Comparative Evaluation of the Post Set Hydrophilicity of Commercially Available Elastomeric Impression Materials - An Invitro Study

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Abstract

Introduction: A clear understanding of the hydrophilic properties of elastomericim pression materials post setting, is of paramount importance to obtain accurate casts. **Objective:** The post set hydrophilicity of elastomeric impression materials has not been fully established. The purpose of this study was to measure and compare the contact angle of three elastomeric impression materials with water after setting. **Materials and method:** The hydrophilic properties of set polyether and two vinylpolysiloxane (VPS) impression materials were analyzed with respect to their water contact angle measurements. Impression discs were made using a metal die and ring. Deionized ultra-filtered water was placed on each disc and contact-angle measurements were made at 0, 15, 30, 45 and 60 s using sessile drop method. **Results:** The data were analyzed using repeated ANOVA. A one way ANOVA was carried out to determine the comparison between the groups followed by post hoc Tukeys test. Repeated measures ANOVA was done for the comparison within the groups followed by a pairwise comparison using Bonferroni's adjustment. The level of significance was set at $P< 0.05$. The mean values of contact angles for polyether were significantly lower than both the vinyl polysiloxanes (VPS) at all measurement times.There was no significant difference amongst the contact angle measurements of VPS materials**. Conclusion:** Within the limitations of this study, commercially available PE was more hydrophilic compared the tested elastomeric impression materials.

Keywords: Polyether; Vinylpolysiloxane; Hydrophilic; Contact angle; Drop Shape Analysis.

Introduction:

The hydrophilicity of an elastomeric impression materials during setting is regarded as a key factor that affects the wetting of the oral hard and soft tissues and therefore accurate detailed reproduction of prepared tooth surfaces[1].In turn,wettability influences the capacity of the set material to be poured with gypsum slurries without trapping air bubbles[1,2]. An ideal dental impression material would be hydrophilic in its unset state in order to wet a tooth with saliva present on its surface[3]. Reversible hydrocolloid materials have been replaced by elastomeric impression materials likePolyether(PE) and Vinylpolysiloxane(VPS) for many applications due to their superior dimensional stability and surface reproduction coupled with their great elastic recovery and tear resistance[4,5]. An accurate impression of the preparation may be proven useless, if the material has poor wetting properties, since it may lead to air entrapment and void formation in the master cast[4].

PE materials have been developed to improve the ability of the non-set material to wet the soft and hard tissues of the mouth and to provide a better wettability by water during gypsum cast fabrication[6]. In VPS impression material, the polymerized silicone rubber consists of siloxane bonds surrounded by aliphatic hydrocarbons, making the material inherently hydrophobic. Hence,non-ionic surfactants such as nonylphenoxy poly(ethyleneoxy) ethanol homologs are added[3,7,8] to improve the hydrophilicity.

Previous studies[9,10] have shown that the contact angles of hydrophillicVPS were not significantly different from those of PE, and as a result, their pourabilitywith dental stone was comparable.These studies also suggested that there is a negative correlation between mean contact angles and the ability of the impression material to be poured with dental stone without air bubble entrapment[9,10]. Other studies also reported better wetting ability of the hydrophilic VPS, when compared with that of the hydrophobic ones; however, the contact angle values of these materials were significantly higher than those ofPE[11].

The hydrophilicity of an impression material can be assessed by measuring the advancing contact angle of water on its surface[12,13,14].A high contact angle (>90 degrees) is an indication of poor wettingsuggesting greater hydrophobicity,lower contact angle indicates increased wettability suggesting greater hydrophilicity[13].

Therefore, the purpose of this study was to evaluate post set hydrophilicity of three commercially available elastomeric impression materials comprising one PE and two VPS materials. Since the degree of hydrophilicity of current hydrophilized VPSimpression materials compared to PE materials is contradictory, a PE impressionmaterial was tested for comparison.The null hypotheses isthat there is no significant difference in post set hydrophilicity of three commercially available elastomeric impression materialsto be tested.

Materials and methods:

The study was initiated after obtaining clearance from the institutional ethical committee (AJEC/REV/266/2019). The materials used in this study comprised of commercially available PE and two VPSimpression materials.Advancing contact-angle measurements were made on the set surfaces of elastomeric impression materials.A stainless-steel die with rings were used to make 15 discs of each impression material,resulting in total of 45 discs. The round impression discs, which were 25 mm in diameter and 3mmin thickness, were made according to manufacturer's instructions at room temperature (23°± 2°) and were left for an extra 30s beyond the recommended setting time before removing them from the ring.

The discs from 3 different impression materials were divided into 3 groups.

Group A –Discs made of polyether impression material.

Group B-Discs made of VPS material.

Group C-Discs made of VPS material.

Each disc was tested with 5 separate dropletsof deionized ultra-filtered water, with 2 contact-angle measurements made for each at 0, 15, 30, 45 and 60 seconds, resulting in 150 measurements for each material tested per timepoint.

The contact angle of water droplets was measured using a sessile drop method (Halmarc's contact angle meter HO-IAD-CAM-01). A disc was placed on the platform of the video contact angle machine just below the needle, from which a 1-µL water droplet was dispensed from the 100-µL pipette and the contact angle was

measured in degrees using the contact angle measuring software. A video recording was made showing waterdroplet activity on the disc surface, so that contact-angle measurements could be made at the specified time intervals. The recording was stopped every 15s to make 2 measurements as described above.

Statistical analysis

The data analysis was carried out using SPSS for windows (SPSS ver 22; IBM Corp., Armonk,NY). A one-way ANOVA was carried out to determine the comparison between the groups followed by post hoc Tukeys test. Repeated measures ANOVA was done for the comparison within the groups followed by a pairwise comparison using Bonferroni's adjustment. The level of significance was set at $P< 0.05$.

Results:

The mean contact angles for Group A were lower than those of Group B and Group C at all measurement times (Graph 1). Repeated measures ANOVA was carried out to compare average contact angles of the materialsover time and a post-hoc test with Bonferroni correction was applied for pairwise comparison. There wasa significant difference in contact angle between Group Aand Group C ($P<0.01$) and between Group A and Group B ($P<0.01$) at all time intervals. However, there was no significant difference in the contact angle measurements between Group Band Group Cduring 60 seconds ($P>0.01$) (Table 1).A post hoc test revealed a significantdifference between all the three groups at 0 seconds,15 seconds,30 seconds,45 seconds and 60 seconds.

Discussion

This study evaluated the post set hydrophilicity of three commercially available silicone impression materials under simulated clinical conditions. The post set hydrophilicity deals with the ability of the set impression material to be poured with gypsum materials to produce accurate casts without incorporation of any air bubbles.

An ideal impression material should have a relative affinity for liquids such as water, organic fluids and gypsum products and the affinity is determined by the adhesive forces between the molecules of the impression material and that of the liquid in contact. This affinity should be present in both pseudoplastic and the elastic stages of the impression materials.

The results of the contact angle measurements of water on elastomeric impression materials indicates that PE impression material had significantly lower contact angle values compared to VPS impression material. Therefore,the null hypothesis was rejected.PE contains polar oxygen atoms, which have an affinity for water resulting in lower contact angles and better hydrophilicity. VPS material proved to be less hydrophilic than PE which could be attributed to the presence of hydrophobic aliphatic hydrocarbon groups surrounding the siloxane bond.

Hydrophilic elastomeric impression materials enable the gypsum mix to flow over the material at a reduced contact angle.This decreased contact angle allows for displacement rather than entrapment of air. Hydrophilic elastomeric impression materials help prevent erroneous cast fabrication and facilitates the fabrication of an accurate dental prosthesis[16].

Water contact angles are most frequently used to determine the hydrophilic properties ofimpression materials after they have set. The materials exhibiting values greater than 90° are hydrophobic, while those exhibiting values smaller than 90° are hydrophilic[17]. A wetting angle of 0° corresponds to absolute wetting, in which the drop spreads to form a film on the surface.

The various techniques for measuring contact angles aresessile drop, captive bubble, and Wilhelmy plate methods[18,19]. The sessile drop technique is the most common technique used formeasuring contact angle where a liquid drop is placed on a surface and the contact angle ismeasured directly.The DSA[10] has been used in the study to analyze the hydrophilic properties of the set polyether and VPS impression materials through

contact angle measurements[13]. This method gives an edge over other methods in terms of procurement and direct generation of results.

By incorporating non–ionic surfactants the wettability of VPS materials can be improved[19]. Thesurfactants contain specific hydrophilic and hydrophobic regions.The hydrophilic fraction of surfactant favors the interaction with water molecules and the hydrophobic fraction assists to be distributed in the siliconized matrix[3,18].Lee et al.studied the effect of incorporating different surfactants in impression materials and found that contact angles decreased as the concentration of a non-ionic surfactant increased[20].

The study presents two limitations. First, in vitro tests at room temperature may differ from the clinical setting, as temperature may affect setting properties. Second limitation is disinfectant solutions used in a clinical setting may affect the wettability which has not been used in the current study.

Conclusion

Within the limitations and the methods used in the study following conclusions were drawn

1. The mean contact angle values for commercially available PE were lower than those of the two commercially available VPS materialstested at all measurementtimes and the difference in the contact angle measurement was significant.
2. There was no significant difference in the contact angle measurements between the two tested VPS impression materials.

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Table 1: Pairwise comparison of contact angle of water on impression materials between 0-60s

Sl. No.	Materials	Mean difference	SE	P value (95% CI)
1	Group A vs Group C	4.51	1.5	0.011 (0.8,8.2)
2	Group B vs Group A	1.3	1.54	0.99 (-3.7, 3.7)
3	Group A vs Group B	-4.5	1.5	0.011 (-8.27, -0.8)

GRAPH 1: Mean contact angle of drops at different time intervals within the groups