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RESEARCH ARTICLE

Evaluation of Acrylic Resin Surface Wettability Impregnated with Antifungal Agent

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ABSTRACT

Denture stomatitis and other fungal infections have increased the demand for developing modified denture base materials by incorporating active pharmaceuticals to minimize these problems. Fluconazole is one of the frequently used medications to treat fungal infections particularly those caused by *Candida Albicans* which have been incorporated with acrylic resin denture base material. Surface wettability play a significant role in the success of this mechanism. This study was performed to evaluate the effect of fluconazole incorporation with acrylic resin (polymethylmethacrylate) on surface hydrophilicity of the denture base material. Two groups of specimens were prepared and tested in this study, control and fluconazole-loaded, with 8 specimens for each group. The experimental group specimens were loaded with 10% fluconazole of powder-polymer ratio during the mixing stage of specimens' preparation. All specimens were submitted to water contact angle measurements. The results showed that there was no statistically significant difference in surface hydrophilicity of the acrylic resin between the groups. Fluconazole impregnation to acrylic resin did not affect the surface hydrophilicity of the denture base material.

Keywords: Acrylic resin; Fluconazole; Surface wettability

1 Introduction

Acrylic resin, specifically polymethylmethacrylate (PMMA), is widely used in dentistry, medical, and industrial applications due to its versatile properties, such as mechanical strength, transparency, ease of handling and molding, in addition to its biocompatibility. In dentistry, PMMA is primarily utilized in the construction of dental prostheses, which include partial or full dentures, crowns, bridges, and other restorative dental devices [1][2][3][4][5]. This polymer shows acceptable mechanical and physical properties which made it suitable for such types of restorations as they require sufficient strength and durability to withstand the occlusal load during mastication [6][7]. PMMA is mainly available in clear and pink forms to make the denture matching the color of oral tissues when being worn by the patient for acceptable esthetics [8]. Giving that the oral cavity contains a diverse range of microorganisms, there is a great incidence of biofilm formation on the denture surface especially when it is worn for long periods of time with insufficient disinfection practice [9]. Denture stomatitis which is a common inflammation that affect the oral mucosa of denture wearers is caused by *candida albicans*. It usually affects up to 67% of the denture wearers especially when keeping the denture worn overnight with poor oral hygiene [10][11]. Fluconazole is a drug that belongs to azole antifungal group that is used for prevention and treatment of a variety of yeast and fungal infections particularly those which are caused by *candida albicans* [12][13]. According to the literature, one of the solutions proposed for this problem was to impregnate the denture base with antifungal or antibacterial drugs to condition the denture surface by decreasing the susceptibility of microorganism adhesion and to act as a drug delivery system for eluting certain doses of the drugs to the oral tissues for some cases that require this level of treatment. Drug impregnation process can be achieved by adding the drug material to PMMA polymer during manufacturing stage of the denture [14][15]. Although some drug additions might

significantly affect the color properties of the acrylic denture [16], constant elution and minimal change in mechanical properties of acrylic dentures has been successfully proven in some studies [17][18]. It was found by a previous study that loading PMMA with fluconazole at a concentration of 10% would deliver a constant daily dose of the drug at simulated oral environment for 28 days. This sustained antifungal release was confirmed with no significant effect n several surface and mechanical properties of the PMMA [19]. Observing surface properties of the modified denture base material is crucial since it would significantly impact the biological behavior of the material in the oral cavity [20][21]. It is hypothesized that surface hydrophilicity is a contributing factor for the success of drug impregnated denture surface in reducing the incidence of biofilm formation. It enhances the interaction between the impregnated denture surface and the oral environment [22], thus, by aiding in the prevention of microbial adhesion and biofilm formation on the denture surface. Therefore, this study aims to evaluate surface wettability (hydrophilicity) of acrylic resin denture base material impregnated with fluconazole antifungal drug.

2 Methods

2.1 Specimens preparation

A total of 16 specimens were manufactured and used in this study. The specimens were made from clear heat-cured acrylic resin material (Veracril, Colombia). Wax patterns were designed for dental stone mold preparation. The specimen's dimensions were 30mm length 10mm width and 3mm thickness. The ordinary procedures were followed for heat cure acrylic resin processing including wax elimination, acrylic resin packing, thermal curing in a water bath, deflasking, and finally finishing and polishing. The experimental group were prepared similarly except for fluconazole powder loading to the acrylic resin powder at a powder concentration of 10% as recommended by the literature [13]. Both control and experimental specimens were surface wiped with 70% ethanol solution and Texwipe tissue before being submitted for surface hydrophilicity test by conducting water contact angle's measurements.

2.2 Testing method and statistical analysis

Contact angle measurements were conducted by placing a water droplet on the specimen's surface using a platinum needle which was heated after each droplet placement to eliminate any possible contamination. A digital microscope (Digimicro, China) was used for taking micro-images for the droplets on the acrylic resin surface with magnification power of 200X. For more accurate and reliable results, only droplets with diameter of less than 2mm were included in the study to minimize gravitational effect and to improve droplet profile. Then, digital images were taken for each droplet by the digital microscope. The images were processed via ImageJ software for contact angle measurements of both sides of the droplet as shown in Figure (1) to avoid any possible receding effect of the droplet as a result of manual placement on the surface.

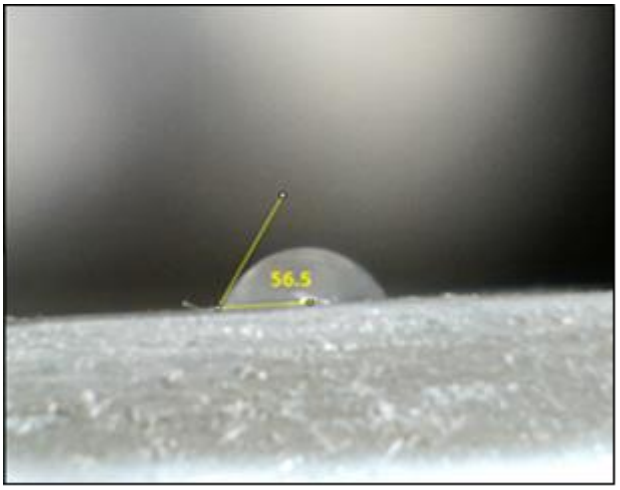

Figure 1: *Micro-image with contact angle measurement*

The average angle data was calculated as shown in Table (1). The experiment was conducted under controlled temperature of (23 ± 2°C), and relative humidity of (50 ± 5%). The collected data were analyzed statistically for significant difference using IBM SPSS software (Version 20) by performing Independent Sample T Test as well as descriptive statistics.

3 Results

According to Table (1), the normality test was performed for the contact angles' data. Kolmogorov-Smirnov and Shapiro-Wilk tests suggest that the data follows a normal distribution. The p-value for Kolmogorov-Smirnov test was 0.200 which is greater than the commonly used significance level of 0.05, indicating that the data does not significantly deviate from normality. Similarly, the Shapiro-Wilk test p-value was higher than 0.05 that also supports the assumption of normal distribution of the study data. Based on the descriptive statistics for the study groups, the control group's mean value was 54.41° (SD = 9.36°), while the fluconazole-loaded group's mean value was 45.68° (SD = 11.26°) as shown in Table (2). This indicates that control group displays a higher mean contact angle compared to the fluconazole-loaded group, with a slightly lower standard deviation. Since Levene's test for equality of variances indicated that the assumption of equal variances was not violated (p = 0.55) suggesting that the variances between the two groups (control and fluconazole-loaded) are equal, the Independent Sample T test for significant difference showed that the p-value was 0.11 which indicates that there was no significant difference in the contact angles' measurements between the study groups (p-value > 0.05) as illustrated in Table (3).

Table 1: *Normality test for the study groups' data*

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Contact Angle	0.08	16.00	0.200*	0.99	16.00	1.00

Table 2: *Descriptive statistics of the study groups' data*

Groups		N	Mean	Std. Deviation	Std. Error Mean
Contact Angle	Control	8.00	54.41	9.36	3.31
	Fluconazole-loaded	8.00	45.68	11.26	3.98

Table 3: *Independent sample T test results*

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Contact Angle	Equal variances assumed	0.37	0.55	1.69	14.00	0.11	8.73	5.18	-2.37	19.83
	Equal variances not assumed			1.69	13.55	0.11	8.73	5.18	-2.41	19.87

4 Discussion

When a material is placed in a biological environment, certain reactions would develop at the interface between the material and the biological medium. Therefore, studying materials' surface properties is necessary to understand such behavior. Then, the surface would be carefully designed to simulate the intended biological reaction depending on the purpose of the restoration. Removable dentures are mainly constructed from acrylic resin specifically PMMA resin. Wettability plays a significant role in the interaction between materials and biological tissues, influencing factors such as adhesion, comfort, and overall performance, in addition to determining the incidence of biofilm formation. The combination of antimicrobial drug with the denture base material has significantly minimized the biofilm formation [23][24]. A common issue associated with PMMA denture wearing patients is the development of denture stomatitis which is a condition caused by *Candida Albicans*. Fluconazole is one of the frequently used drugs for the treatment of this condition. The molecular structure of this synthetic medication is composed of Triazole ring, Fluorophenyl Group, and hydroxyl group as illustrated in Figure (2). Although Fluorophenyl is significantly hydrophobic, the presence of hydroxyl and triazole dominate that effect and promote more surface hydrophilicity. PMMA is chemically based on methacrylate group and methyl group which reflect a more hydrophobic nature for the material.

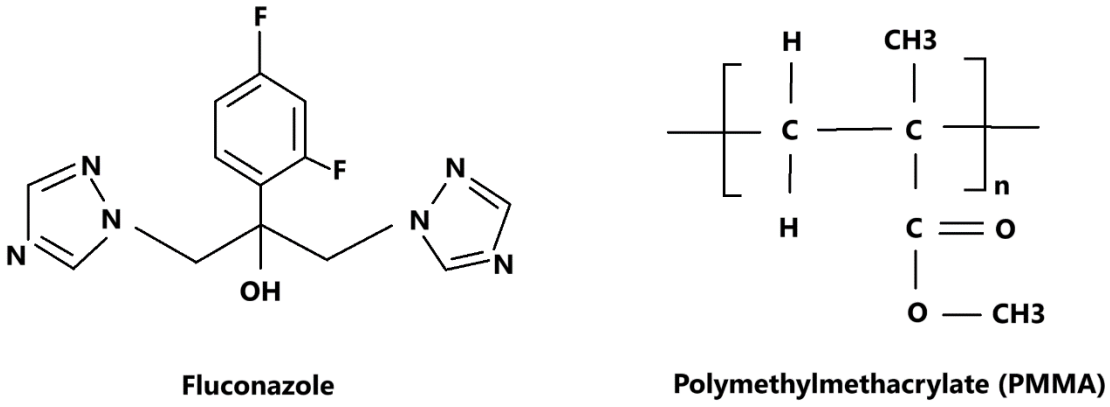

Figure 2*: Molecular structures for fluconazole and PMMA*

According to this study, fluconazole-loaded PMMA have shown lower mean contact angle value which indicates more surface hydrophilicity. This might be due to the hydrophilic nature of the drug that relatively enhanced the property for the modified PMMA [25]. However, the greater data variance observed in this group, as indicated by the standard deviation, was not statistically significant following the t-test analysis. According to Yildirim and his associates, it was found that increasing surface wettability of the acrylic resin denture base material by glow discharge treatment would increase the incidence of candida albicans fungus adherence on the denture surface [26]. However, other studies reported that hydrophobic *Candida albicans* adhesion to acrylic resin denture base material can be minimized by increase surface hydrophilicity [27][28]. This study concluded that Fluconazole antifungal drug impregnation to acrylic resin material did not change the surface wettability of the resin to a significant level. Further studies testing other antimicrobial drugs additions to acrylic resin denture base material is highly encouraged.

5 Conclusion

Surface wettability is a contributing factor in the success of antimicrobial modified denture base material. This study was conducted to evaluate the impact of fluconazole antifungal drug incorporation to acrylic resin denture base material on its surface hydrophilicity. The study results showed no significant effect on surface hydrophilicity resulted from fluconazole incorporation with acrylic resin denture base material at a

loading concentration of 10% powder-powder ratio. Further studies on water sorption and solubility are encouraged for future work.

6 Declarations

6.1 Competing Interests

The author declares that there is no conflict of interests regarding the publication of this paper.

6.2 Publisher's Note

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