة أسيبتوبرينت، لتقييم خشونة السطح، وصلابة السطح، ودقة أبعاد مادة الطباعة. تم قياس أوزان أقراص عينات مواد الطبعات البوليمرية قبل الغمر وبعده مباشرةً لتحديد ما إذا كان هناك تغيير في خصائص المادة. أُجريت دراسة في مجموعة البوليمرات الطبية المتقدمة بالمركز الليبي لأبحاث البوليمرات لتقييم خصائص أسطح مواد الطبعات البوليمر التعويضية. وتضمن تحليل البيانات المتوسط والانحراف المعياري وحسابات تحليل التباين أحادي الاتجاه. وأظهرت الدراسة أن خصائص أسطح مواد طباعة البوليمر السنية تتأثر بطرق التطهير. وتحديدًا، بالنسبة لمادة الألجينات، وُجدت فروق ذات دلالة إحصائية في خصائص السطح بين المجموعة الضابطة (قبل الغمر) وبعد الغمر في محلول زيتا 7 ورذاذ أسيبتوبرينت. أما بالنسبة لمادة السيليكون الإضافي (المعجون)، فقد وُجد فرق ذو دلالة إحصائية في خصائص السطح بين المجموعة الضابطة وبعد الغمر في محلول زيتا 7، بينما لم يُظهر الغمر في الرذاذ فرقًا ذا دلالة إحصائية. أما بالنسبة لمادة السيليكون المكثف (المعجون)، فقد وُجدت فروق ذات دلالة إحصائية في خصائص السطح بين المجموعة الضابطة وبعد الغمر في كل من محلول زيتا 7 ورذاذ أسيبتوبرينت. وخلصت الدراسة إلى أن طرق التطهير يمكن أن تؤثر على خصائص أسطح مواد طباعة البوليمر السنية.