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The effect of some disinfectant solution on the surface roughness of poly methyl methacrylate -Based Polymers

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ABSTRACT Objectives: The study aims to evaluate the effect of some disinfectant solution on surface roughness of three types of PMMA-Based Polymers.

Materials and Methods: Three types of PMMA (conventional –PMMA, Zirconium Oxide Nano-Fillers (zro2) were added to conventional PMMA, CAD/CAM PMMA-based polymers) are then immersed in three types of disinfectant solutions (Chlorhexidine 2%, Glutaraldehyde 2%, Sodium hypochlorite 1%). Distilled water was used as control, to measure the effect of these solutions on flexural strength after immersion for 8 hours. Between the immersion procedures, specimens were kept in distilled water at room temperature (23±2°C) for 16 h. Each day, a fresh denture cleanser solution was prepared and the process was continuously repeated for 30 days.

Results: The results showed that 1% sodium hypochlorite significantly increases the surface roughness of all types of PMMA that used in our study.2% chlorhexidine and 2 % glutaraldehyde insignificantly increases the surface roughness. .

Conclusion: There was effects on surface roughness after immersion the specimens in disinfectant solutions..

Keywords: poly methyl methacrylate, Zirconium Oxide Nano-Fillers, Chlorhexidine, Glutaraldehyde, Sodium hypochlorite, flexural strength.

I. INTRODUCTION

For many years, Dentures have been used to treat edentulism for many years and are regarded the gold standard. [1] ,Because of its simplicity of manipulation and handling, lack of toxicity, good esthetic quality, suitable weight, and simplicity of reparability, durability in the oral environment, low solubility, reasonable cost, and low water sorption, it became the most preferred denture base material. [2], Due to the brittleness of PMMA on touch, acrylic dentures are liable to breakage both intra-orally and extra-orally. [3]

PMMA, on the other hand, has been criticized for its mechanical properties. Dimensional changes, crack resistance, remnant monomers, and a great incidence risk of denture-associated infections are only a few of the disadvantages of PMMA. [2], the use of denture cleaners on a daily basis might affect the physical and mechanical characteristics of denture base material. To prevent negative results, consider the consistency of the disinfectant with the form of substance to be disinfected when using a disinfectant for a dental prosthesis. [4]

Methacrylate is stable polymers that do not decompose into constituent monomers in methacrylate-based dental products. Non-polymerized monomers. [5]

For the past 100 years, denture materials and processes have been unable to evolve. Around 1910, the “age of thermoplastics” began, with the substitution of Vulcanite with polymethyl methacrylate (PMMA) and a compression molding process. [6] ,Denture acrylic resins are named and categorized based on how they are manufactured, including auto-polymerizing resin, light cure acrylic, heat-cure acrylic resin, and resins polymerized specially in microwave processing.[7]

Heat-cured acrylic resins are an example of acrylic resins that use the heat polymerization method, and they are frequently used in denture base manufacturing because they are less expensive, easier to apply, and require fewer tools. [8]

Roughness, stiffness, and wettability of acrylic denture surfaces have all been linked to denture-associated stomatitis. "Small indentations or irregularities that characterize a surface and have an influence on wetting, adhesion consistency, and brightness," according to the definition of surface roughness. [2], Surface roughness is determined by the presence of porosity and other flaws in the material. The roughness of a restorative or prosthetic material's surface influences its properties and may reduce its durability. Furthermore, increased surface roughness

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encourages microbe adhesion and the formation of biofilms. [9]

Heat-cured acrylic resin denture cleanser is thought to cause roughness on the denture's surface. Acrylic resin denture cleaners have a negative effect on this. Surface roughness in acrylic resin dentures encourages bacteria, plaque, and food debris to adhere to the surface. [8] ,Surface roughness affects Candida albicans adherence and early biofilm development on acrylic surfaces, most likely because PMMA provides a larger surface area and protected locations for colonization. Some studies have found a direct relationship between surface roughness and Candida albicans; both plaque accumulation and the organism's adherence were boosted when surface roughness was increased. [10]

NaClO, as a strong oxidant, can also cause significant sludge foaming and the subsequent release of dissolved organic matter during on-line chemical cleaning of membranes in MBRs. [11], Chlorhexidine digluconate, which has fungicidal properties and is also useful in controlling denture biofilm, is one of the solutions used for cleaning and disinfecting full dentures. Despite their protective properties, prolonged use of these cleansers has been linked to certain negative side effects. Denture bases can become stained if chlorhexidine solutions are used for an extended period of time. [12], Glutaraldehyde is a disinfectant that kills germs by penetrating resin surfaces, disintegrating biofilm, and blocking enzymatic activity of microorganisms. An immersion period of minutes has been shown to be suitable for disinfecting heat-cured acrylic resin. [13]

II. MATERIALS AND MEHODS

Materials disinfectant solutions used in this research work are listed in Tables (1).

Equipment:

The Equipment used in this study included the following:

- Universal testing machine (jianqiao-china).
- Surface roughness tester TR200 / TR220 (Beijing TIME-china).
- CAD\CAM milling machine (dentium-south Korea)
- Digital Vernier caliper (synttek01-10, China).
- Elecronic kitchen scale (swarg – india)
- Dental flask and clamp
- Sheet wax
- Lab top dell (china)
- Glass dishes
- Dental lab micro motor (surident- India)
- Rubber bowel.
- Spatula.
- Water distiller (Aifan, AF-WD11, china).
- polishing machine (black and decker – USA)

Specimens processing

1 Conventional PMMA and zro2 PMM

Sheet wax used to make sample of specimens 60 x 10 x 2 mm according to recommendations of ISO 20795-1:2008, that used to make mold Figure (2-1), by flasking it in dental stone and after setting of stone, wax was eliminated and based on the manufacturer's instructions, the heat-polymerized acrylic resin (3:1) was mixed and left to reach a dough stage at room temperature. Acrylic dough was packed into the mold; the flask halves were closed and pressed using a hydraulic press for 5 min. The flask was placed into a water bath curing unit and processed by heating it to 100°C for 30 min. The flask was slowly cooled to room temperature for 30 min followed by an immersion in cool tap water for 15 min before deflasking. After complete polymerization and cooling, the flask was opened and the acrylic specimens were taken out of the flask and finished using acrylic bur, where any excess resin was removed. Finishing of the specimens was done using silicon carbide discs (Grit 600) by a polishing machine (black and decker –USA) at 250 rpm, followed by a cloth wheel, and a 0.5-µm diamond suspension to polish. All the specimens were examined to confirm proper dimensions using a digital caliber with 0.01 mm accuracy (Electronic Digital Caliper). The specimens were divided into four test groups for each test, according to type of disinfectant solutions.

2. CAD\CAM PMMA

By using hyperdent cam software, the design of specimens was made 60 x 10 x 2 mm according to recommendations of ISO 20795-1:2008. And milled by using CAD\CAM milling machine (dentium-south Korea) figure (2-2), cutting sprue by disk bur Finishing of the specimens was done using silicon carbide discs (Grit 600) by a polishing machine at 250 rpm.

Disinfectant solution preparation

The specimens of each subgroup were immersed at the same time in the individual denture box for 8 h with the surface to be measured facing upward, ensuring that the solution covered all specimens). Specimens immersed in distilled water served as the control group. Between the immersion procedures, specimens were kept in distilled water at room temperature (23±2°C) for 16 h. Each day, fresh denture cleanser solution was

prepared and the process continuously repeated for 30 days.

1. Glutaraldehyde 2%:

Glutaraldehyde 25% was diluted by add 1250 ml of dstilled water to 100 ml of glutaraldehyde to obtaine 2% glutaraldehyde

C1 x V1 =C2 x V2

25% x 100 ml = 2% x V2

V2= 1250 ml

2. Sodium hypochlorite 1%:

Sodium hypochlorite 5.25 % was diluted by add 525 ml of dstilled water to 100 ml of sodium hypochlorite to obtaine 1 % sodium hypochlorite

C1 x V1 =C2 x V2

5.25 % x 100 ml = 1% x V2

V2= 525 ml

3. Chlorhexidine 2%

Already prepered to 2% concentration

Experiments criteria

•All test samples prepared according to recommendations of ISO 20795-1:2008.

•The procedures of testing were done at room temperature of (23± 2°C) and (50 ± 10%) relative humidity

•Materials, nanoparticles and the water that used in this study were kept in closed container at (23±2°C) temperature and (50±10%) relative humidity.

The experimental Design

1- Control group (in distilled water): 5 specimens of pmma

5- Group B1 (conventional PMMA immersed in 2%glutaraldehyde solution):5 specimens.

6- Group B2 (conventional PMMA immersed in 2%chlorhexidine solution):5 specimens.

7- Group B3 (conventional PMMA immersed in 1% sodium hypochlorite solution):5 specimens.

Measurement of flexural strength

All samples were tested for flexural strength with a 3-point bending test with a universal testing at a crosshead speed of 2 mm/min. A load was applied by a centrally located rod until fracture occurred. The acrylic specimens were inserted in universal testing machine with no delay. The initial applied force was zero followed by a gradual increase. The amounts of flexural strengths in MPa were calculated according to the formula sf= 3×P×L/ 2×b×h2

F = the maximum applied force in Newton;

L = the distance between the supporter arms of the machine in mm,

b = the width of the specimens in mm, measured immediately prior to water storage

h = the height of the specimens in mm, measured immediately prior to water storage; as it was mentioned,

the amount of L, b and h were 50 mm, 10 mm and 2 mm respectively.

Statistical Analysis:

The results were statistically analyzed including mean and standard deviation after all data has been collected.

SPSS statistics version 25 (IBM, USA) was used to achieve the Statistical analysis as following:

1. One-way analysis of variance (ANOVA) was used to show if there is a significant difference among groups of dental plaster.

2. Duncan's multiple range tests was used to determine the levels of significance among the experimental dental plaster groups.

$p \leq 0.05$ was used for Statistical Analysis for all tests..

III.RESULTS

Figure (1) shows the mean and standard deviation values of surface roughness of Conventional PMMA that was immersed in different disinfectant solutions.

one-way analysis of variance (ANOVA) that shown in Table (2), values of surface roughness of Conventional PMMA that was immersed in different disinfectant solutions(Chlorhexidine , Glutaraldehyde, Sodium hypochlorite), distilled water used as control. That shows significantly different at $P \leq 0.05$.

Surface roughness is increased significantly when immersed in 1% Sodium hypochlorite and no significant difference between the control and the other solutions

Table (3) Duncan's Multiple Range Test for Surface roughness of Conventional PMMA that was immersed in different disinfectant solutions(Chlorhexidine , Glutaraldehyde, Sodium hypochlorite), distilled water used as control

Duncan's Test show significant difference between the control and 1% sodium hypochlorite ,But no significant difference between the control and 2%chlorhexidine and 2% glutaraldehyde , also no significant difference between 1% sodium hypochlorite and 2%chlorhexidine and 2% glutaraldehyde

IV.DISCUSSION

The surface roughness of denture materials is critical because it might impact the binding of bacteria directly or indirectly. Microorganisms can adhere to denture rough edges, particularly the tissue surface. [14], Because of

porosity, the roughness profile is strongly related with residual MMA monomer. So, for a week before testing, the specimens were submerged in distilled water to decrease the quantity of residual MMA monomer. [15], Roughness has an impact on the patient's comfort and the durability of the prosthesis. A smoother surface produces superior esthetic outcomes while retaining less biofilm. [16]

Surface roughness, as described by Ra values, is a well-known approach for determining surface textures in research. Ra values to measure surface roughness were recorded and compared before and after cleaning chemical exposure in the current investigation. The surfaces of all specimens got considerably rougher after immersion treatments. The increase in roughness, however, did not reach 2 Mm, which is considered a threshold value for microbial colonisation. [15] the clinically acceptable Ra value for acrylic resin, according to ISO 20795-1, is 0.2m.[17]

Several in vitro and in vivo experiments have demonstrated that chemical treatments are efficient in removing biofilm, food debris, and cigarette stains from the denture surface. Chemical cleaners can fully disinfect dentures, but it is vital to understand how these chemicals affect the characteristics of denture base material over time. Surface roughness impacts biofilm development by providing retentive regions for food waste and bacteria. An increase in surface roughness might make biofilm removal even more difficult. [18], when subjected to denture cleaners, the roughness of denture foundation acrylic resin has been frequently documented, and alterations in surface morphology have been detected. [19] ,Although studies have revealed a change in surface roughness of the acrylic resin denture base when exposed to denture cleaners, the influence of denture cleaners on the characteristics of acrylic resins during lengthy immersion durations has not been thoroughly explored. Over time, the cumulative action of disinfectants can have a detrimental impact on the mechanical and surface characteristics of acrylic. As a result, in the latest investigation, the time of day 30 was taken into account for placing the samples in the disinfectant solutions. [14]

The roughness values of the samples disinfected with 1 percent sodium hypochlorite increased as compared to the control group but did not differ from the other groups. According to current research, samples submerged in 1% sodium hypochlorite had a statistically significant increase in roughness when compared to the control group. [16]

The roughness of acrylic specimens was enhanced by sodium hypochlorite ($p < 0.05$). The current study's findings are consistent with those of Porwal A et al., Paranhos HDFO et al., Carvalho CF et al., Da Siva FC et al., and Pisani MX et al., who discovered that sodium hypochlorite produced changes in the surface roughness of acrylic. (Sharma, P.,et al,2017),Savabi show that Disinfection solutions containing 1% sodium hypochlorite and 2% glutaraldhyde can have a negative impact on the flexural strength of the investigated denture base resins. [20]

According to Duyck et al. and Pinto et al., frequent chemical cleaner immersions considerably enhance the surface roughness of acrylic base material. According to Schwindling et al., chlorhexidine can induce a small increase in surface roughness but has no influence on Ra. These disparities can be attributed to a variety of variables, including immersion length, PMMA polymerisation, and denture polishing procedures [15], Immersion in glutaraldehyde, indicate that immersion in these cleaning agents had no effect on the roughness of typical acrylic resin. Immersion in chemical solutions for denture cleaning should not cause any physical, mechanical, or chemical changes to the denture materials. [21]

V.CONCLUSION

After 30 days of immersion the specimen in disinfectant solutions the following point can conclude our study: 1% sodium hypochlorite disinfectant solution significantly increases the surface roughness of conventional PMMA, 2% glutaraldehyde disinfectant solution increases the surface roughness of conventional PMMA but not significantly. 2% chlorhexidine disinfectant solution the surface roughness of conventional PMMA but not significantly..

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Table (1): Materials disinfectant solutions used in this research

Product	**Manufacture**
conventional PMMA	Integra-turkey
Glutaraldehyde	Avonchem-UK
Chlorhexidine	Cerkamed – Poland
sodium hypochlorite	Cerkamed – Poland

Table (2): ANOVA for Surface roughness of Conventional PMMA that was immersed in different disinfectant solutions (Chlorhexidine, Glutaraldehyde, Sodium hypochlorite), distilled water used as control

S.O.V	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.780	3	.593	3.675	.035
Within Groups	2.583	16	.161		
Total	4.363	19			

S.O.V: Source of variance; df: Degree of freedom; F: F value.; Sig: Significance.

Table (3): Duncan's Multiple Range Test for Surface roughness of Conventional PMMA that was immersed in different disinfectant solutions(Chlorhexidine , Glutaraldehyde, Sodium hypochlorite), distilled water used as control

Duncan

		Subset for alpha = 0.05	
VAR00001	N	1	2
1.000	5	.79980	
2.000	5	1.13660	1.13660
3.000	5	1.16900	1.16900
4.000	5		1.63780
Sig.		.187	.079

Means for groups in homogeneous subsets are displayed.

N: number of sample.

Figure (1) Mean and standard deviation of flexural strength values Conventional PMMA that was immersed in different disinfectant solutions