

# Wettability of two different artificial saliva substitutes on injection moulded heat polymerized acrylic resin and CAD-CAM acrylic resin: an in vitro study.

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## Abstract

**Aim:** The purpose of this in vitro study was to evaluate the wettability of two different artificial saliva substitutes on injection moulded heat-polymerized acrylic resin and CAD-CAM acrylic resin and to compare these properties with natural saliva and distilled water.

**Materials and method:** Forty heat polymerized (injection moulded) acrylic resin specimens and forty CAD-CAM acrylic resin specimens were fabricated with each specimen measuring 10x10x2mm. Four groups of liquids namely distilled water, Wet mouth™, Mouth Kote™ and human saliva were used. A contact angle goniometer was used to measure the contact angles. Two contact angle readings were obtained on the right side and on the left side of the test specimen. The observations were recorded and a mean of the two readings was calculated. The same procedure was repeated for all specimens (heat cure resin and CAD-CAM) with all the four test groups of liquids.

**Results:** Contact angle measurements were significantly higher in Wet mouth™ and Mouth Kote™ solution of heat cure resin group compared to the CAD-CAM group ( $p$ -value<0.05 for both). Mouth Kote™ had lower mean contact angle ( $62.63 \pm 4.59$ ) than Wet mouth™ ( $77.46 \pm 9.16$ ) on CAD/CAM denture base resin. Mouth Kote also had lower mean contact angle ( $70.80 \pm 4.79$ ) than Wet mouth™ ( $97.77 \pm 7.79$ ) on injection moulded denture base resin.

**Conclusion:** Mouth kote had better wettability than wet mouth on both CAD-CAM and injection moulded acrylic resin. Both the saliva substitutes had better wettability on CAD-CAM than on injection moulded acrylic resin.

Citation: Quraish Lal, et al. (2023) Wettability of two different artificial saliva substitutes on injection moulded heat polymerized acrylic resin and CAD-CAM acrylic resin: an in vitro study  
Dentistry 3000. 1:a001 doi:10.5195/d3000.2023.184  
Received: May 11, 2021  
Accepted: July 18, 2021  
Published: February 14, 2023  
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## INTRODUCTION

Xerostomia is a condition characterized by qualitative and/or quantitative alteration in salivary secretion with/without increased dehydration of the oral mucosa.[1] It is a commonly reported condition, with prevalence around 22%-26% in general population and upto 82%-83% in patients seeking palliative care.[2]

Dry Mouth predisposes to oral irritation and epithelial atrophy, which may progress into inflammation, fissuring, and ulceration. Furthermore, lack of saliva

significantly hampers denture retention and causes dysphagia. [3] The physical forces involved in the retention of a denture are adhesion, cohesion, capillarity, atmospheric pressure, surface tension, and viscosity, which are directly or indirectly dependant on saliva.[4] Moreover, there is an increased incidence of oral candidiasis in xerostomia patients.

Artificial saliva substitutes were introduced as a replacement for natural saliva in individuals presenting with hyposalivation. [5] In such

patients, for a denture to have sufficient adhesion to the supporting mucosa; the artificial saliva substitutes must flow over the denture surfaces with ease to ensure adequate wetting. [4]

Wettability is defined as the tendency of an adhesive to spread or wet the adherent. [6] The propensity of a liquid to spread enhances, when the contact angle decreases. Therefore, the contact angle is a reliable inverse measure of wettability.[4] Contact angle can be defined as the equilibrium angle of contact of a liquid

on a rigid surface, measured within the liquid at the contact line where three phases (liquid, solid, gas) meet.[7]

Heat polymerized acrylic resin is the most preferred and popular choice of material among clinicians and patients. The contact angles of heat polymerized acrylic resin on artificial saliva and distilled water have been found to be  $66.6 \pm 5.5$  and  $64.1 \pm 3.6$  respectively. [4] On human saliva, heat polymerized acrylic resin has shown mean contact angle of  $58.42 \pm 1.68$ . [6] However, the denture fabrication process with this material is a time-consuming procedure and involves a lot of manual labour. Certain other disadvantages include residual monomer content, polymerisation shrinkage and processing errors like porosities. To overcome these drawbacks, computer-aided design/computer-aided manufacturing (CAD/CAM) based materials have shown to provide more predictable outcomes.

Although sufficient evidence exists in literature regarding the superior mechanical and handling properties of CAD-CAM poly-methymethacrylate (PMMA), there is insufficient evidence on the wettability of these polymers with salivary substitutes. The best choice of material in patients suffering from xerostomia still remains debatable and inconclusive. Therefore, this in vitro study was undertaken to evaluate the wettability of two different artificial saliva substitutes on heat-polymerized

acrylic resin and CAD-CAM acrylic resin and to compare these properties with natural saliva and distilled water. The null hypothesis of the study was that there is no difference in wettability of the two test resins with the different artificial salivary substitutes.

## MATERIALS AND METHODS

Two types of denture base materials (specimens) were used including injection moulded heat polymerized acrylic denture base material (SR, Ivocap High Impact, Ivoclar Vivadent, Liechtenstein) and CAD-CAM denture base material (Bloomden™, China).

Four groups of liquids were used for contact angle measurements. These were: distilled water, Wet Mouth™ (sodium carboxy methyl cellulose 0.5% w/v, Glycerine 30%w/v; ICPA Health Products Ltd), Mouth Kote™ (xylitol, sorbitol, yerba santa; Parnell Pharmaceuticals) and human saliva.

Each of these liquids were tested on 20 acrylic denture base specimens each (heat polymerized n=10 and CAD-CAM n=10).

### *Fabrication of specimens*

Forty heat polymerized injection moulded acrylic resin specimens and forty CAD-CAM acrylic resin specimens (in accordance with the Power Analysis) were fabricated with each specimen measuring 10x10x2mm.

*Injection moulded specimens:* Pre-proportioned capsules of resin and

monomer (SR, Ivocap High Impact, Ivoclar Vivadent, Liechtenstein) were combined and loaded in the cap vibrator (Ivoclar Vivadent) for 5 minutes. The flask halves were clamped in the frame under 6,000 lbs of pressure and the mixed capsule was inserted. This assembly was connected to a compressed air supply (6 bar/85 psi) to enable the plunger to descend and push the material into the mold. Total injection time was programmed to ten minutes, at room temperature. Specimens measuring 10x10x2mm were obtained after processing.

*CAD/CAM specimens:* CAD/CAM PMMA discs (Bloomden™, China) of 98 mm diameter and 25 mm height were scanned in the DC5 milling system (Dental Concept Systems GmbH, Ulm, Germany). A layout of a square block measuring 10x10x2mm was designed on the CAD file. The 5-axis milling system was used to mill these blocks.

The specimens were finished as per manufacturer's instructions to obtain an even thickness of 2 mm using acrylic finishing burs. However, no polishing was done for the surface to be tested (tissue surface) to simulate the intaglio surfaces of denture bases.

All the specimens were subjected to thermocycling for 10,000 cycles while they were immersed in alternating water baths at  $5 \pm 1^\circ\text{C}$  and  $55 \pm 1^\circ\text{C}$  with a 60-second dwell time. [8]

For decontamination of the surface of the specimens to be tested, the specimens were first cleaned with

soap water and then wiped clean with universal solvent (100% ethanol). The specimens were then immersed in an ultrasonic cleaner for 15 minutes.[9] After the cleaning procedure, the test specimens were dried in an oven at 44°C for half an hour and then brought down to the room temperature.[6]

The heat polymerized specimens were numbered sequentially and randomly divided into four groups of ten specimens each. Similarly, CAD-CAM specimens were also numbered and randomly divided into four groups.

A morning sample of human saliva was collected from a medically healthy male donor. Unstimulated whole saliva was collected by requesting the donor to relax and tilt his head forward in order to drool the saliva from the lower lip into a test tube.

#### Contact angle measurement

A contact angle goniometer (fig. 1), consisting of a photography area and computer software (SCA 20 DataPhysics, Germany), was used to measure the contact angles. Using a pipette, 10 microlitres was collected from the test-tube. The test resin specimen was placed in the center of the table of the goniometer and human saliva was dropped on it from the pipette (fig. 2). Contact angle measurements were done on the software (SCA 20 DataPhysics, Germany). Two contact angle readings were thus obtained on the right side and on the left side of the test specimen (fig. 3). The observations

were recorded and a mean of the two readings was calculated.

The same procedure was repeated for all specimens (heat cure resin and CAD-CAM) with all the four test groups of liquids.



Fig. 1. Contact angle goniometer.

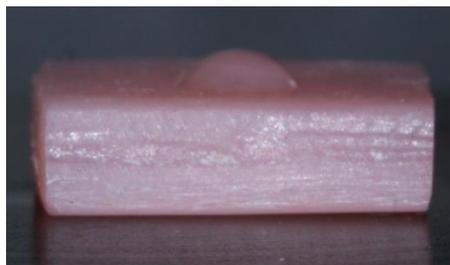


Fig. 2. Denture base specimen with 10 microlitre drop of human saliva.

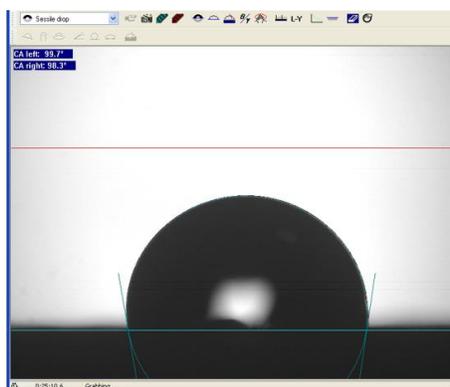


Fig. 3. Contact angle measurements shown on the software (SCA 20 DataPhysics, Germany)

## RESULTS

The mean contact angles of the four test solutions on CAD-CAM and injection moulded heat polymerized acrylic resin are summarized in Table 1. The inter-group statistical comparison of distribution of means of continuous variable is done using independent sample t test for two groups and by one-way analysis of variance (ANOVA) with Post-Hoc Bonferroni's correction for multiple group comparisons for more than two groups. The underlying normality assumption was tested before subjecting the study variable to t test and ANOVA.

Contact angle measurements were significantly higher in Wet Mouth™ and Mouth Kote™ solution of heat cure resin group compared to the CAD-CAM group (p-value<0.05 for both) indicating that both the artificial saliva substitutes had better wettability on CAD-CAM denture base (table 1).

Mouth Kote™ had lower mean contact angle ( $62.63^\circ \pm 4.59$ ) than Wet Mouth™ ( $77.46^\circ \pm 9.16$ ) on CAD/CAM denture base resin. Mouth Kote also had lower mean contact angle ( $70.80^\circ \pm 4.79$ ) than Wet Mouth™ ( $97.77^\circ \pm 7.79$ ) on injection moulded denture base resin (table 2).

Among the four solutions used, Mouth Kote™ had best wettability (least contact angle) followed by human saliva, Wet Mouth™ and distilled water in both the groups of specimens (CAD-CAM and heat polymerized).

**Table 1.** Inter-material group comparison (CAD-CAM vs injection moulded) of mean angular measurement according to type of solution.

Solution	Angle (Deg)				P-value
	CAD-CAM (n=40)		Injection Moulded (n=40)		
	Mean	SD	Mean	SD	
Distil (n=10)	95.31	4.67	88.17	4.34	0.037*
Wet Mouth (n=10)	77.46	9.16	97.77	7.79	<b>0.005**</b>
Mouth Kote (n=10)	62.63	4.59	70.80	4.79	<b>0.025*</b>
Human Saliva (n=10)	73.94	6.26	75.92	5.77	0.617 <sup>NS</sup>

P-value by independent sample t test. P-value <0.05 is considered to be statistically significant. \*P-value<0.05, \*\*P-value<0.01, NS-Statistically non-significant.

**Table 2.** Inter-Solution group comparison of mean angular measurement.

Solution	Angle (Deg)			
	CAD-CAM (n=40)		Injection Moulded (n=40)	
	Mean	SD	Mean	SD
Distil (n=10)	95.31	4.67	88.17	4.34
Wet Mouth (n=10)	77.46	9.16	97.77	7.79
Mouth Kote (n=10)	62.63	4.59	70.80	4.79
Human Saliva (n=10)	73.94	6.26	75.92	5.77

**P-value (Inter-Solution)**

Distil v Wet Mouth	0.003**	0.115 <sup>NS</sup>
Distil v Mouth Kote	0.001***	0.001***
Distil v Human Saliva	0.001***	0.026*
<b>Wet Mouth v Mouth Kote</b>	<b>0.013*</b>	<b>0.001***</b>
Wet Mouth v Human Saliva	0.999 <sup>NS</sup>	0.001***
Mouth Kote v Human Saliva	0.081 <sup>NS</sup>	0.999 <sup>NS</sup>

P-value by ANOVA with Post-Hoc Bonferroni's correction for multiple group comparisons. P-value <0.05 is considered to be statistically significant. \*P-value<0.05, \*\*P-value<0.01, NS-Statistically non-significant.

## DISCUSSION

The null hypothesis was rejected since a statistically significant difference was found in wettability of the two test resins with the different artificial salivary substitutes.

Heat polymerized acrylic resin dentures are the most commonly used type of material by clinicians. However, its fabrication is a time consuming procedure and involves a lot of manual labour. One of the fastest evolving aspects of modern prosthodontics is CAD/CAM technology. Dentures fabricated using this technique involve minimal time and manual labour. Other disadvantages of heat polymerized dentures such as polymerization shrinkage and the possibility of porosities in the denture are also addressed by the CAD/CAM technique.

For a denture to show adequate adhesion to the supporting tissues, the saliva must wet and flow easily over both the contact surfaces i.e. intaglio surface of the denture and the denture bearing mucosa. The flow properties seem to have a huge impact on the clinical efficacy of saliva or its substitutes in addition to viscosity of the liquid; since saliva helps enhance the retention of complete dentures through multiple factors. Wettability on oral mucosa and denture base resin is indispensable for the maintenance of lubrication and denture retention. Patients with hyposalivation have

problems with mastication, swallowing, and speech. Dry mouth makes the mucosa prone to irritation and epithelial atrophy; leading to possible inflammation, fissuring, and ulceration. Wettability can be measured in terms of the contact angle that a liquid forms with the surface being tested. Contact angle has been found to be inversely proportional to wettability.

Current treatment options for patients with xerostomia include intrinsic and extrinsic approaches. Intrinsic approach involves using sialogogues such as pilocarpine and cevimeline. The extrinsic approach is to administer salivary substitutes. The aim of developing salivary substitutes is to attain a viscoelastic configuration comparable to that of human whole saliva. A variety of materials have been used as artificial saliva substitutes over the years. These substitutes have proved to be excellent agents for the palliative treatment of hyposalivation at present. They provide increased lubrication and moisturizing effect of the oral cavity and are available in a range of formulations such as gels, sprays, solutions and oils. The commonly used substitutes are mucin based or carboxymethyl cellulose (CMC) based or herbal saliva substitutes. However, mucin-based saliva substitutes are obtained from porcine gastric tissues which makes it unacceptable for people who keep away from pork. Carboxymethyl cellulose based substitute such as Wet Mouth™, on the other hand, is derived

from natural cellulose. Mouth Kote™, the saliva substitute used in the study, contains yerba santa which is a natural herb and sorbitol which is a natural sweetener.

Aydin et al, in their study concluded that the mucin, carboxymethylcellulose, and concentrated ion materials all had superior wetting properties than human saliva on the denture base resin.[1] Vissink et al[10] had similar results in their study. However, Ramanna PK [11] did not find any significant difference between the contact angles of human saliva, distilled water and a CMC based saliva substitute. The current study indicates that the herbal saliva substitute has better wettability than CMC based saliva substitute. Ziad Al-Dwairi [12] et al measured the contact angles made by CAD-CAM and PMMA with distilled water and found no significant difference between the contact angles in the two groups. The current study shows that there is a significant difference between the contact angles of the saliva substitutes on CAD/CAM and injection moulded PMMA. Reijden et al [13] believed that new saliva substitutes should not only possess suitable rheological properties but also need more muco-adhesive activity so that the retention of a saliva substitute may be enhanced by acrylic resins binding onto the mucous layer of the oral mucosa.

The limitations of the study include that in vitro investigations cannot duplicate the clinical situation.

Clinically, the tissue surface of the denture is irregular, whereas the surface of the test specimens was flat. A better understanding of the flow properties of human saliva and salivary proteins may be a rational approach for the development of a more effective artificial saliva substitute. Dynamic contact angle measurements will give a better insight into the rheological properties of the saliva substitutes.

Within the limitations of this study, it is recommended that CAD/CAM denture bases should be given along with Mouth Kote™ in patients having hyposalivation.

## CONCLUSION

Mouth Kote had better wettability than Wet Mouth on both CAD-CAM and injection moulded acrylic resin. Both the saliva substitutes had better wettability on CAD-CAM than on injection moulded acrylic resin.

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