

IMPERFECTIONS IN PLASTER SURFACES CAUSED BY THE RELEASE OF HYDROGEN GAS OF POLYVINYLSILOXANE IMPRESSION MATERIALS

ABSTRACT

PURPOSE: The purpose of this study was to evaluate the number of bubbles of hydrogen liberation from different polyvinylsiloxane impression materials. **MATERIAL AND METHODS:** A metallic stainless steel jig containing six receptacles, like trays, was constructed to accommodate the impression materials. The molds were poured immediately, and at 1 hour, 12 hours and 24 hours in order to evaluate the number of bubbles present in each sample. Each sample was made of improved stone (type IV), totaling 48 samples for each polyvinylsiloxane impression material. After setting, the surface of each sample was inspected under a light microscope at 40x magnification and the number of bubbles was recorded. Results were submitted to statistical analysis by ANOVA and Tukey Test ($p=.05$). **RESULTS:** ANOVA test showed statistically significant differences among the polyvinylsiloxane impression materials, as determined by the number of bubbles ($p<.05$). The Tukey test showed statistically significant differences among the three groups ($p<.05$). **CONCLUSIONS:** Statistical differences were found between addition silicone with regard to the ideal time to wait for the plaster cast, showing that Aquasil results in fewer bubbles in plaster, followed by the President and Simply Perfect samples.

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INTRODUCTION

The clinical success of a dental prosthesis depends largely on the accuracy of the materials and molding techniques. The surface properties of molding materials have an important role in the accurate reproduction of oral structures, which is a prerequisite for high-quality prostheses. Due to its excellent dimensional stability, good work time, and elastic recovery, the polyvinylsiloxane impression material gained popularity among dentists¹⁻⁴ The main problem, in relation to the use of these materials, is the presence of bubbles in the plaster models after the casting of the mold.⁵⁻⁶ These bubbles, when located in critical areas of the preparation, such as margins and retentive grooves, make the plaster models unsuitable for the desired application.

The formation of bubbles in the plaster models has been related to the low wettability of the molding material prior to plaster application⁷⁻⁸ or to solutions of calcium sulfate (gypsum) that is related with the wettability of the material, since some.⁹⁻¹⁰ To overcome this shortcoming, the inclusion of some non-ionic surfactants has significantly increased molding material wettability, reducing the presence of bubbles during the spraying of plaster; however, the same studies comment that bubbles are still present.^{9,11-12} Some studies even describe other factors contributing to the formation of bubbles, such as consistency of

material¹³, type of syringe¹⁴⁻¹⁵, diameter of the tip of the syringe, method of manipulations¹⁶ and polymerization products¹⁷.

The release of byproducts in the reaction of addition seems to be a point of contention in the literature.^{2,18} There is no formation of by-products, provided that the correct proportion of vinyl silicone and hybrid silicone is maintained and there are no impurities. On the other hand, if the appropriate balance is not maintained between the masses or impurities are found during the reaction, there will be production of hydrogen gas, causing bubbles forming pin-points on the surface of the mold. The hydrogen gas will also appear if there is presence of moisture or waste silane groups, which react with the carbohydrates that are present in the base polymer.²

In 1985, Nicholson¹⁷ reported that hydrogen is not a direct product of the polymerization reaction of polyvinylsiloxane impression materials, but it is released during the reaction. Some manufacturers add palladium to absorb the gas and to reduce the amount of bubbles in the plaster model but, in many cases, it is still possible to observe the formation of bubbles even while carefully following the suggestions of the manufacturer, thereby inadvertently increasing the cost of the material.¹⁷

Thus, it seems reasonable to search, among the different brands of

polyvinylsiloxane impression materials, for one with which it is possible to create plaster dies with lower numbers of defects and greater reproducibility. The purpose of this study is to assess the amount of bubbles in plaster dies using different polyvinylsiloxane impression materials, varying the time until casting. The hypothesis of this study was that there were statistically significant differences among the time to casting.

MATERIAL AND METHODS

A device made of stainless steel divided in two parts was constructed for this study, including one upper and one lower part. The sections are complementary, with dimensions of 90 mm height, 125 mm width and 100 mm in length, with the following characteristics: the lower part presents itself with six squares that are 25 mm long, 25 mm wide and 15mm high, for the simulation of preparations; while the upper has units for the simulation of rectangular trays, with 30 mm long, 30 mm wide and 20mm high. Four holes were made at each corner of the device in the vertical direction, where the guide pins guarantee the correct alignment. Along the top and bottom edges of the closed device, there was a space of 5 mm to cushion the force of compression (Figure 1a, 1b e 1c).

The materials used were polyvinylsiloxane impression materials, as shown in Table 1.

The materials were handled in accordance with the manufacturer's recommendations in a room with a controlled environment (temperature $20^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and air humidity of $55\% \pm 10\%$), by the double mixture technique. It was manipulated the heavy material, placing it within the tray, while the lighter material was also manipulated and placed on the heavy material, and the stainless steel device was embedded up to its full closed. After the polymerization of materials, the top was disconnected from the base, thus enabling the achievement of the negative impressions of the areas of relief; the specimens were ready for casting (Figure 2).

Each material was subjected to four treatment conditions (A - immediately, B - 1 hour, C - 12 hours and D - 24 hours), considering the time until casting with plaster type IV (Velmix - Kerr - West Collins Orange - USA). The powder was mixed inside the bottle and sprayed on the liquid in a rubber mortar, with agglutination of the material aided by light stirring with a metallic spatula for 1 minute, attaining a creamy consistency. Small portions of plaster were added on the mold with the help of a camel brush number 2 (Tigre of Brazil - Rio Claro - Brazil), under an electric vibrator (VH SOFTLINE - VH Equipamentos Médicos e Odontológicos e Acessórios - Araraquara -Brazil) for the elimination of air bubbles incorporated at the time of espatulation. The total number of specimens

were 144, forty-eight specimens for each group (12 for each time period) were evaluated. The

plaster stirring and casting were developed by a unique operator.

Figure 1 (a, b e c) - Metallic stainless steel device.

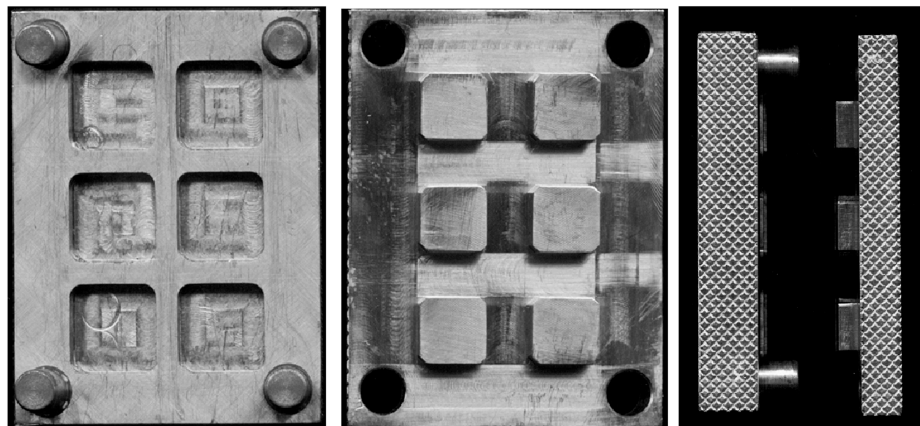


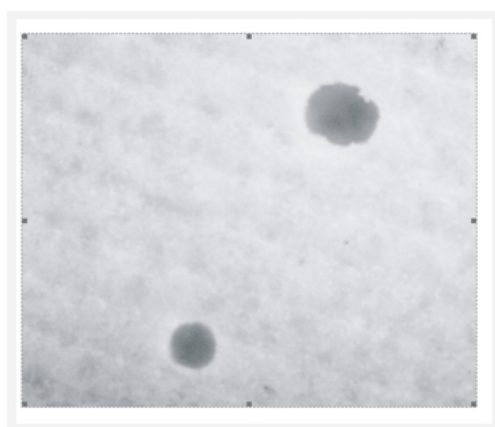
Table 1: Addition silicones.

Material	Manufacture	Composition	Lot
President	Coltene/Whaledent – Altstätten - Suíça	The manufacturer gives no details about the composition of this product	HK-409
Aquasil	Dentsply – Petropolis – Brasil	Silicon Dioxide – Amorphous, Silicon Dioxide –Crystalline, Calcium Sulfate, Hydrophobic Amorphous Fumed Silica, Titanium Dioxide	9801000497
Simply Perfect	Discus Dental – Culver City - USA	The manufacturer gives no details about the composition of this product.	W9188006

Figure 2 - Negative impressions of the areas of relief



Figure 3 - View of holes on optical microscopy.



After the setting time, models were removed from trays and examined directly below light microscopy (Carl-Zeiss - Standort Göttingen - Germany) at 40X magnification to analyze the imperfections created on the surface. There was recorded the total number of bubbles present on the region's largest model which was in contact with the molding material, in other words, on the top of the specimens (Figure 3). The edges of the model were not analyzed.

RESULTS

All results were submitted to one-way analysis of variance (ANOVA) and Tukey's test

for multiple comparisons (with a significance level of 5%). The comparison between the material and the number of bubbles in terms of time and different brands is listed in Table 2. ANOVA shows the materials and the Tukey test shows statistically significant differences between Aquasil and Simply Perfect ($p < .05$).

DISCUSSION

The results of this study accepted the hypothesis that there are statistically significant differences among the time to casting.

A major problem in the evaluation of materials for elastomeric impression is the influence that it suffers from a variety of factors. In this work, possible variations due to these factors were controlled by standardizing the amount of material used, espatulation, working time and the environment.

Metal tapered abutments with known dimensions and benchmarks for measuring were mounted on the bow to simulate real conditions in the mouth; plastic replicas of standardized dental abutments have always been widely employed. One of the advantages of this device is that it provides uniform molds that are 4 mm thick, considered appropriate for great dimensional stability of the material, as advocated by Millstein et al.¹⁹, Donovan and Chee²⁰. Other advantages of this device for use would be: its rigidity to prevent distortion of the material²¹ and the unidirectional direction

of matrix opening, which contributes to the lack of tension induction, mainly in the region of the abutments, since movements of the weighbridge when the tray is removed from the mouth can lead to compromising distortions.²²

However, it was not the purpose of this study to evaluate the thickness of the film elastomer and its involvement in distortion, but rather the slow release of hydrogen gas from the silicone material during additional polymerization.¹⁷

Several interpretations can be made in this study: the formation of bubbles on the surface of the plaster occurred in all three brands examined. While it is recommended by the manufacturer that the mold is cast after 30 minutes for the Simply Perfect and President and 1 hour for the Aquasil, the time factor proved to be significant in terms of the amount of bubbles formed within each group. This finding is in accordance with the study of Panichuttra et al.²³. Notably, the trademark Simple Perfect had the highest average for the number of bubbles in all times studied.

Although it was not studied the liberation of hydrogen gas the explanation for

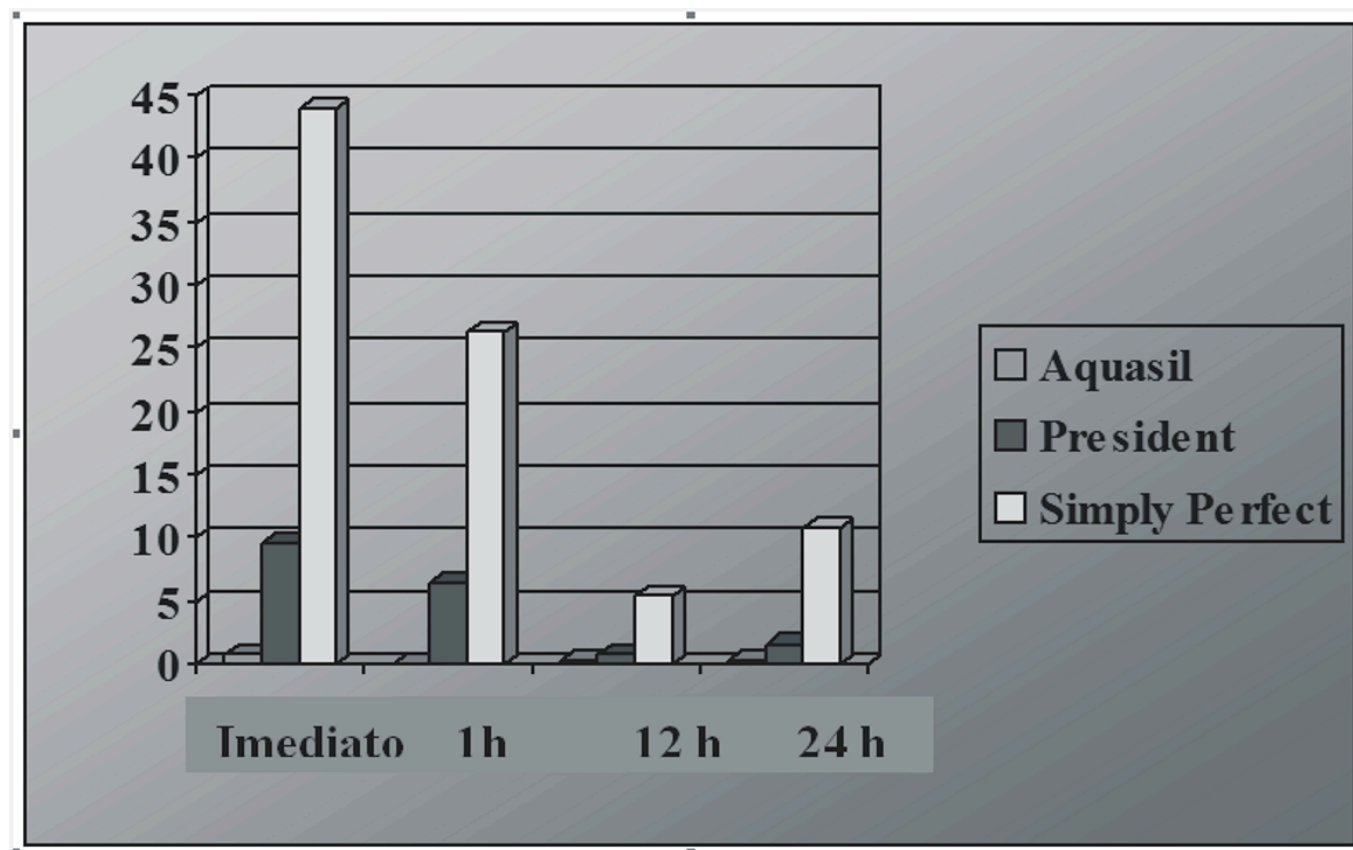
the Simply Perfect behavior suggested to point to an exaggerated release of hydrogen gas, since the other materials have significantly lower averages with regard to the number of bubbles (Table 2, Figure 4). Two hypotheses may explain the poor results for this material: the outbreak of hydrogen to the most superficial layer of specimens may not have occurred to the same extent as with models derived from the Aquasil or President. Alternately, the average achieved is due the substantial mismatch of plaster with this type of molding material, further analysis can be carried out to evaluate the compatibility between the molding material and plaster in question: this point is worthy of further analysis. The discrepancy observed between the averages of Simply Perfect and the two other silicones can be described to the incorporation of bubbles at the time of manipulation, but it is not expected because the vibration method was used for casting the plaster, as well as the self-mixture technique used for fluid materials.⁴ There was no pattern or equation that could be established for the amount of bubbles formed over time, although the materials had been pre-dosed correctly.

Table 2 - The mean and standard deviation of the number of shortcomings in terms of time .

	Immediate	1 hour	12 hours	24 hours
Aquasil	0.83 ^a (0.09)	0.08 ^a (0.01)	0.25 ^a (0.02)	0.33 ^a (0.03)
President	9.58 ^b (0.87)	6.42 ^b (0.42)	0.67 ^a (0.05)	1.58 ^a (0.19)
Simply Perfect	44.00 ^c (4.29)	26.25 ^c (2.23)	5.33 ^b (0.48)	10.92 ^b (0.97)

* Groups with the same superscripts (columns) are not statistically significant ($p < 0.05$).

Figure 4 - Comparison between the material and the number of bubbles in terms of time and different brands.



The results for President with regard to the number of bubbles are better than those reported by Vassilakos and Fernandes¹². No attempt was made to assess the density of bubbles on the surface of mm² at the abutment surface, since the geometry seems inappropriate and location can occur randomly.¹⁵ In order to resolve this issue, Panichuttra et al.²³ built on a metal grid where the central squares at the defective corners were seen as bubbles. The authors observed an average of 73 bubbles for the silicone said to be hydrophilic, higher than the levels observed in this study (Simply Perfect, 44 bubbles in the immediate curing). It should also be understood that the trapping of bubbles exists

not only in terms of material wettability, but also with regard to plaster viscosity and material smoothness²⁴ which is diluted in this study due to the smoothness of polished steel. Despite the big difference between the various materials in terms of the amount of bubbles, it cannot be said that the use of any one of them is inadvisable. However, it can be said that how greater the number of bubbles for a given material, greater was the chance of one of these bubbles being located in a place that requires great precision (for example the cervical end), and thus preventing the work. There are few studies in the literature regarding the slow release of hydrogen gas. Others studies are needed in order to identify,

quantify and explain the extent to which byproducts influence the frequency of inadequate abutments.

CONCLUSION

- Statistical analysis showed that the release of hydrogen gas more negatively influences the Simply Perfect than the President and Aquasil specimens, according to the number of bubbles recorded for each group.
- Within the limits of this study, statistical differences were found among addition silicone with regard to the ideal time to wait for the plaster cast, showing that Aquasil should be poured nearly 1 hour and the President and Simply perfect should wait more than 1 hour for the plaster cast.

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