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The effect of some disinfectant solution on the flexural strength of poly methyl methacrylate -Based Polymers

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ABSTRACT Objectives: The study aims to evaluate the effect of some disinfectant solution on flexural strength 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 1% sodium hypochlorite significantly decrease the flexural strength of all types of PMMA that used in our study.2% chlorhexidine and 2 % glutaraldehyde insignificantly decrease the flexural strength. .
Conclusion: There was effects on flexural strength after immersion the specimens in disinfectant solutions..
Keywords: poly methyl methacrylate, Zirconium Oxide Nano-Fillers, Chlorhexidine, Glutaraldehyde, Sodium hypochlorite, flexural strength.

I. INTRODUCTION

For decades, the most prevalent material for denture fabrication has been acrylic resin polymethayl methacrylate (PMMA). [1], PMMA (polymethyl methacrylate) is a biocompatible organic polymeric composite that is used to make denture bases. [2]

Acrylic resins are ethylene-derived organic compounds (polymers) that result from the reaction of methylpolymethacrylate and methylmethacrylate, which are typically supplied in powder and liquid form, respectively. Polymerization is the joining of monomers in a molecule, which is a malleable and moldable mass. [3]

For medical and financial purposes, conventional dentures are still the safest option in many cases. A perfect denture base material would have ample technical and functional features, as well as biocompatibility and aesthetics. Polymethyl methacrylate is one such material (PMMA). [4]

Denture bases with high thermal conductivity improve patient comfort, tissue preservation, taste sensitivity, and reduce the sensation of the denture as a foreign body in elderly patients. Polymers are generally regarded as thermal insulators due to their lower internal thermal conductivity than metals and ceramics. [5]

A typical material used as a denture base is heat cured acrylic resins. [6], PMMA is often sold as a powder–liquid mixture. The powder contains a pure polymer (PMMA), as well as colors and nylon or acrylic plastic fibers to modify the physical characteristics and appearance of the powder to mimic oral tissues (such as gums, mucosa). A methyl methacrylate monomer, as well as cross-linking agents and inhibitors, is included in the liquid part. [7]

The mechanical qualities of acrylic bases are very essential and flexural strength (FS) is the one that has gotten the most attention. ISO 20795-1(2008) for dental base polymers defined a defined minimum limit for any acrylic resin FS of any polymerized material must not be less than 50 MPa, The value for denture-base polymers is 65 MPa, according to ADA Specification No. 12 and ISO 1567. [8], Flexural strength indicates material performance under static load circumstances, whereas impact strength testing comprises a measurement of energy absorbed by the material prior to fracture. [9]

The mechanical properties of dental materials are crucial to their clinical performance and are strongly linked to both processing and composition. Complete dentures, for example, which are used to restore esthetic and functional function in edentulous patients, are subjected to

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severe and complex mastication pressures that might cause fractures. Patients may find it challenging to improve resistance by increasing denture thickness, highlighting the need to consider other methods for enhancing the acrylic resin's mechanical properties. [10]

Flexural strength is one of the physical properties that can be impaired by the use of cleansers, since denture base resins can fail clinically due to flexural exhaustion. The effect of cleansers on the surface roughness of acrylic resins is also important because it may affect microorganism adhesion and retention, which can exacerbate oral problems. [11], Because of their high effectiveness against a wide variety of pathogens, including microbes, fungi, and viruses, chlorine-active compounds and hypochlorites in particular have been extensively used as disinfectants in hospitals, food institutions, and the water industry over the past 50 years. [12]

Sodium hypochlorite is a low-cost antibacterial with a broad spectrum of action. However, on metallic surface has a corrosive action and on the skin has irritative effect that will limit its uses [13], Chlorhxidin is an antimicrobial agent with a wide range of action. Its antimicrobial activity is due to its cationic bisbiguanide molecular form, which is bacteriostatic at low concentrations and bacteriocidal at high concentrations, resulting in cytoplasm coagulation and precipitation. It also has the property of substantivity. [14], Chlorhexidine has a wide range of antimicrobial action, particularly against Candida albicans. As opposed to its activity against suspended cells, the susceptibility of C. albicans biofilms to chlorhexidine was found to be substantially decreased. [15], Glutaraldehyde is a saturated dialdehyde that is widely used as a high-level disinfectant and chemical sterilant. Aqueous glutaraldehyde solutions are acidic and, in general, are not sporicidal. Only after the solution has been "activated" (made alkaline) with alkalinating agents to a pH of 7.5–8.5 does it become sporicidal. These activated solutions have a minimum shelf life of 14 days due to the polymerization of glutaraldehyde molecules at alkaline pH temperatures. This polymerization inhibits glutaraldehyde molecules' active sites (aldehyde groups) from executing their biocidal activity. [16]

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 flexural strength of Conventional PMMA that was immersed in different disinfectant solutions.

one-way analysis of variance (ANOVA) that shown in Table (2), values of flexural strength of Conventional PMMA that was immersed in different disinfectant solutions(2% Chlorhexidine ,2% Glutaraldehyde, 1% Sodium hypochlorite), distilled water used as control. That shows significantly different at $P \leq 0.05$.

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

IV.DISCUSSION

Denture base materials should have sufficient flexural strength to resist deformation under masticatory stresses while also reducing the risk of denture breakage. Several variables influence the flexural strength of PMMA denture base material, including material type, reinforcing materials, and/or denture hygiene immersion solutions. Denture cleansers are useful in keeping dentures clean and, as a result, decreasing oral disorders like denture stomatitis. Denture cleaners, on the other hand, may influence the flexural strength of the denture base material, reducing denture life; Denture cleaners may have an effect on the flexural strength of the denture base material, reducing denture life. The existence of residual monomers, which function as plasticizers, is one of the reasons that decrease the mechanical characteristics of PMMA. To address this problem, the specimens in the current research were maintained in distilled water for two days before to testing in order to minimize residual monomer. Because of its purity, distilled water was utilized as the control in this experiment. [17]

Long-term immersion in a variety of available disinfectants has no effect on the flexural capabilities of PMMA denture base material, according to many investigations. Davi et al, on the other hand, found that flexural strength was affected after immersion in 1 percent sodium hypochlorite for 180 days in a simulated environment. [18],Because of the bleaching effect and the presence of free chlorine, alkaline hypochlorite (NaOCl) solutions remove stains and food debris. [17] ,Sharma in 2017 found that immersion in 1% NaOCl resulted in a significant reduction ($p<0.05$) in flexural strength. This is consistent with the findings of Davi LR et al. and Pisani MX et al., who both found a reduction in flexural strength with the application of 1% NaOCl. [11]

Both chlorhexidine and glutaraldehyde had the least influence on denture base resin flexural strength. The flexural strength of denture base acrylic resin did not differ significantly between Glutaraldehyde and Chlorhexidine disinfectants. [19]

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 decreases the flexural strength of conventional PMMA, zro2 PMMA and CAD\CAM PMMA. 2% glutaraldehyde disinfectant solution decrease the flexural strength of conventional PMMA but not significantly2% chlorhexidine disinfectant solution decrease the flexural strength 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 flexural strength of Conventional PMMA that was immersed in different disinfectant solutions(Chlorhexidine , Glutaraldehyde, Sodium hypochlorite), distilled water used as control

ANOVA

S.O.V	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1127.661	3	375.887	6.272	.005
Within Groups	958.853	16	59.928		
Total	2086.514	19			

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

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

Duncan[a]

		Subset for alpha = 0.05	
VAR00001	N	1	2
4.000	5	60.79240	
3.000	5	70.94260	70.94260
2.000	5		74.66680
1.000	5		81.57560
Sig.		.055	.055

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