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Effect of Chemical Disinfectants on Tenile Strength, Shore Hardness, and Color Stability of Acrylic Denture Base Material

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ABSTRACT:

The capability of disinfecting dental prostheses to rapidly inactivate pathogenic microorganisms without compromising the denture base resins is essential. The objective of this inquiry was to ascertain how chemical disinfectants affected the mechanical properties of acrylic base materials (shore hardness, tensile strength, and color stability) this investigation was carried out to establish a foundation for the comparison of tensile strength, shore hardness, and color stability tests of acrylic denture bases treated with disinfectants using 2% Glutaraldehyde, 4% chlorhexidine, and 5.25% sodium hypochlorite.

Specimens were prepared according to all manufacturer recommendations. Before being submerged in the chemical disinfection, the samples were polished and then kept in distilled water at 37 degrees Celsius for about 50 plus or minus two hours. For each of the following alternatives, each sample was immersed for 10 minutes: 2% glutaraldehyde, 4% chlorhexidine gluconate, or 5% sodium hypochlorite. The samples were then immersed in water for a further three minutes. The disinfection procedures were repeated four times.

The data was analyzed statistically using SPSS, which stands for Statistical Package for the Social Sciences. The ANOVA test was used to find statistically significant differences between the groups that were tested. For multiple comparisons between the control and experimental groups, the Dunnett test was utilized. The findings of this investigation indicate that the immersion of samples in disinfectant solutions does not induce any discernible alteration in the characteristics of acrylic, in contrast to the immersion of samples in distilled water.

It may be concluded that the disinfectant solutions used were suitable for disinfection based on the findings of testing the mechanical qualities of the acrylic materials.

Keywords: Acrylic resin, color stability, chemical disinfectant, shore D hardness, tensile strength.

1 INTRODUCTION

Acrylic resin is an example of a dental polymer [1]. Hot cure acrylic resin is currently the most frequently used and recognized polymeric denture base material, although many other resins outperform polymethylmethacrylate (PMMA) in one or more qualities. No other resin can achieve the same level of aggregate performance as PMMA [1]. Touraj et al. (2019) calculated that it comprises the vast majority of prosthodontic plastics (95 percent) [2].

Acrylic resins continue to be the preferred material for denture bases owing to their commendable aesthetic qualities, sufficient strength, minimal water absorption and solubility, absence of toxicity, ease of repairability, capacity for accurate reproduction, and ability to retain pattern details and dimensions indefinitely [3].

There is a significant risk of microbial cross-contamination among health practitioners, particularly those in the dental field. Disease transmission may occur during dental procedures between patients and auxiliary personnel, laboratory technicians, and auxiliary staff if preventative and control measures are not stated. Cross-contamination and microbiological transmission in prosthetic laboratories have been identified in numerous studies as potential hazards in dentistry clinics [4,5]. Denture disinfection, which can be accomplished via microwave irradiation [6] or immersion in chemical solutions [7], is indispensable throughout the appliance and denture fabrication process to ensure that cross-contamination does not occur [8,9]. Regarding the inactivation of bacteria without causing damage to denture materials, care must be taken while selecting the disinfectant for use during immersion.

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All prosthetic appliances must be thoroughly cleaned before receipt by the dentist's office and upon arrival at the laboratory, using an effective chemical disinfection solution. This process ensures that cross-contamination does not occur [5,10].

Glutaraldehyde, sodium hypochlorite, iodoform, phenol, chlorhexidine, ethanol, and quaternary ammonium compounds are often employed as chemical disinfectants [11].

Aim of this study:

This is intended for an investigation to establish a foundation to compare the tensile strength, shore hardness, and color stability tests of an acrylic resin denture base with the disinfectants 4% chlorhexidine, 5.25 percent sodium hypochlorite, and 2% glutaraldehyde.

2 MATERIAL AND METHOD

Following immersion in three disinfection solutions along with distilled water, two hundred forty acrylics were assessed for variations in tensile strength, color stability, and indentation hardness, and the formal sample size calculation was not performed before starting the study, the number of specimens in each group was based on similar previous research and the availability of materials. To simulate the real-life scenario when the technician and dentist disinfect the prosthesis in equal measure twice, a total of four cycles of disinfection were applied to the specimens. Furthermore, the cleaning process that takes place during to sending and return of the prosthesis to the laboratory, in four groups for each test,

Group A: was the control group (without disinfectant)

Group B: was disinfected in 5.25% sodium hypochlorite

Group C: was disinfected in 4% Chlorhexidine

Group D: was disinfected in 2% glutaraldehyde.

For simulating the master plate for indentation hardness and color stability testing, a base plate wax was made with the following dimensions: length (30mm x 15mm x 2.5mm), width (25mm x 4mm x 2.5mm), and thickness (25mm x 4mm x 2.5mm). In contrast, dumbbell-shaped samples constructed specifically for the tensile strength test by slicing a wax block to the dimensions specified in ISO 527-2:1993.

Acrylic resin denture bases (Lucitone 199, Dentsply International Inc., Charlotte, NC, USA) were utilized in the current investigation. The mold was prepared in the same manner. Acrylic specimens were prepared using conventional methods. Following the completion and polishing process, the samples underwent conditioning in distilled water for a duration of 50± 2 hours at 37ºC before undergoing testing following ADA specification No. 12. (1999).

Regarding the disinfection protocols:

Group A was the control group (without disinfectant)

The remaining specimens underwent a four-time cycle of disinfection, which included soaking in disinfectant for 10 minutes followed by three minutes in water. accordingly Group B in 5.25% sodium hypochlorite, Group C in 4% Chlorhexidine, Group D in 2% glutaraldehyde.

2.1 INDENTATION HARDNESS TEST

80 specimens made of acrylic resin denture base were made using the measurements of (30 × 15 × 2.5) mm length, width, and thickness, to be used for measuring the indentation hardness of acrylic.

After the disinfection procedure had been made, Shore hardness tester type D utilized to determine the sample' indentation hardness. Each specimen was measured by making three indentations and then taking the average of those measurements.

2.2 TENSILE STRENGTH TEST

80 specimens made of acrylic resin denture base were prepared according to the dimensions given by ISO 527-2:1993 to be used for measuring the tensile strength test of acrylic.

After the disinfection procedure had been made, the tensile strength was measured for all four groups by using a computerized universal testing machine.

After the disinfection procedure had been made, the tensile strength was measured for all of the four groups by using a computerized universal testing machine.

2.3 COLOUR STABILITY TEST

80 rectangular specimens made of acrylic were prepared with the dimensions of (25 × 4 × 0.5) mm length, width, and thickness, which were used to colour stability test.

After the disinfection procedure had been made for all groups, an objective approach was used to measure the color stability test., we used a spectrophotometer to quantify the light absorption of every specimen at a 400 Nanometre wavelength.

2.4 STATISTICAL ANALYSIS

The statistical software package Statistical Package for the Social Sciences (SPSS version 26) was applied to the data analysis. The subsequent statistical approaches were implemented:

a) Significant differences between the testing groups were determined using the Analysis of Variance one-way (ANOVA) test.

b) For several comparisons between the experimental and control groups, the Dunnett test was utilized.

3 RESULT

Regarding the descriptive statistics reveal that in the tensile strength test, the control specimens have the highest mean value, and the specimens immersed in sodium hypochlorite have the lowest mean value, in the shore hardness test the control specimens have the highest mean value, and the specimens immersed in glutaraldehyde has the lowest mean value and in color stability test the chlorhexidine specimens has the highest mean value and the samples submerged in water(control) has lowest mean value.

While according to one way analysis of variance (ANOVA) and the Dunnett's test, revealed a nonsignificant difference between the experimental and control groups for each tensile strength test, shore hardness test, and color stability test as shown in table (1,2,3).

Table 1. Mean and S.D. of Tensile Strength Test Results for acrylic

Groups	Mean±SD (MPa)	P-Value Dunnett test	Sig.
Control	62.07 ± 1.19	-	-
5.25% Sodium hypochlorite	60.81± 1.79	0.438 C-S	NS
4% Chlorhexidine	61.94 ± 0.80	0.916 C-CHX	NS
2% Glutaraldehyde	61.60 ± 1.99	0.998 C-G	NS

Table 2. Mean and S.D. of shore hardness Results for acrylic

Groups	Mean±SD Kg/mm^2	P-Value Dunnett test	Sig.
Control	60.7 ± 1.22	-	-
5.25% Sodium hypochlorite	59.0± 0.97	0.830 C-S	NS
4% Chlorhexidine	59.6± 1.20	0.306 C-CHX	NS
2% Glutaraldehyde	58.8±1.18	0.490 C-G	NS

Table 3. Mean and S.D. of Color Stability test Results for acrylic

Groups	Mean±SD 400nm	P-Value Dunnett test	Sig.
Control	-0.024± 0.10	-	-
5.25% Sodium hypochlorite	-0.033± 0.11	0.996 C-S	NS
4% Chlorhexidine	-0.034± 0.04	0.996 C-CHX	NS
2% Glutaraldehyde	-0.030±0.02	0.999 C-G	NS

4 DISCUSSION

Hardness is a property that distinguishes resistance to indentation from resistance to scratching or wear [12,13]. Indentation hardness tests that are most frequently applied to dental materials include the Vickers, Shore, Rockwell, and Knoop models. For evaluating denture base materials, the Shore D Durometer test appears to be the most practical and advantageous instrument due to its ability to get an average reading across a significant surface area of the material while remaining unaffected by minute surface imperfections. Considering the consequences of disinfectant solutions on the shore hardness of acrylic resin specimens, a forty-minute immersion in solutions containing 2% glutaraldehyde, 4% chlorhexidine, and 5.25% sodium hypochlorite yields no discernible reduction in shore hardness. This conclusion may be attributed to the absence of solvent-causing chemicals, such as alcohol, in the immersion solutions, The findings align with those of the study conducted by Inas et al. [14] that non-significant reduction in shore hardness was noted in acrylic resin materials after seven days of immersion in disinfection solutions containing 2% glutaraldehyde, 0.5% chlorhexidine, and 0.5% sodium hypochlorite.

When a material is subjected to stresses in the same direction as its elongation, its tensile strength is the internally induced force that prevents this from occurring [15]. The significantly higher mean values of tensile strength observed in the acrylic resin specimens may be attributed to the crosslinked chain that forms a close polymer network, thereby increasing the molecular weight. Additionally, the covalent bonds between the molecules reduce the mobility of polymer segments by securing the chain more rigidly together [16], the obtained results are in agreement with those of [17]. A greater tensile strength was reported in the crosslinked specimens compared to the simple methyl methacrylate. Concerning the impact of disinfectant solutions on specimens composed of acrylic resin, the analysis reveals the following: These mechanical properties are not significantly altered by forty minutes of immersion in 2% glutaraldehyde, 4.25% sodium hypochlorite, and 4% chlorhexidine. The chemical disinfectants utilized in this investigation do not significantly modify transverse strength or surface texture or color, hence this result is hypothesized to be accurate, Similar findings were also obtained by the following researchers [18-21].

Resistance to environmental degradation is referred to as the "color stability" of a pigment or surface coating [22]. In addition to possessing satisfactory mechanical properties, the color stability of several denture bases that facilitate and accelerate processing is particularly noteworthy. Spectrophotometers were utilized to assess the color stability in the current investigation. The findings of this research indicate that there was no substantial alteration in color following immersion in a disinfectant solution and distilled water. As previously shown by [23], they concluded that discoloration of various acrylic resins was least induced by disinfectants containing 1% sodium hypochlorite and 2% glutaraldehyde. Furthermore, the results shown here align with the conclusions that were reported by [24,25], which suggested that 24-hour immersion in denture cleansers did not have an impact on the color stability of traditional PMMA and nylon materials. A study conducted by [25] examined the impact of five disinfectants—acid glutaraldehyde (2%), alkaline glutaraldehyde (2%), sodium hypochlorite (5.25%), iodophor, phenol—on five denture base resins. Except for iodoform, the examined materials exhibited negligible variations in color during both short and extended periods of immersion (7 days).

CONCLUSION

Acrylic resin denture base material can be disinfected for forty minutes in 2% Glutaraldehyde, 4% Chlorhexidine gluconate, and 5.25% Sodium hypochlorite solutions without inducing clinically perceptible or statistically significant changes in their physical or optical properties.

Spectrophotometer analysis confirmed that no substantial color alteration occurred among the tested acrylic resins.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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