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ORIGINAL RESEARCH

EFFECT OF CLOVE AND CHLORHEXIDINE DISINFECTANT SOLUTIONS ON DIMENSIONAL ACCURACY AND IMPACT STRENGTH OF HEAT CURE ACRYLIC DENTURE BASE MATERIAL

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Abstract

Background: Heat-cured acrylic resin (PMMA) is the most commonly used material for denture bases because of its favorable properties. However, dentures easily accumulate microbes so maintaining a clean denture is very important to preserve oral health. A chemical or herbal immersed denture cleanser is the most widely used method by patients. The goal was to assess the efficiency of two disinfection solutions, one chemical (chlorhexidine digluconate 0.20% CHX) and the other ethanol herbal extract (clove), on the dimensional accuracy and impact strength of heat-cure acrylic-resin material.

Materials and Methods: The study design was divided into two main groups, the first was dimensional accuracy (I) which had 24 specimens of heat cure acrylic material as the same specimen was used in each subgroup measurement for this test while the second was impact strength (II) which had 56 specimens. These main groups were divided to three subgroups: first before immersion, for measured impact strength with (n=8), while for dimensional accuracy all 24 specimens was measured and the second subgroup with (n=8) for immersion of specimens in the three disinfectant solutions (CHX, clove, and distilled water, D.W. as a control group) separately for 3 nights then 7 night.

Results:For the dimensional accuracy, the results show that dimensional reduction happened mostly between immersion and baseline measurement rather than during the two immersion periods. The mean dimensional accuracy before immersion showed 102.57mm, this value decreased to 102.05mm, 101.98mm after 3 nights and 7 nights sequentially with p-value below 0.0001, while the measurements of various disinfectant solutions at identical time showed the mean with 101.62mm, 101.63mm for CHX and 103.23mm,103.44mm for clove in 7 and 3 nights respectively and an overall p-value of 0.2905 which showed no statistically significant difference between the solutions. Whereas the result show that impact strength maintained a constant level throughout the observed period, the mean value before immersion was 0.058 kJ/m², while 0.059kJ/m², 0.059kJ/m² after 3 and 7 nights of immersion with p-value of 0.7318, 0.7849 sequentially with no significant difference, while the groups showed highly significant differences between them (p < 0.0001). The pairwise analysis showed that the clove group had significantly higher impact strength values than the CHX group (p < 0.0001) .

Conclusion:The clove solution provided the best balance of safety and performance, showing the least negative impact on the resin's physical properties while supporting both dimensional accuracy and fracture resistance of heat cured acrylic-resin material followed by chlorhexidine .

Keywords: Dimensional accuracy; Sudden shock; Heat cure resin; Clove; Chlorhexidine.

INTRODUCTION

A wide range of polymers are commonly used for various applications in clinical dentistry^{1,2}. Amongst

these, poly methyl methacrylate (PMMA) is a polymer that is most commonly used in dental laboratories (to make orthodontic retainers, dentures, and repair), dental

clinics (for relining dentures and temporary crowns), and industry (such as fabrication of artificial teeth)^{3,4}. PMMA is an odorless polymer of acrylic acid that was reported by Redtenbacher in 1843⁵.

Prosthetic restorations need to be performed in complex oral environments (biofunctionality) without exerting any adverse effects on the surrounding tissues⁶. The PMMA should have good mechanical properties (such as high elastic modulus, proportional limit, resilience, fatigue strength, and impact strength) to withstand the forces of mastication without failure. In addition, other properties such as having low specific gravity (light weight), thermal conductivity, ease of cleaning, and low cost are favorable for patient comfort⁷. Denture base materials are exposed to complex masticatory stresses in the oral cavity. Therefore, good mechanical properties are required for the functional performance of denture base materials (biofunctionality). Considering the significance of the mechanical properties, several modifications have been reported for various mechanical properties of PMMA, including its flexural strength^{8,9}, impact strength^{10,11}, fracture toughness and surface hardness¹².

Although the flexural strength demonstrates a material's ability to withstand tensile, compressive, and shear stresses, the fracture toughness and impact strength of PMMA are also important for denture base applications. The fracture toughness describes a material's ability to resist crack propagation due to notches or defects present in the surface¹³. The impact strength describes the amount of impact energy required to cause a fracture¹⁴, it can be remarkably reduced by the presence of tiny surface deflection as a result of wear and tear. Even a micron-sized surface defect may act as a notch for crack propagation and fracture¹⁵. One of the most frequent complications with acrylic dentures is structural failure. This often occurs when a patient accidentally drops the prosthetic or during the repetitive stress of chewing which leads to material fatigue and eventual deformation¹⁶. If the cleaning agents used by patients weaken the resin, the frequency of these breakages and oral lesions linked with dentures, such as angular cheilitis, traumatic ulcers increases. The prevalence of total and partial edentulism is rising with age¹⁷ so edentulism affects the patient's dental and general health, denture placement can create major changes in the oral environment and have a detrimental impact on the health of oral tissues. Consequently, determining how various disinfectants affect the physical integrity of acrylic is a high clinical priority¹⁸.

Several ways for disinfecting dentures have been suggested. Effective hygiene usually involves a mix of

mechanical scrubbing and chemical soaking. Common options include chlorhexidine, alkaline peroxides, or acidic cleaners. However, researchers are increasingly looking at natural alternatives like plant extracts and essential oils due to their antibacterial properties and safety profiles¹⁹. They should be able to effectively kill microorganisms without damaging the denture's material surface²⁰. Therefore, one of the safest and simplest methods is to disinfect the prosthesis by soaking it in chemical disinfectants. Denture cleaners should ideally reduce or eradicate biofilm while preserving the physical and mechanical properties of the denture base material¹⁶. However, according to a number of studies, the extended use of denture cleaners can generate severe negative effects on the physical and mechanical qualities, including the surface roughness, dimensional accuracy, and hardness of denture base resins²¹. When selecting the optimum denture-base material, one essential comparison to consider is the denture-base's dimensional stability following immersion. Thus, it is clinically important to recognize if denture cleaners affect the characteristics of acrylic resin²². This study was designed to compare the effects of 0.20% chlorhexidine and a herbal clove extract on the impact strength and dimensional accuracy of heat-cured acrylic.

MATERIAL AND METHOD

The research was divided into two primary categories to test dimensional accuracy (I) and impact strength (II). Each category divided into three subgroups of eight samples. The subgroups typify one before immersion in the three solutions and the two other groups represented the three immersion media in two different times: Clove extract, Chlorhexidine (CHX), and Distilled Water (D.W.) which represented the control group, the scheme of procedures shown in Figure (1).

Preparation of Herbal extracted disinfectant solution:

The clove (*Eugenia caryophyllata*), family of *Myrtaceae*. These dried clove buds were grounded to a powdered form. The powder was immersed in 100% ethanol for 30 hr. Three hundred grams of fine powdered was mixed with 1 L of ethanol; then, it was centrifuged at 12000 rpm for 10 mins. The supernatant was collected, and all the solvent was evaporated in hot air oven at 50°C. From 300 g of powder dissolved in 1 L of ethanol, 18 g of residue (extract) was obtained. The extract obtained after processing was then desiccated and stored in an air tight container at room temperature (25°C). Final solution was formulated by dissolving 0.4 g of extract in 10 ml of deionized water^{23,24}.

The chemical solution used in this study was Chlorhexidine (CHX) 0.20% mouthwash, manufactured by: Laboratorios KIN S.A. DIGONAL 200-Spain²⁵.

Dimensional accuracy test procedure:

For this test 24 specimens had been prepared from heat-cured acrylic resin material and in order to maintain standard dimension of acrylic specimens, Four smooth circular metal discs made up of steel measuring 50mm x 3mm with mark three reference points 1, 2 and 3 by forming a “v”-shaped notch of 2 mm depth is machined. Then a very thin layer of Vaseline will be applied on to the surface of metal disc for ease of removal. The disc invested in type III dental stone²². The stone was mixed according to manufacturer’s instruction, 100gm of powder added to 23ml of distilled water with a low speed vacuum mechanical spatulation for 30 seconds. Gentle vibration was used for 1 minute to get rid of air babbles, then the mixture was poured in to the lower half of the flask²⁶. In each flask one metal disc specimen was inserted into the investing stone which then allowed to set for 1 hour before pouring a second layer of stone as. After setting, the stone was coated with separated medium, then the upper half of the flask was filled with stone and left for another 1 hour²⁷. After final setting time two halves of the standard brass processing flask separated and the metal disc took out. Stone mold thoroughly wash, allow to dry and very thin layer of cold mold seal applied and allow to dry²². The heat-cured acrylic resin mixed at Powder (polymer) and liquid (monomer) were mixed together in glass jar according to manufacturer’s instruction, the top of the glass jar is screwed on, the material changes from a sandy, sticky, to a dough like consistency at this consistency was packed into the created molds contained in the flask²⁸. The acrylic dough was packed into the flask using a hydraulic press, the closing force was applied slowly until metal to metal contact of the flask s portions was obtained at 3000 bar. The flask was then placed under the clamp press and waited for period of 30 minute before curing (for heat cured materials), this would allowed the liquid to penetrate the powder thoroughly. The heat-cured acrylic resin was cured by two steps polymerization of water bath 70°C for 30 minutes, then proceed at 100°C for 30 minutes, then the flask was left aside for slow bench cooling 2 hr before opening²⁶. Heat cured acrylic resin specimens were finished, any excess acrylic was removed from the processed specimens by the used of handpiece with stone wheel burs at low speed. Care was taken not to heat the specimens during grinding, because this may cause distortion of the specimens. The specimens were polished from both sides as usual manner that used for polishing of acrylic removable prosthesis by using smoother aluminum oxide papers of 400 grit and a rag wheel with slurry pumice was used for polishing the specimens. Then a final high polish was given to the specimens with a rag wheel and Rouge polishing material²⁹. As the Poly methyl methacrylate (PMMA) undergo unavoidable dimensional changes during fabrication, such as thermal expansion on heating, contraction on cooling and polymerization contraction³⁰

all the twenty four specimens measured with Auto cad (3D) program, which is used to measure dimensional accuracy. Artic scanner (Luxembourg) used, to take an image to the specimens and then transferring it to computer to get the measurements digitally before being immersed in the three solution³¹ as the scheme procedure shown in Figures (1), each specimen was measured in an ordered sequence, the distance between reference marks 1 and 2; the distance between reference marks 1 and 3; and the distance between reference marks 2 and 3 these lines made as imaginary triangle, then calculated the perimeter with a millimeter (mm) as a unit of measurement for them³².

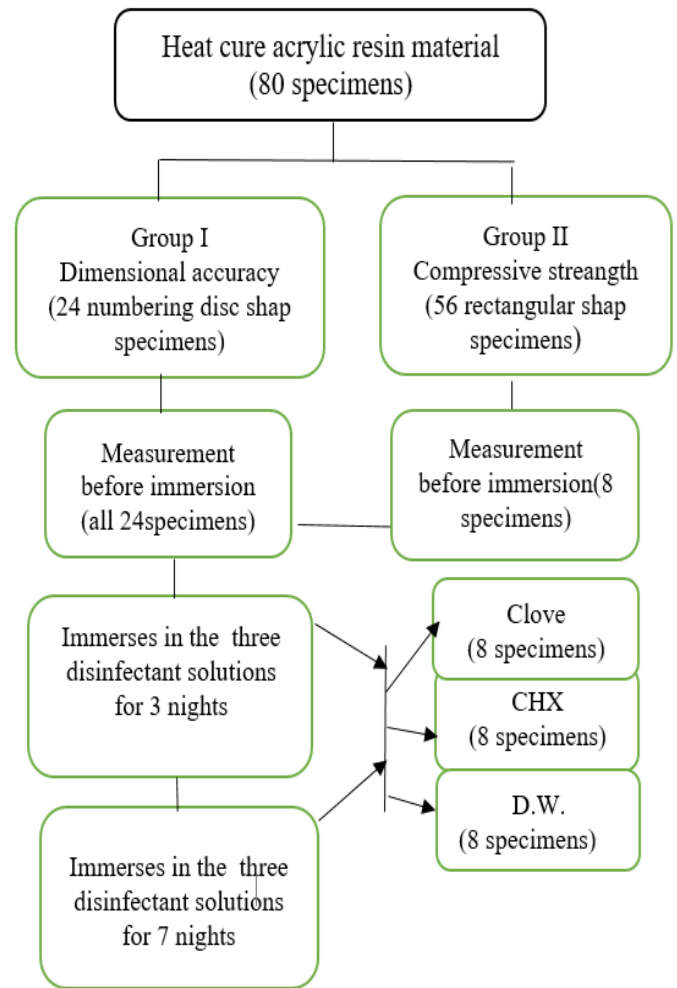


Figure 1. Diagram for procedure of study.

Then the twenty four specimens divided into three section, the first eight specimens with marked number in order from 1 to 8 for clove solution, the second eight (9-16) for CHX solutions and the last eight specimens (17-24) immersed in distill water (D.W.) that act as control group for 21 hours which was equivalent to 3 nights of immersion. Then the twenty four specimens will be washed with D.W. and measured the three distances and calculate the perimeter²². The specimens again will be immersed into their own individual solutions with the same order for 49 hours which is equivalent to one week of immersion per 7 hour nights, later washed with (D.W.)

and measured again³¹. All tests were carried out at room temperature (28 C°) and in dry environment as illustrated in Figures (2).

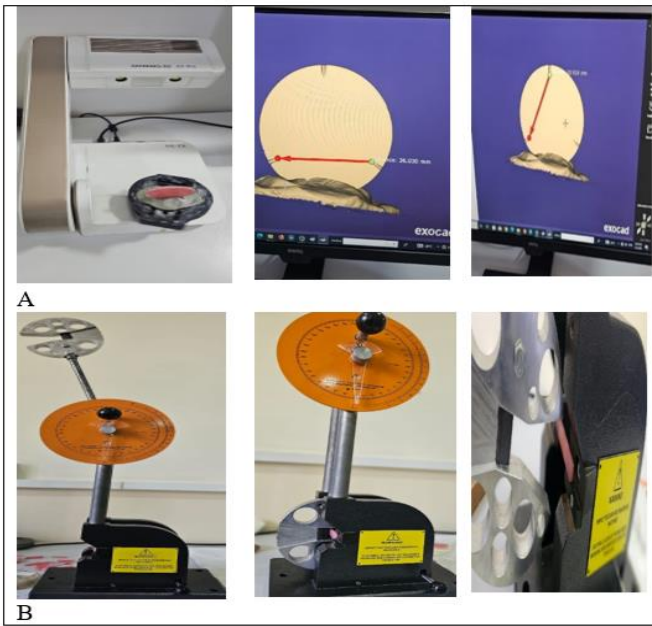


Figure 2. A: Measurements of specimens for dimensional accuracy by Artic scanner (Luxembourg). B: Measurements of specimens for sudden shock by Impact tester MT3016 PROBADOR IMPACTO (pendulum type impact tester).

Impact strength test procedure:

Fifty six specimens prepared of heat-cured acrylic resin for this test. A smooth rectangular shape metal of (65 × 10 × 3 mm) to meet the requirements of International Standards Organization (ISO) specification number 20795-1 are machined to maintain standard dimension of acrylic specimens with reference point²⁹, A “v”-shaped notch was prepared at a distance of 35 mm and a depth of 2 mm with an angle of 90°. These dimension standardized according to the size of the sample holder of the equipment used to test the impact strength²⁹.

The metal sheet invested and the heat cure resin specimens prepared²³ in a same manner as with the specimens of dimensional accuracy group (I).

The division of the specimens into groups and the process of immersing period for the impact strength group (II) had been just like the groups in the dimensional accuracy measurements and as shown in Figures (1). All the samples of each group were tested on Impact tester MT3016 PROBADOR IMPACTO (pendulum type impact tester) on the notched samples. The samples kept in a sample holder in a vertical direction with the “v” notch facing the pendulum, in which the energy stored was 2 joule. The pendulum released from its zero position, and the reduction swing

immediately after breaking the specimen indicated by the position of the pointer attached on the dial scale and impact energy was achieved¹⁷ as showed in Figure (2). The impact strength was calculated using the following formula¹⁷: Impact strength (kJ/m²) = E/TW, where: E = the absorbed energy (kJ), W = the specimen width (m), T = the specimen thickness at the notch base (m).

Statistical analyses

The impact strength and dimensional accuracy were presented in mean and standard deviation. The normality of the indicators was confirmed by a Q-Q norm and used the parametric for all statistical analyses. The comparisons of the impact strength and dimensional accuracy over time and overtime by disinfectant solutions were examined in the Bonferroni correction test. The comparisons of the impact strength and dimensional accuracy at night 3 and 7 among disinfectant solutions were examined in ANOVA one-way and their pairwise in a Tukey test. The significant difference was determined in p <0.05. The statistical calculations were performed using JMP®, Version 18.0. SAS Institute Inc., Cary, NC, 1989–2023.

RESULTS

Effectiveness of the chlorhexidine and clove solutions on dimensional accuracy:

The study showed remarkable outcomes in study group related to the effectiveness of both chlorhexidine (CHX) 0.20% and clove solutions on dimensional accuracy, The table 1 and figure (3) presents the dimensional accuracy changes of the samples over time. The mean dimension before immersion showed a value of 102.57 with a standard deviation of 2.80.

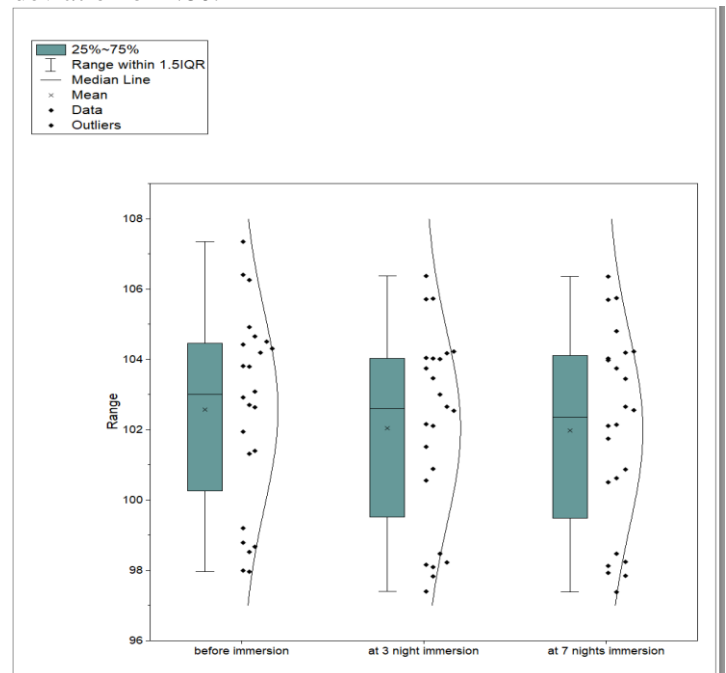


Figure 3. Dimensional accuracy of the cases over time

Table 1. Comparisons of dimensional accuracy between times periods

Comparison	Mean (mm) (SD)		Mean difference (95% CI)	P-value
	Time 1	Time 2		
3 nights vs. B.I	102.05 (2.75)	102.57 (2.80)	-0.53 (-0.64 to -0.41)	<0.0001
7 nights vs. B.I	101.98 (2.80)	102.57 (2.80)	-0.60 (-0.86 to -0.33)	<0.0001
7 nights vs. 3 nights	101.98 (2.80)	102.05 (2.75)	-0.07 (-0.29 to 0.15)	0.5164

SD= standard deviation, B.I = Before Immersion

The mean value decreased to 102.05 with a standard deviation of 2.75 after 3 nights which resulted in a difference of -0.53 with a 95% confidence interval between -0.64 and -0.41 and a p-value below 0.0001 which showed a statistically significant decrease. The mean dimensional accuracy after 7 nights reached 101.98 with a standard deviation of 2.80 which compared to the dimensional accuracy of 102.57 that existed before immersion resulted in a difference of -0.60 which showed a 95% confidence interval between -0.86 and -0.33 and a p-value below 0.0001 which demonstrated a significant change. The comparison of 7 nights with 3 nights produced a minimal difference of -0.07 which showed a 95% confidence interval between -0.29 and 0.15 and did not reach statistical significance because of the p-value 0.5164. The results show that dimensional reduction happened mostly between immersion and baseline measurement rather than during the two immersion periods. The table 2 and figure (4) explores dimensional changes over time according to the type of disinfectant solution.

Table 2. Comparisons of dimensional accuracy between times periods by disinfectant solutions.

Comparisons	Mean (mm) (SD)		Mean difference (95% ci)	P-value
	Time 1	Time 2		
CHX 3 nights vs. B.I 7 nights vs. B.I 7 nights vs. 3 nights	101.63 (2.79)	102.33 (2.77)	-0.71 (-0.90 to -0.51)	<0.0001
	101.62 (2.82)	102.33 (2.77)	-0.71 (-0.96 to -0.46)	1 0.0003
	101.62 (2.82)	101.63 (2.79)	-0.004 (-0.09 to 0.09)	0.9087
Clove 3 nights vs. B.I 7 nights vs. B.I 7 nights vs. 3 nights	103.44 (1.37)	104.03 (1.45)	-0.59 (-0.76 to -0.43)	<0.0001
	103.23 (1.78)	104.03 (1.45)	-0.80 (-1.62 to 0.01)	1 0.0532
	103.23 (1.78)	103.44 (1.37)	-0.21 (-0.98 to 0.56)	0.5381
D.W. 3 nights vs. B.I 7 nights vs. B.I 7 nights vs. 3 nights	101.08 (3.43)	101.36 (3.43)	-0.28 (-0.46 to -0.10)	0.0083
	101.08 (3.43)	101.36 (3.43)	-0.28 (-0.46 to -0.09)	0.0099
	101.08 (3.43)	101.08 (3.43)	0.005 (-0.001 to 0.01)	0.2014

SD= standard deviation, B.I = Before Immersion, CHX= Chlorhexidine 0.2%, D.W.= Distilled water,

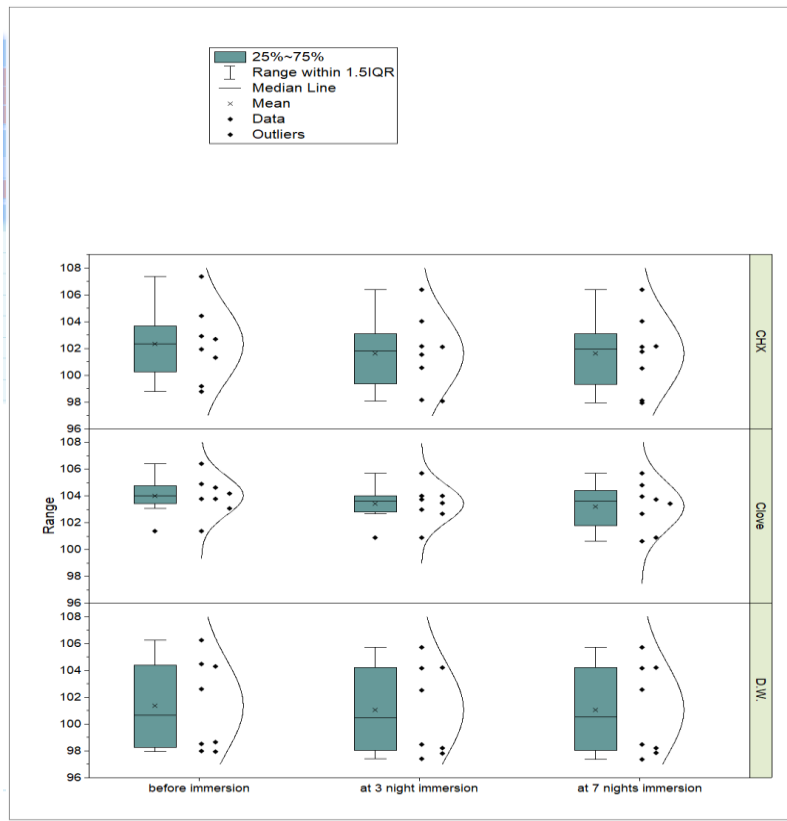


Figure 4. Dimensional accuracy of the cases over time by disinfectant solutions

The CHX solution showed a dimension reduction from 102.33 to 101.63 after 3 nights of testing, which resulted in a mean difference of -0.71 (95% CI: -0.90 to -0.51 ; $p < 0.0001$). The 7 nights measurement showed a similar difference to the baseline measurement with a difference of -0.71 ($p = 0.0003$), while the 7 nights to 3 nights comparison showed no difference (-0.004 ; $p = 0.9087$). The clove solution showed a dimension reduction from 104.03 to 103.44 after 3 nights of testing, which resulted in a significant mean difference of -0.59 (95% CI: -0.76 to -0.43 ; $p < 0.0001$). The 7 nights to baseline comparison showed a mean difference of -0.80 , which approached but did not reach statistical significance ($p = 0.0532$), while the difference between 7 nights and 3 nights was not significant ($p = 0.5381$). The distilled water group showed a dimension reduction from 101.36 to 101.08 after 3 nights of testing, which resulted in a mean difference of -0.28 (95% CI: -0.46 to -0.10 ; $p = 0.0083$). The 7 nights to baseline comparison showed a significant difference ($p = 0.0099$), while the 7 nights to 3 nights comparison showed no significant difference ($p = 0.2014$). The table 3 compares the dimensional measurements of various disinfectant solutions at identical time intervals.

Table 3. Comparisons of dimension at 3 and 7 nights among and between mouth wash

	at 7 nights immersion			
	No.	Mean (mm)	SD	P-value
CHX	8	101.62	2.82	0.2905
Clove	8	103.23	1.78	
D.W.	8	101.08	3.43	
3-night immersion				
mouth wash	No.	Mean (mm)	SD	P-value
CHX	8	101.63	2.79	0.2040
Clove	8	103.44	1.37	
D.W.	8	101.08	3.43	
SD= standard deviation, CHX= Chlorhexidine 0.2%, D.W.= Distilled water,				

At 7 nights, the mean dimensions were 101.62 (SD = 2.82) for CHX, 103.23 (SD = 1.78) for clove, and 101.08 (SD =

3.43) for distilled water, with an overall p-value of 0.2905 which showed no statistically significant difference between the solution groups. The p-value of 0.2040 demonstrated no significant difference between the three solutions types because the mean dimensional accuracy at 3 nights were 101.63 for CHX and 103.44 for clove and 101.08 for distilled water. The study found that solutions type had the same effect on dimensional measurements which showed changes over time.

Effectiveness of the chlorhexidine and clove solutions on impact strength:

The table 4 and figure (5) evaluates the change in impact strength time periods.

Table 4. Comparisons of the impact strength outcomes over times

Comparison	Mean (kj/m ²) (SD)		Mean difference (95% CI)	P-value
	Time 1	Time 2		
3 nights vs. B.I	0.059 (0.001)	0.058 (0.000)	0.0001 (-0.001 to 0.001)	0.7318
7 nights vs. B.I	0.059 (0.001)	0.058 (0.000)	-0.0001 (-0.001 to 0.001)	0.7849
7 nights vs. 3 nights	0.059 (0.001)	0.059 (0.001)	-0.0003 (-0.001 to 0.0006)	0.5165

SD= standard deviation, B.I = Before Immersion

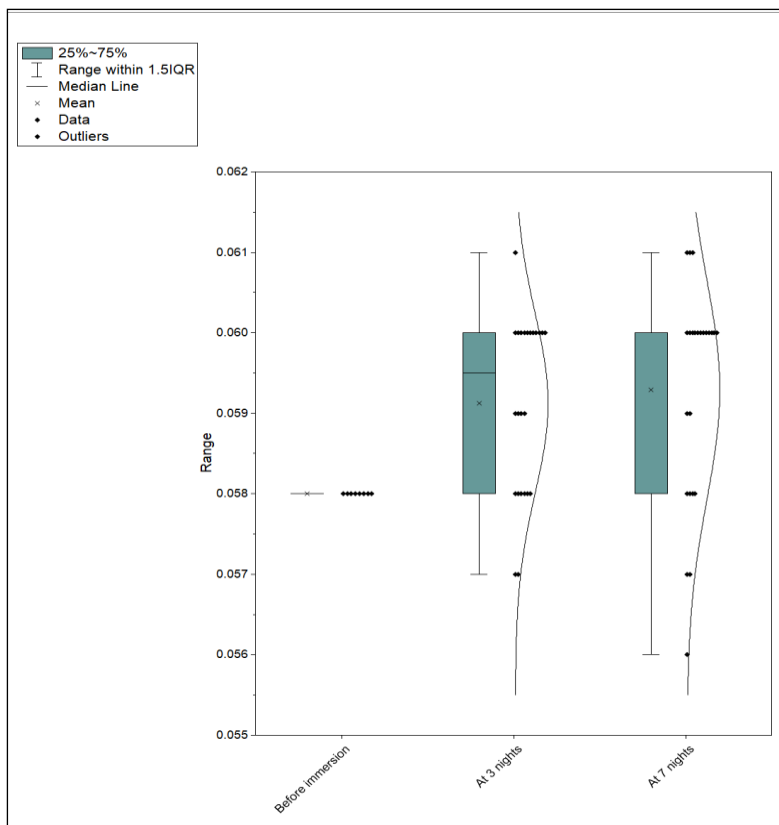


Figure 5. Impact strength of the cases overtime

The mean value impact strength before immersion was 0.058, while it was 0.059 (SD = 0.001) after 3 nights of immersion. The two time periods had a mean difference which measured 0.0001 and the 95% confidence interval extended from -0.001 to 0.001. The p-value showed no significant difference at 0.7318. When the values after 7 nights were compared with the baseline before immersion, the mean remained approximately similar (0.059 vs. 0.058), with

a mean difference of -0.0001 (95% CI: -0.001 to 0.001) and a p-value of 0.7849 , again showing no significant change. The comparison between 3 nights and 7 nights shows that impact strength values remained the same because all values were 0.059 . The mean difference produced a value of -0.0003 with a 95% confidence interval which extended from -0.001 to 0.0006 and a p-value of 0.5165 . The results show that sudden shock maintained a constant level throughout the observed period.

The table 5 figure (6) evaluates changes in the impact strength between 3 and 7 nights according to the type of disinfectant solutions.

Table 5. Comparisons of the impact strength over time by disinfectant solutions

7 nights vs. 3 nights	Mean(kj/m ²) (SD)		Mean diff (95% ci)	P-value
	time 1	time 2		
CHX	0.0579 (0.0012)	0.0581 (0.0010)	-0.0003 (-0.0011 to 0.0006)	0.5165
Clove	0.0604 (0.0005)	0.0596 (0.0011)	0.0008 (-0.0002 to 0.0017)	0.1114
D.W.	0.0596 (0.0007)	0.0596 (0.0005)	8.7e-19 (-0.001 to 0.0009)	1.0000

SD= Standard Deviation, CHX= Chlorhexidine 0.2%, D.W.= Distilled water,

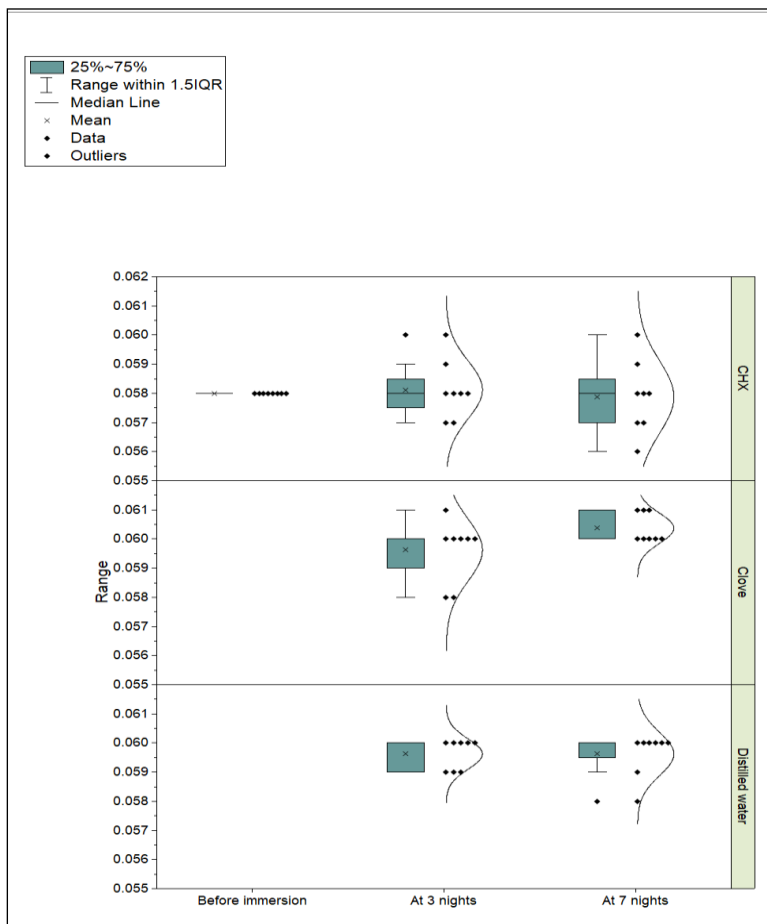


Figure 6. Impact strength of the cases overtime by disinfectant solution.

The chlorhexidine (CHX) mouthwash showed a slight increase in the impact strength with its mean value rising from 0.0579 (SD = 0.0012) at 3 nights to 0.0581 (SD = 0.0010) at 7 nights. The mean difference between these groups was -0.0003 (95% CI: -0.0011 to 0.0006) with a p-value of 0.5165 which was not statistically significant. The clove solution showed a mean value decrease from 0.0604 (SD = 0.0005) to 0.0596 (SD = 0.0011) which resulted in a mean difference of 0.0008 (95% CI: -0.0002 to 0.0017) and a p-value of 0.1114 which showed no statistically significant results. The mean values for distilled water remained unchanged at 0.0596 during the two measurement periods while the average value difference of 8.7×10^{-19} (95% CI: -0.001 to 0.0009) with a p-value of 1.0000 showed that immersion time did not create any substantial changes in an impact strength across all disinfectant treatments.

The table 6 shows three solutions groups which include chlorhexidine (CHX) and clove and distilled water.

Table 6. Comparisons of the impact strength at 3 and 7 nights among disinfectant solutions.

	No.	Mean (kj/m ²)	SD	P (pairwise comparisons)
At 3 nights				
CHX	8	0.0581	0.0010	0.0033
Clove	8	0.0596	0.0011	Clove >CHX (p=0.0078)
D.W.	8	0.0596	0.0005	Distilled water >CHX (p=0.0078)
			2	
At 7 nights				
CHX	8	0.0579	0.0012	<0.0001
Clove	8	0.0604	0.0005	Clove >CHX (p=<0.0001)
D.W.	8	0.0596	0.0007	Distilled water >CHX (p=0.0021)
SD= Standard Deviation, CHX= Chlorhexidine 0.2%, D.W.= Distilled water,				

The study evaluated impact strength through mouthwash use which lasted three nights and seven nights. The CHX group produced a mean impact strength value of 0.0581 after three nights which had a standard deviation of 0.0010. The clove and distilled water groups showed higher mean values which reached 0.0596. The measurements showed low variability because clove had an SD of 0.0011 and distilled water had an SD of 0.00052. The statistical analysis demonstrated significant group differences because the p-value reached 0.0033. The pairwise comparison showed that the clove group had higher mean impact strength results compared to CHX group results which reached statistical significance at p 0.0078. The distilled water group showed a significantly higher value than the CHX group which reached statistical significance at p 0.0078. The CHX mouthwash produced lower sudden shock values after three nights than both clove and distilled water. The same pattern that occurred during the first six nights continued to appear after seven nights. The CHX group again demonstrated the lowest mean value which measured approximately 0.0579 with a standard deviation of 0.0012. The clove group demonstrated the highest mean value 0.0604 with an SD of 0.0005, while the distilled water group had a mean of 0.0596 with an

SD of 0.0007. The statistical analysis demonstrated that the groups showed highly significant differences between them (p < 0.0001).

The pairwise analysis showed that the clove group had significantly higher impact strength values than the CHX group (p < 0.0001). Distilled water showed significantly higher values when compared to CHX group (p = 0.0021).

DISCUSSION

This investigation explored how immersion in Clove extract and CHX affects the mechanical durability of heat-cured acrylic resins. Because prosthetics are frequently transferred between clinical settings and dental labs for adjustments or repairs, disinfection is essential for stopping cross-contamination³³. Our data shows that using herbal or chemical agents can actually benefit the material's integrity. By comparing the samples after immersion into their original state which represented the sample prior to immersion, we gained a clearer understanding of how these solutions influence the resin. Dimensional accuracy is a cornerstone of successful dental restorations, as it ensures that the device fits well and functions correctly³⁴. Our results mirror the work of Satapathy *et al.*³⁵, who noted that chemical and microwave methods worked well over 7 to 21-day

periods. Interestingly, our study also found that herbal solutions resulted in the lowest amount of dimensional shifting. Furthermore, in the Wahyuni and Nawia investigation³⁶, which found identical results when using herbal and chemical disinfectants, it was discovered that immersing in herbal extract resulted in a lower dimensional change value than chlorhexidine 0.2%. Also for the results of sudden shock, which is an important property of acrylic denture base material, dentures tend to fracture if accidentally dropped on a hard surface. Sudden shock results were similar with Zhang *et al.* study³⁷, suggesting most of the chemical disinfectants Do Not Reduce the physical properties of denture base resin as this outcome also aligns with Elhagali *et al.* and Al-Thobity *et al.*^{38,39}, clarifying that commercial disinfectants have a slight effect on the tested properties. On the other hand, Alwaeli and Alsegar study⁴⁰ discovered that these disinfectant solutions had a detrimental effect on impact property as their study indicated that the use of disinfectant solutions marginally diminishes the hardness of heat polymerized resins, which was advocated by the Ahmad study earlier⁴¹, which stated that standard heat-cured acrylic cannot be safely immersed in chemical or herbal solutions containing alcohol because of its reduction of impact strength. On the contrary, our research was built on the works of Ahmed and Jaffer's research article²³ on the two disinfectants Clove and CHX solutions, proving these solutions help keep surfaces smooth and germ-free. Further testing on other mechanical traits is still necessary.

Satisfaction results reported from this research recommend further studies of this herbal solution on the properties of more advanced denture resin materials. Despite some limitations in the study, we faced some challenges with testing equipment, as most impact-testing machines are designed for heavy metals rather than light dental polymers.

CONCLUSION

As a summary, the study found that solution types had the same effect on dimensional measurements which showed changes over time, with no significant difference between the three solution types. In addition, the impact strength showed the clove group had higher impact strength results, meaning, the material is able to withstand sudden force better compared to CHX group, which reached statistical significance at $p = 0.0078$. Although chlorhexidine is a "gold standard" for antimicrobial action in dental applications, it is often associated with adverse effects on physical properties. As a result of the study, the clove-based treatment provides a more robust, stronger solution for denture cleansing.

DECLARATION

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Ethical approval

Ethical approval was obtained from the Research Ethics Committee of the University of Duhok, Duhok, Iraq;

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