ORIGINAL RESEARCH

# Evaluation of Wettability of Three Saliva Substitutes on Heat-polymerized Acrylic Resin—An *In vitro* Study

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## Abstract

**Aim:** The aim of the present study was to evaluate the wettability of three saliva substitutes on heat-polymerized acrylic resin.

**Materials and methods:** Heat-cured acrylic resins 150 were made and divided into three groups containing 50 samples each, i.e., group 1 Aqwet, group 2 Biotene, and group 3 Mouthkote. The prepared wax pattern was cut using 30 × 30-mm two square glass plates along the sides using a sharp carver. The uniformity of the wax samples was checked using the wax gauge. The wax samples were invested using dental plaster in varsity flasks. The samples were prepared using conventional heat-cure denture base acrylic resin. A goniometer was used to calculate receding and advancing contact angles for dynamic contact angle analysis.

**Results:** The least mean value of advancing and receding contact angles was seen in group 1 Aqwet (68.12 ± 1.30 and 58.56 ± 0.10) followed by group 2 Biotene (81.64 ± 0.88 and 74.89 ± 0.45), and group 3 Mouthkote (85.76 ± 1.02 and 80.63 ± 0.66). A significant difference was found between the groups statistically with a *p* value of 0.001. A significant difference was found on multiple comparisons between group 1 vs group 3 and group 1 vs group 2 with different receding and advancing contact angles of saliva substitutes analyzed with Turkey's *post hoc* test.

**Conclusion:** The lowest advancing and receding contact angle values were significantly seen in the Aqwet saliva substitute followed by Biotene and Mouthkote on heat-polymerized acrylic resin.

**Clinical significance:** The clinical significance of the saliva substitute's good wetting property on acrylic denture base. The quality of life of the patients with xerostomia can be improved using a suitable saliva substitute.

**Keywords:** Acrylic denture, Contact angle, Saliva substitute, Xerostomia.

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## Introduction

Saliva is the most significant component produced by the salivary exocrine gland in the stomatognathic system. Saliva is known to be an important factor for the maintenance of the system's health and function. The approximate volume of saliva present in the oral cavity is 1 mL with a mean range of salivary output being 500 to 1500 mL.[1] The percentage of unstimulated saliva contributed by parotid, submandibular, and sublingual glands is 20, 65, and 7 to 8%, respectively, and about 10% of saliva is secreted from other minor glands. The unstimulated salivary rate below 0.1 mL/min is called hypofunction. The normal acceptable salivary flow rate is anything above 0.1 mL/min.[2]

The complete denture retention can be affected by mechanical, surgical, physical, psychological, and physiological factors. The physical factors are further divided into cohesion, atmospheric pressure, interfacial surface tension, and adhesion. These physical factors act in the fluid medium between the mucosa and the denture base. The rheological properties including adhesiveness and elasticity possessed by the salivary mucin aid in denture retention. The main function of the saliva is to protect the oral cavity and gastrointestinal (GI) contiguous epithelium. Common functions of the fluid component of the salivary secretions include mastication and speech, taste perception facilitation, bolus formation and solubilization of food, lubrication and cleansing of the oral hard and soft tissues, and removable prosthesis retention.[3]

The retention of the complete denture is obtained by the combined action of physical forces and muscular forces. The physical forces among the denture base, supporting tissues, and interposed salivary film and the muscular forces exerted by the lips, cheeks, and the tongue help to retain the denture. The attraction of the unlike molecules is termed as adhesion, which is one of the essential forces involved in the retention of denture.[4]

The wettability of solid to liquid surfaces plays an important role in adhesion. The tendency to spread on the solid surface represents the liquid's wetting power. The solid surface to liquid wettability is determined by the measurement of the contact angles formed between them. A better tendency to wet the surface appears with lower contact angle and the complete wetting occurs with the zero-degree contact angle.[5]

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By considering the importance of the wettability of the saliva on acrylic denture base and its effects in patients with hypofunction, this study was conducted to compare and evaluate the wettability of three available saliva substitutes on heat-polymerized acrylic resin.

## Materials and Methods

This *in vitro* study was conducted in the Department of Prosthodontics, SJM Dental College & Hospital, Chitradurga, Karnataka.

### Preparation of Samples

One hundred and fifty samples of heat-cured acrylic resin were made. These 150 samples were distributed equally into three groups based on the saliva substitutes considered in the study:

**Group 1:** Aqwet (Cipla Ltd.)
**Group 2:** Biotene (GlaxoSmithKline, USA)
**Group 3:** Mouthkote (Oryx Pharmaceuticals).

### Preparation of Wax Patterns

Modeling wax sheets of thickness 1.5 mm were placed one upon the other to obtain a thickness of 3 mm, to compensate for the acrylic loss during the finishing process to obtain a 2 mm uniform thickness in the final samples of the acrylic resin. Using a sharp carver, the wax strips were cut along the sides of the 30 × 30 mm measuring two square glass plates used to get the required dimension of the wax (Fig. 1). The wax gauge was used to check the uniformity of the wax samples.

### Heat-Cured Acrylic Resin Samples' Preparation

Using a dental plaster in a varsity flask, the wax samples were invested. The conventional acrylic denture base resin from "Dental Products of India" was used. The manufacturer's instructions were followed during flasking and processing of the acrylic resin. About 150 samples were prepared. The samples were stored for 24 hours under water. As in clinical practice, even a thickness of 2 mm was obtained by polishing the samples using a sandpaper and cherry stones. To simulate the clinical practice, no finishing was done for the tissue surface which needs to be tested. Manually, the polished surface was finished using a sandpaper to get a flat surface in all samples. Using soft cotton dipped in saturated household soap water, the samples were cleaned for 5 minutes and then rinsed well under running water. To remove the household soap residues, the samples were cleaned with sprit. The samples were then immersed for 15 min in sonic denture cleanser and were dried before viewing under an electron microscope. The electron microscope was used to scan the effectiveness of the finishing and cleaning procedure with a magnification of 2000×.

### Assessment of Contact Angles

A goniometer was used to measure the receding and advancing contact angles for dynamic contact angle analysis (Figs 2 and 3). The substitute for saliva to be tested was dispensed on the sample using a syringe. To measure the receding and advancing contact angles, a standardized volume (10 µL) of fluid was allowed to be used on the sample surface. A high-speed camera in the goniometer was used to record the dispensed drop contour on the surface of the sample.

The receding and advancing contact angles were determined by the goniometer system's program. The angle formed by the baseline of the drop and a tangent line at the three-phase (solid/liquid/vapor) was called the contact angle. The contact angle formed after the liquid has receded from the surface was a measure of receding angle, while the measure of the contact angle of the liquid drop when dispensed on the dry sample surface was an advancing contact angle. The new samples were placed after obtaining the values. In the first group, the procedure was repeated for 50 samples. The procedure was repeated for all the other sample groups and the measurements made were recorded.

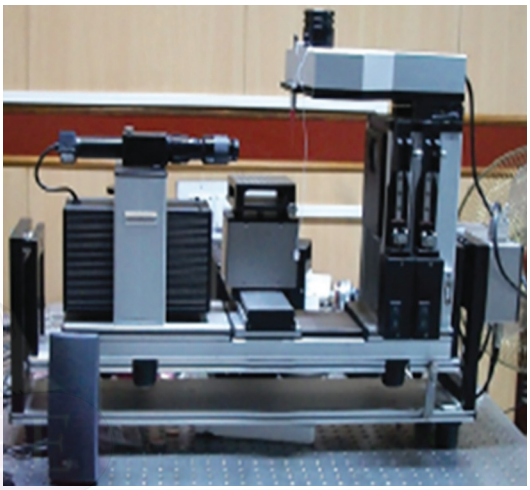

**Fig. 2:** Goniometer used in the present study

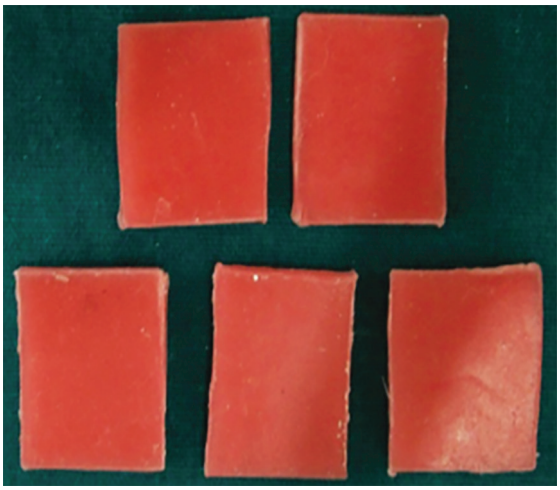

**Fig. 1:** Wax pattern preparation

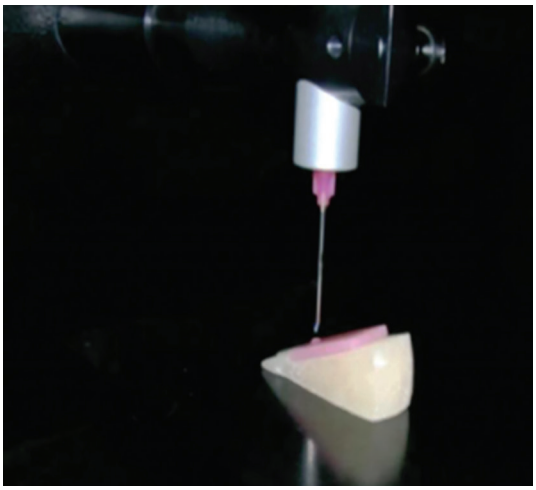

**Fig. 3:** Contact angle measurement

### Statistical Analysis

The statistical procedures were done on windows version 20.0 using statistical package for the social sciences (SPSS). Analysis of variance (ANOVA) test and Tukey's *post hoc* test's statistical analysis methods were adopted. To test the significance in the difference in the three groups' contact angle value, the "ANOVA test" was carried out. To verify the significance of contact angle difference in a pair of groups, "Tukey's *post hoc* multiple comparison tests" were used. A *p* value of less than 0.05 is considered to determine the level of significance.

## Results

The advancing angle comparison of mean values is shown in Table 1. The least mean value of advancing angle was found in group 1 (Aqwet) with 68.12 ± 1.30, followed by group 2 (Biotene) with 81.64 ± 0.88 and group 3 (Mouthkote) with 85.76 ± 1.02. There was a statistically significant difference between the groups with a *p* value of 0.001.

The receding angle comparison of mean values is shown in Table 2. The least mean value of advancing angle was found in group 1 (Aqwet) with 58.56 ± 0.10, followed by group 2 (Biotene) with 74.89 ± 0.45 and group 3 (Mouthkote) with 80.63 ± 0.66. There was a statistically significant difference between the groups with a *p* value of 0.001.

Tukey's *post hoc* test revealed the saliva substitute's multiple comparisons of advancing angles between the groups with a significant difference found between group 1 vs group 2 and between group 1 vs group 3 as presented in Table 3.

Tukey's *post hoc* test revealed the saliva substitute's multiple comparisons of receding angles between the groups with a significant difference found between group 1 vs group 2 and between group 1 vs group 3 as presented in Table 4. Overall, Aqwet was the better saliva substitute than Biotene and Mouthkote on heat-polymerized acrylic resin.

## Discussion

An adequate supply of saliva helps for the preservation and maintenance of the oral tissue. The presence of adequate flow of saliva, composition, and consistency is critical in patients who are completely edentulous. Before and after fabrication of the denture, it is important to know the characteristics of the saliva and is imperative for the prosthodontist to pay attention.[6]

The tension related to material surface wetting and the surface energy was examined by measuring the contact angle. The material's surface energy corresponds to the degree of wetting, and the wetting capability and the contact angle of the drop vary inversely. Contact angle can reflect the wettability of denture materials and it was influenced by many factors, such as surface roughness, surface characteristics, and environmental temperature.[7] The wettability on the solid surface is measured by the contact angle's meeting point at the solid–air–liquid, which is a widely known technique. The obtained values depend on the surface tension of the liquid, surface energy of the solid substrate, and surface topography.[8,9]

Saliva substitutes, also known as artificial saliva, are liquid or aerosol products that are sprayed into the mouth. They are mainly designed to relieve the pain and discomfort from chronic dry mouth and moisten, especially for regular use. The present study was conducted to compare the three saliva substitute's wettability on heat-cured acrylic resin using a goniometer by calculating the contact angle. Contact angle goniometers help to determine the surface tension of any liquid in gas or the interfacial tension between any two liquids. If the difference in densities between the two fluids is known, the surface tension or interfacial tension can be calculated by using the pendant drop method. The advancing angle's mean values from all the groups were compared. The wettability was more on heat-polymerized acrylic resin, as the contact angle was the lowest in Aqwet. For the upper complete denture's optimum retention, good wetting by the saliva substitute on the heat-polymerized acrylic resin is of critical importance. The mean measurement of the advancing angle showed a statistically significant difference in Aqwet when compared with the other two remaining groups. This may be due to the least contact angle of Aqwet to that of two groups as the wettability increases with low contact angle. These comparison results were similar to that of Sharma and Chitre's study.[10]

**Table 1:** Mean value comparison of advancing angle

| | *Saliva substitutes* | *N* | *Mean ± SD* | *F value* | *p value* |
|---|---|---|---|---|---|
| Advancing angle | Group 1—Aqwet | 50 | 68.12 ± 1.30 | | |
| | Group 2—Biotene | 50 | 81.64 ± 0.88 | 28.410 | **0.001** |
| | Group 3—Mouthkote | 50 | 85.76 ± 1.02 | | |

Bold values are highly significant

**Table 2:** Mean value comparison of receding contact angle

| | *Saliva substitutes* | *N* | *Mean ± SD* | *F value* | *p value* |
|---|---|---|---|---|---|
| Receding contact angle | Group 1—Aqwet | 50 | 58.56 ± 0.10 | | |
| | Group 2—Biotene | 50 | 74.89 ± 0.45 | 27.196 | **0.001** |
| | Group 3—Mouthkote | 50 | 80.63 ± 0.66 | | |

Bold values are highly significant

**Table 3:** Multiple comparisons of different saliva substitute's advancing angle using Tukey's *post hoc* test

| *Groups* | *Compared with* | *Mean difference* | *Significance* |
|---|---|---|---|
| Group 1—Aqwet | Group 2—Biotene | −13.52 | **0.001** |
| | Group 3—Mouthkote | −17.64 | **0.001** |
| Group 2—Biotene | Group 1—Aqwet | 13.52 | **0.001** |
| | Group 3—Mouthkote | −4.12 | 0.09 |
| Group 3—Mouthkote | Group 1—Aqwet | 17.64 | **0.001** |
| | Group 2—Biotene | 4.12 | 0.07 |

Bold values are highly significant

**Table 4:** Multiple comparisons of different saliva substitute's receding contact angle using Tukey's *post hoc* test

| *Groups* | *Compared with* | *Mean difference* | *Significance* |
|---|---|---|---|
| Group 1—Aqwet | Group 2—Biotene | −16.33 | **0.001** |
| | Group 3—Mouthkote | −22.07 | **0.001** |
| Group 2—Biotene | Group 1—Aqwet | 16.33 | **0.001** |
| | Group 3—Mouthkote | −5.74 | 0.07 |
| Group 3—Mouthkote | Group 1—Aqwet | 22.07 | **0.001** |
| | Group 2—Biotene | 5.74 | 0.06 |

Bold values are highly significant

Mathrawala and Hegde[11] study found that Aqwet's wettability was better than those of other substitutes used in their study.

All the three group's mean receding angles were compared. The contact angle of Aqwet showed low angle indicating more wettability on heat-cured polymerized acrylic resin. This result is similar to the studies conducted by Sharma and Chitre,[10] Bikash and Seema,[12] and Mohsin et al.,[13] showed that Aqwet saliva substitutes containing thickening agents for increased moistening, lubrication, and longer relief of surface of the oral cavity in patients with xerostomia so it helps for the retention of the denture.

Denture comfort is known to depend on the equilibrium contact angle and denture retention on contact angle hysteresis. Experimental results and theoretical considerations clearly demonstrate the exceptional cases, such as solids, which are perfectly wettable ($\partial = 0°$). The advancing contact angle on the dry solid surface with liquid front (advancing contact angle $\partial A$) is different than the receding contact angle ($\partial R$).[14] When receding of the liquid front on the solid surface occurs, the mechanism of dewetting occurs at the first contact angle variation, followed by the liquid–solid contact angle displacement.

There are many important conditions which influence the retention of the denture in the mouth which needs to be considered before selecting the denture base materials and shaping the denture. For example, the retention can be increased in cases with low receding angles and low advancing angles with the denture base surface. The roughness of the adherent surface is the factor which can affect the contact angle's magnitude of fluid on the surface of the solid, which differs with respect to the solid. The surface roughness of the same group test specimens with the same denture base material was an uncontrollable variable. During the evaluation of the contact angle, the surface roughness variability of denture base materials should be taken into consideration. Along with denture retention, these salivary substitutes also help in the management of patients with salivary gland dysfunction requiring enough stimulation of the residual gland function with sialogogues or, in severe cases. The present saliva substitutes are intended to act as a replacement of the lubricative, protective, and mucoadhesive function of the natural saliva.[15]

The study conducted by Niedermeier and Kramer[16] emphasizes the primary responsibility of palatal gland salivary secretion in the physical retention of the maxillary complete dentures. Xerostomia or complete loss of saliva flow is both harmful and unpleasant to the patients. Other than the irritation of the tissue, the condition predisposes to the occurrence of periodontal diseases and candida infections. This causes discomfort and affects the retention of the denture.

Limitation of the present study is surface contamination of the studied surface that may produce a change in the surface tension of water which in turn can induce an error in the calculated contact angle values. The contamination may be of microbial nature due to the formation of metabolites and of chemical nature due to the residual monomer migration to the surface from the polymer.

## Conclusion

This study concluded that the saliva substitute Aqwet significantly has the lowest advancing and receding contacting angle values followed by Biotene and Mouthkote on the polymerized heat acrylic resin. Consistency, quality, and optimal salivary flow are nearly essential not only for the fabrication of the denture, but also for the stability and retention of the denture. The prosthodontist during fabrication of the complete dentures in edentulous patients must give due attention to the patient's salivary nature as this can lead to success and lasting effect of the denture.

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