Evaluation of Elastomeric Impression Materials' Hydrophilicity: An in vitro Study

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Abstract:

Introduction: Hydrophilicity of dental impression materials is crucial for obtaining an accurate impression and necessary for the production of a well-fitting cast restoration. The most common technique for evaluation of hydrophilicity is a contact angle measurement. The aim of the present in vitro study was to compare the water contact angles of four groups of elastomeric impression materials, before and during setting. **Material and methods:** Flattened specimens (n=10) of tested impression materials were prepared by the use of a Teflon mold with specific dimensions. A 5μl droplet of deionized water fell on the specimen, and photos were taken using a Nikon D3200 DSLR camera and a 105 mm macro lens (Nikorr, Nikon) in specific time points. **Results:** A comparison of the contact angle measurements of the impression materials initially, after mixing, revealed statistically significant differences ($p<.05$). it was found that PE impression material had significant lower contact angle initially comparing to the CAD.The contact angles measured during setting were significantly lower compared with those measured at initial time points for all the tested groups. Moreover, all tested impression materials presented a stepwise development of hydrophilicity in the setting stage, which was not observed at the initial time point t1. The PE presented lower measured contact angle values both at t1 and t2 examined time points. **Conclusions:** It was concluded that the PE impression material presented statistically significant lower contact angles initially comparing to CAD. Both impression materials developed a stepwise hydrophilicity.

Keywords: Contact Angle, Impression Materials, Hydrophilicity, Elastomeric Impression Materials

Introduction:

Impression materials are used to copy the teeth and surrounding oral structures by creating a dental impression poured with dental plaster to fabricate a dental cast. This procedure provides a tridimensional and accurate mouth replica, allowing dental work even in the absence of the patient.

Dental models enable dentists to perform a better diagnosis and treatment planning since the teeth can be meticulously visualized and studied from angles that are difficult to see in the patient's mouth. Particular treatment, such as removable and fixed prostheses, can be executed thanks to dental casts. The final restoration or prosthesis fit depends on how accurately the impression material has recorded the tissue details.

Alginate and agar have disadvantages, like dimensional instability and low tear strength, which led to the manufacture of elastomeric (also known as rubber-based) impression

materials. First came polysulfide, then condensation silicone followed by polyether, and then addition silicones.[1,2]

With the advancement in technology, digital dentistry is also making its way into the field.[3]

Accuracy is the key word for an impression material to be considered clinically successful so that all the supragingival and subgingival prepared tooth details can be impressed and an accurate stone cast can be produced. Thus, accurate impression is necessary for the production of a well-fitting cast restoration.[4,5] Over the years, a variety of impression materials have been introduced in the field of prosthetic dentistry. Reversible hydrocolloids, alginate materials, polysulfides, condensation polysiloxanes, addition polyvinylsiloxanes (PVS) and polyethers (PE) are representative examples, each presenting advantages and drawbacks.[6] Among the elastomeric impression materials, PVS and PE are the most commonly used materials in dental practice due to their favorable clinical properties and minimal dimensional change.[7,8]

Hence, this study was conducted to carry out the Evaluation of Elastomeric Impression Materials' Hydrophilicity.

Material and methods:

2 groups of dental impression materials were used in this study. The groups were as follows:

A soft polyether impression material PE (Impregum, 3M ESPE)

A CAD/CAM scannable polyvinylsiloxane CAD

Using appropriate mixing recommendations, the PentamixTM3 Automatic Mixing Unit was set up with the soft base and catalyst. Water contact angle measurements were used to assess each material's hydrophilicity both before and after setting. The preparation of flattened specimens involved the use of a Teflon mould with predetermined dimensions. Mould was always made with a mixing tip implanted to prevent air entrapment and subsequent bubble production. The Teflon moulds were overfilled, and each imprint material's surface was flattened by sliding a glass slab over it after the impression material had been initially infused into the mould. Each imprint material received 10 specimens, for a total of 20 specimens.A calibrated micropipette was used to capture a 5 l droplet of deionized water, which was then placed above the flattened specimen surface.

All specimens were digitally photographed twice: once right after each impression substance was mixed (t1), and once at 50% of the recommended working time (t2) as per the manufacturer's instructions for each impression material. Drop analysis software integrated with Image J software was used to calculate the contact angle (21, 22). To investigate the relationship between two different time periods of the same content, the Wilcoxon matched-pair test was used. In order to identify variations in sample populations' distributions, the distribution of the materials throughout the same time period was compared and evaluated using non-parametric tests, namely the Mann-Whitney and Kruskal-Wallis tests. The analysis's significance threshold was set at 0.05. Statistical analysis was performed by using IBM SPSS 25.

Results:

Table 1: Mean values and standard deviation of contact angles measurements for allmaterials

Impression material	Mean ± SD	
	Timepoint t1	Timepoint t2
PE	61.667±10.341	45.201±9.387
CAD	107.625± 16.130	96.732±17.456

A comparison of the contact angle measurements of the impression materials initially, after mixing, revealed statistically significant differences (p<.05). it was found that PE impression material had significant lower contact angle initially comparing to the CAD.

The contact angles measured during setting were significantly lower compared with those measured at initial time points for all the tested groups. Moreover, all tested impression materials presented a stepwise development of hydrophilicity in the setting stage, which was not observed at the initial time point t1. The PE presented lower measured contact angle values both at t1 and t2 examined time points.

Discussion:

Elastomeric impression materials are in common use. The impression taken should be highly precise, thus, requiring specific care when manipulatingthese materials. There are 4 groups of elastomers; polysulfide, condensation silicone, addition silicone and polyether; each differ in their setting mechanism and their physical and chemical properties. The impression material is inserted into the patient's mouth in a viscous state and transforms into viscoelastic state, upon withdrawal, influencing the residual deformation. The requirements are minimal residual deformation or maximal elastic recovery. As the mouth is a wet environment a major consideration is hydrophilicity. The wettability which is estimated by measuring either the contact angle of a droplet of water and the substrate post setting or the contact angle of a droplet of impression material and the wet tooth pre setting, determines the interaction of the material with both mouth fluids and gypsum. As the primary end target is to obtain a model depicting accurately the oral details, an attention to the impressions' compatibility with gypsum should also be given.[9]

Since accuracy of dental impressions depends on flowing and wetting properties of the applied impression materials, hydrophilicity is regarded as a major influencing factor in the outcome of an impression.[10] Several studies investigated wettability of the already set impression materials, showing no statistically significant differences between PVS and PE materials.[11] However, wettability of an impression material during its setting time proved to be a field that needs further investigation.[12]

There are several methods for determining wettability of impression materials. Dynamic contact angle sessile drop goniometry and dynamic Wilhelmytensiometry are commonly used.[13] Contact angle measurement was proved to be the most clinically relevant technique. Using this method, the investigator measures the contact angle of a distilled water droplet on a flat surface of a solid specimen of an impression material. The contact angle value may be affected by the drop volume that may be decreased due to evaporation.[14] The lower the contact angle, the more increased is wettability and the greater is hydrophilicity. In this study, the comparison of the contact angle measurements of the impression materials initially, after mixing, revealed statistically significant differences (p<.05). it was found that PE impression material had significant lower contact angle initially comparing to the CAD.

The contact angles measured during setting were significantly lower compared with those measured at initial time points for all the tested groups. Moreover, all tested impression materials presented a stepwise development of hydrophilicity in the setting stage, which was not observed at the initial time point t1. The PE presented lower measured contact angle values both at t1 and t2 examined time points.

In line with the findings of Menees et al.,[15] PE showed the smallest deviations after setting, according to contact angle measurements and thus the best hydrophilic behavior.

The superiority of PE could be attributed to the intrinsic hydrophilicity of PE impressions. Other studies[16] showed that PE favored moist surfaces producing precise reproductions despite the presence of moisture. Also, Shah et al.[17] concluded that PE has a significantly better accuracy than polyvinyl siloxane.

Conclusion:

It was concluded that the PE impression material presented statistically significant lower contact angles initially comparing to CAD. Both impression materials developed a stepwise hydrophilicity.

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