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Evaluation the Effect of Chemical and Irradiation Disinfectants on Some Physical and Mechanical Properties of Flexible Denture Base Material

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الخلاصة

الاهداف: تهدف هذه الدراسة إلى تقييم تأثير طريقتين من التطهير (الكيميائية والإشعاعية) على (صلابة الانبعاج، قوة الشد، قوة اللوي وامتصاص الماء) لمادة قاعدة الطقم المرن باستخدام دورة اللعاب الصناعي، وكذلك لتقييم تأثير الفترات الزمنية للغمس(أسبوع، شهر وشهرين). **المواد وطرائق العمل:** بلغ عدد العينات الكلي لهذه الدراسة (٣١٨) عينة، قسمت إلى ٥ مجاميع وفقاً لنوع المطهرات المستخدمة، وجميع العينات حضرت من مادة الراتنج المرن.اما دورات الغمس المستخدمة في الدراسة فكانت كالآتي: العينات حفظت في الماء المقطر في درجة حرارة (٣٧±١) مئوية لمدة يومين للتكييف بعد ذلك غمرت في اللعاب الصناعي في درجة حرارة (٣٧±١) درجة مئوية لمدة ١٥ ساعة ونصف، ثم غمرت في المطهرات الكيميائية لمدة نصف ساعة في درجة حرارة (٤٥±١) درجة مئوية، وأدخلت في المطهر الإشعاعي لمدة ٦ دقائق يومياً بعد ذلك غمرت في الماء المقطر في درجة حرارة (٢١±٢) درجة مئوية لمدة (٨)ساعات في الليل، تلك الدورة أعيدت كل يوم لمدة (أسبوع وشهر وشهرين) وفي نهاية كل فترة زمنية، تم فحص العينات لتقييم صفات (صلابة الانبعاج، قوة الشد، قوة اللوي و امتصاص الماء). نتائج الدراسة تم تحليلها إحصائيا باستخدام (المتوسط الحسابي والمعيار ألانحرافي)، اختبار (تي) الزوجي، تحليل التباين (الانوفا) واختبار دنكن.**النتائج:** أظهرت نتيجة تلك الدراسة عند المقارنة بين المطهرات انه لا يوجد هناك أي فرق معنوي عند عتبة($p\leq0.05$) في صفات قوة الشد، قوة اللوي وامتصاص الماء بينما ظهر هناك فرق معنوي في صفة صلابة الانبعاج ، وكذلك لا يوجد هناك أي فرق معنوي عند عتبة ($p\leq0.05$) في صفة صلابة الانبعاج بين أوقات الغمس المختلفة بينما هناك فرق معنوي في صفات قوة الشد، قوة اللوي وامتصاص الماء بعد شهر وشهرين من دورات الغمس. **الاستنتاجات:** نستنتج من الدراسة، أن التطهير باستخدام إشعاع الموجات القصيرة أكثر تأثيراً على صفة صلابة الانبعاج. بينما الأوقات المختلفة للغمس في المطهرات كان لها تأثيراً معنوياً على صفات قوة الشد، قوة اللوي وامتصاص الماء بعد شهر وشهرين من دورات الغمس.

ABSTRACT

Aims: To evaluate the effect of two methods of disinfections (chemical and irradiation) on (indentation hardness, tensile strength, torsional strength and water sorption) of flexible denture base material by using artificial saliva cycle. Also, to evaluate the effect of immersion cycle (one week, one month and two months) . **Materials and methods:** Total specimens of this research was 318 specimens, it was divided into 5 groups according to type of disinfectants, they were prepared from flexible resin. They were incubated in a distilled water at 37±1°C for two days for conditioning ,6 specimens for each properties were evaluated as a control. The immersion cycle used was as follows, the specimens were immersed in artificial saliva at 37 ±1°C for 15,5 hr. Then, they were immersed in disinfections solutions for 30 minutes at 45±1°C, for microwave cycle about 6 minutes daily, then they were immersed in distilled water at 21±2°C for 8 hr at night. This cycle was repeated every day for two months. At the end of each period time, the specimens were tested to evaluate the indentation hardness, tensile strength, torsional strength and water sorption properties. The results of the present study were analyzed statistically by (Mean ± standard deviation, ANOVA and Duncan's multiple range test).**Results:** They showed that, In comparison among disinfectants there was no statistically significant difference at $p\leq 0.05$ in tensile strength, torsional strength and water sorption properties while there was a significant in the indentation hardness properties. Also, there were no significant difference at $p\leq 0.05$ in the indentation hardness properties among different times of immersion cycle, while there was a significant difference in tensile strength, torsional strength and water sorption properties after one and two months of immersion cycle. **Conclusions:** Among disinfectants, microwave irradiation had lowest effect on the indentation hardness, while different immersion cycles in disinfectants had a significant effect on the tensile strength, torsional strength and water sorption properties after one and two months of immersion cycle.

Key words: torsional strength, flexible resin, microwave irradiation.

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INTRODUCTION

There are several types of removable partial dentures, all of them use standard denture teeth as replacements of the missing natural teeth. The differences between them are the materials used to support the denture teeth and retain the removable partial denture in the mouth.[1] The therapeutic use of thermoplastic materials had increased drastically in the last decade. This new procedure, during which a fully polymerized basic material softened by heat (without chemical changes) and injected afterwards, had opened up a new chapter in making dentures.[2] Nylon was a generic name for certain types of thermoplastic polymers belonging to the class known as polyamides. These polyamides are produced by the condensation reactions between diamine and a diabasic acid [3].Thermoplastic Nylon differ from acrylics in that they were hot-pressed into shape. No polymerization occurs during moulding or setting, Nylon bonds very poorly to acrylic and cannot be added to itself, which makes relining and repair difficult.[2] Takahashi *et al.*,[4] concluded that the flexible resin liner is softer than the acrylic resin, but is less resilient and could be affected by aging. As a general conclusion, the injection method of the thermoplastic materials brings more advantages in the behavior of the removable partial dentures with clasps, compared with the conventional technology[5]. Denture cleanser is an alternative method to clean the prostheses[6].The use of microwave irradiation to disinfect dentures had been suggested, studies have demonstrated that the effectiveness of microwave disinfection in deactivating potentially pathogenic microorganisms.[7,8] Microwave irradiation for 6 minutes in water at 650 W proved to be completely effective against potentially pathogenic microorganisms.[9] The hardness of denture base materials may undergo changes due to continued polymerization and water uptake, where water absorption into denture base materials act as plasticizer and alter their mechanical properties.[10] Abdulrahman,[11] concluded the acrylic resin and Valplast denture base materials can be safely disinfected with chemicals without any adverse effect on the surface hardness of these materials. Yassin,[12] concluded that the Valplast that left in distilled water for 1 month has shown a change in tensile strength. The water temperature has a marked effect on the diffusion of water into acrylic resins. Therefore, the heat generated by microwave disinfection may enhance the water sorption rate. The absorbed water could act as a plasticizer and decrease the torsional strength.[13] Yunus *et al.*,[3] stated that one of the disadvantages of the early form nylon denture bases is that they have high water sorption. Hassan,[14] concluded that the addition of radio opaque material (15%wt/wt barium sulphate) on the Valplast will produced an acceptable radio-opaque Valplast nylon denture base material and the modified specimens showed slight increasing water sorption properties. The aims of this research were to evaluate the effects of two methods of disinfections (chemical and irradiation) on some physical and mechanical properties(indentation hardness, tensile strength, torsional strength and water sorption) of flexible denture base material by using artificial saliva cycle. Also, to evaluate the effect of immersion cycle (one week, one month and two months) on these properties.

MATERIALS AND METHODS

Valplast thermoplastic nylon (china), flexible denture cleanser (England), protefix tablet(Germany) and saturated salt was used in this research. Total specimens were 318, for indentation hardness (96) specimens were prepared with dimensions of 30×15×3± 0.03mm, tensile strength (96) specimens were constructed with dimensions 90×10×3±0.03mm, for torsional strength (96) dumbbell shape specimens were constructed with dimensions (cylindrical shank 40×4±0.03mm (length and diameter respectively), and sextuple shape heads 15×8 mm (length and diameter respectively) and water sorption (30) specimens were constructed with dimensions (50 ± 1mm in diameter and 0.5 ±0.05 mm in thickness). These specimens divided into 5 groups, distilled water, protifex tablet, flexible denture cleanser, saturated salt and microwave disinfectant (Figure1).

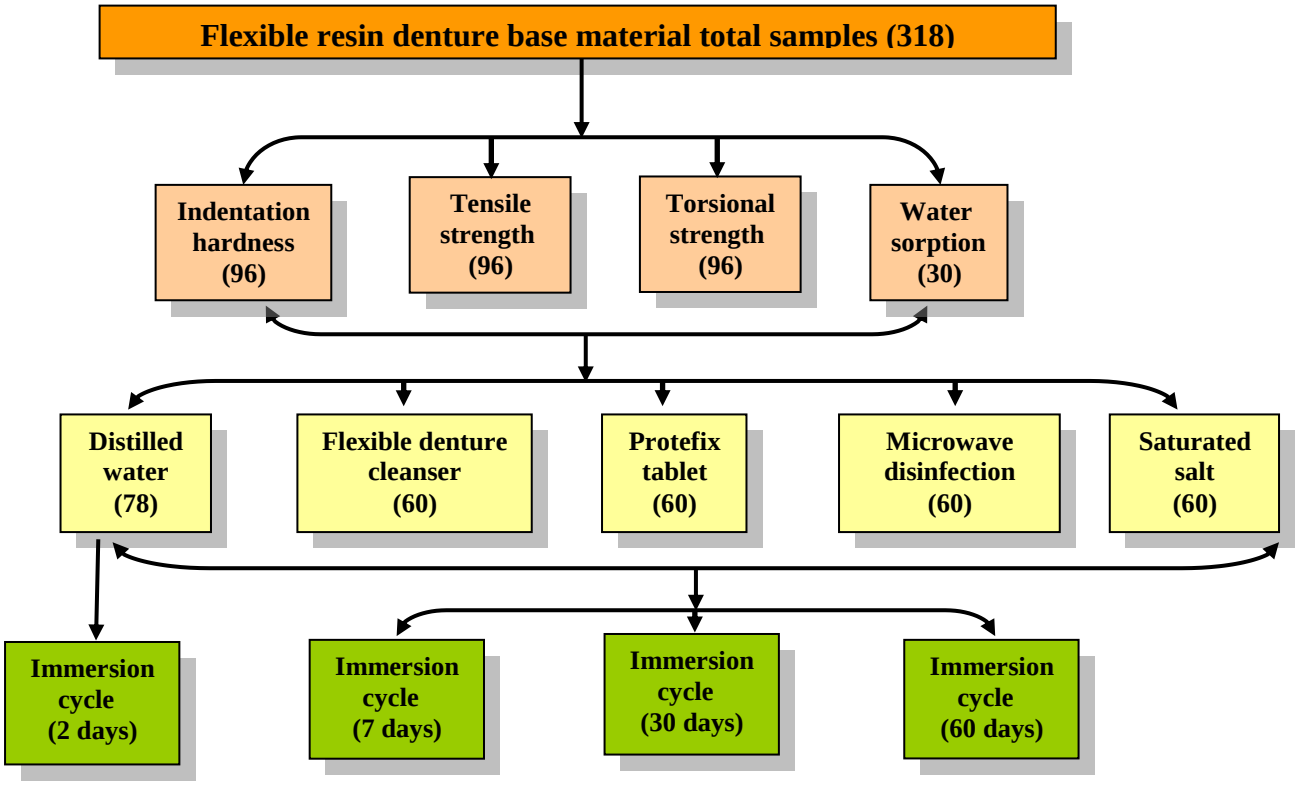


Figure (1): Experimental design of the research.

After preparation of the specimens, start with immersion cycle, The fresh solutions were prepared daily at the beginning of soaking trial (1/2h) in disinfectant solutions. The specimens were removed from the solution washed with distilled water, and dried in air by shaking the specimen for about 30 second. The solutions were removed, the beakers were cleaned and the specimens were immersed in distilled water for 8 h at (21±2°C) then immersed in artificial saliva for about 15.5 h at (37±1°C)in the incubator. For microwave disinfection, the specimens were immersed in 200 ml of distilled water and irradiated with 650 W for 6 minutes[9]. During the microwave irradiation, the water in which used to measure the tensile strength of specimens, the specimens were grasped by two arms of the machine(40 mm between two arms) and the amount of force will applied until fracture of sample occurred in gunt universal testing machine. For torsional strength test, the gunt universal testing machine was used to measure the torsional strength of specimens, the specimens were immersed started to boil (100°C) after approximately 2 minutes and 30 seconds, and remained at this temperature until the end of the 6-minute disinfection time, then the specimens returned to artificial saliva, this cycle was repeated every day for 2 months and the previously mentioned properties were evaluated at (1 week, 1 month and 2 months). For Indentation hardness test, the specimens surfaces were tested for hardness at three different locations, and then the mean was taken for each specimens.[15] The test was done by using Rockwell hardness tester, the specimen was subjected to fixed minor load of 60 kg by weight. For tensile strength test, the gunt universal testing machine was mens were grasped by two arms of the machine(40 mm between two arms), these specimens were tightly positioned in the grips, and a uniform torsional load rate of 0.1 Nm/ min was applied and the amount of force will applied until fracture of specimens occurred. Control software was used to record the force and the angle throughout the testing. For water sorption test, the

specimens were immersed in the solutions and micro wave disinfection according to the study plan. At the end of each period of immersion, they were removed from the solutions and weighed on a digital balance (ANDGX200) with a precision of 0.0001gm. The values for water sorption were calculated for each specimen as follows:

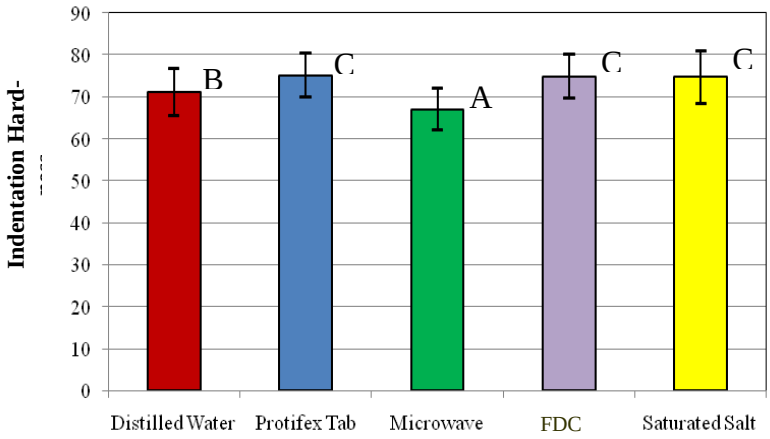
$$Water\ sorption = \frac{Weight\ after\ immersion\ (W_2) - Conditional\ weight\ (w_1)}{Surface\ area\ of\ the\ disk}$$

Water sorption = mg/cm^2 (16).

The following statistical methods were used to analyse and assess the results via SPSS version 11.5 for Windows: Descriptive statistics include mean ± standard deviation values, ANOVA and Duncan multiple range test were used. The statistical results were considered significant at $p \leq 0.05$.

RESULTS

In comparison between disinfectants, Figures (2,3,4,5).



*Different letters mean significant difference at $p \leq 0.05$.

Figure (2): Mean ± SD and Duncan's multiple range test of indentation hardness for Comparison among disinfectants.

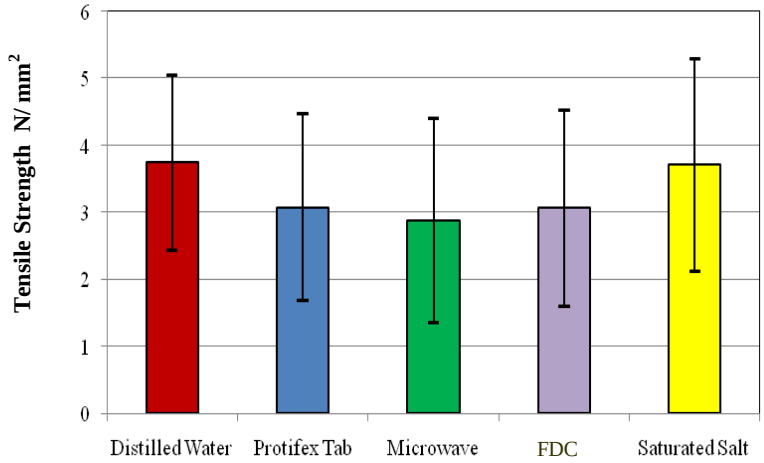


Figure (3): Mean ± SD of tensile strength for Comparison among disinfectants.

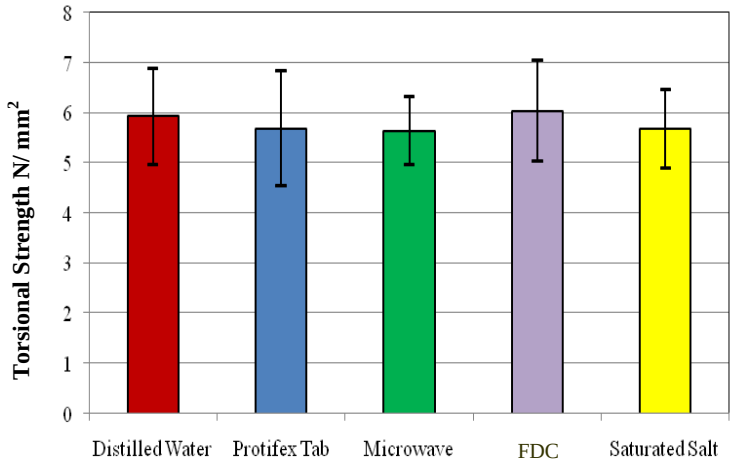


Figure (4): Mean ± SD of torsional strength for Comparison among disinfectants.

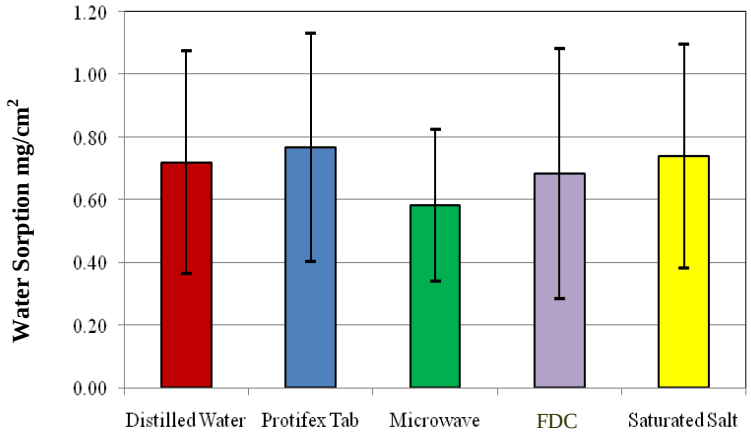


Figure (5): Mean ± SD of water sorption for Comparison among disinfectants.

Demonstrated the mean ± SD values and Duncan's multiple range test of indentation hardness, tensile strength, torsional strength and water sorption. The one way analysis of variance (ANOVA) as shown in Tables (1,2,3,4)

Table (1): ANOVA for Comparison of indentation hardness among disinfectants.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	1186.131	4	296.533	9.745	0.000*
Within Groups	3499.529	115	30.431		
Total	4685.661	119			

Table (2): ANOVA for Comparison of tensile strength among disinfectants.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	15.485	4	3.871	1.817	0.130
Within Groups	245.004	115	2.130		
Total	260.489	119			

Table (3): ANOVA for Comparison of torsional strength among disinfectants.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	2.997	4	0.749	0.864	0.488
Within Groups	99.690	115	0.867		
Total	102.687	119			

Table (4): ANOVA for Comparison of water sorption among disinfectants.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	0.481	4	0.120	0.994	0.414
Within Groups	13.907	115	0.121		
Total	14.388	119			

Demonstrated that there was a significant difference at $P \leq 0.05$ in the indentation hardness of flexible resin among disinfectants and there was no significant difference at $P \leq 0.05$ in the tensile strength, torsional strength and water sorption of flexible resin among disinfectants. In comparison between time intervals, Figure (6,7,8,9)

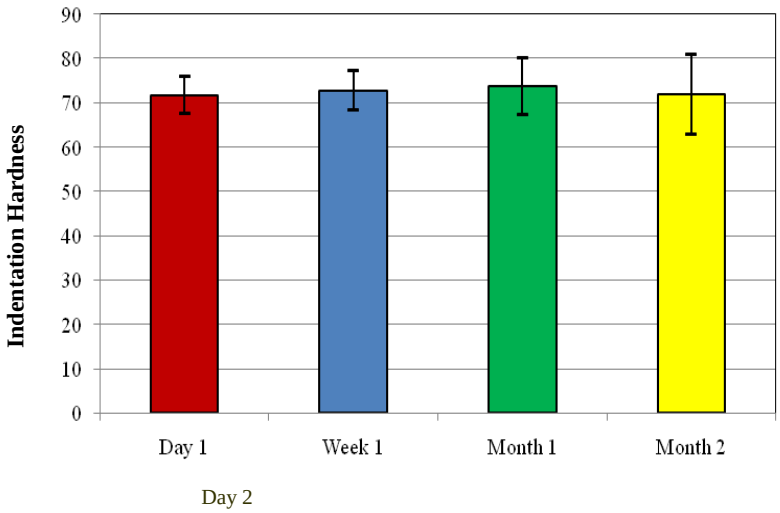


Figure (6): Mean ± SD and Duncan's multiple range test of indentation hardness for Comparison among time intervals.

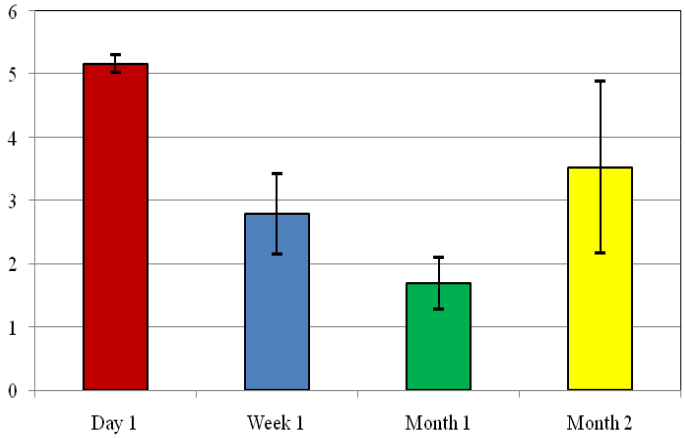


Figure (7): Mean ± SD and Duncan's multiple range test of tensile strength for Comparison among time intervals.

*Different letters mean significant difference at $p \leq 0.05$.

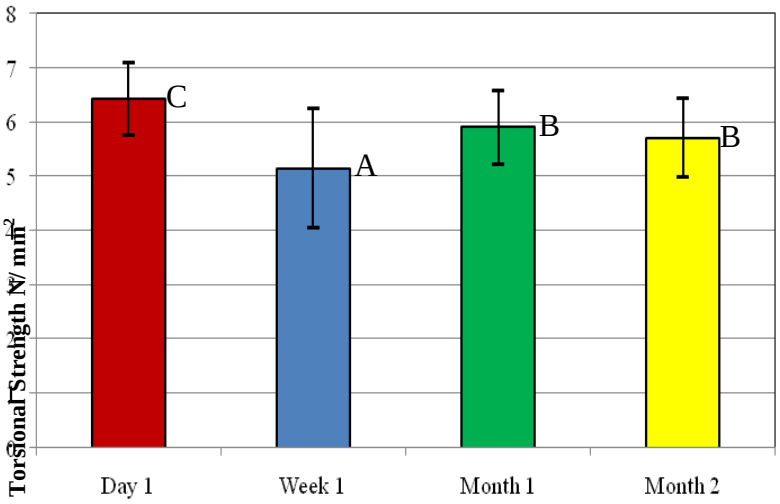
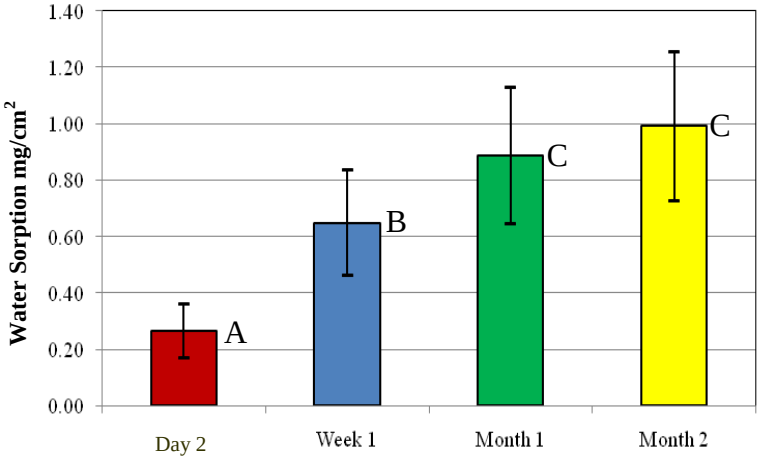


Figure (8): Mean ± SD of torsional strength for Comparison among time intervals.

*Different letters mean significant difference at $p \leq 0.05$.



*Different letters mean significant difference at $p \leq 0.05$.

Figure (9): Mean ± SD and Duncan's multiple range test of water sorption for Comparison among time intervals.

Demonstrated the mean ± SD values of indentation hardness, tensile strength, torsional strength and water sorption. The one way analysis of variance (ANOVA) as shown in Table (5,6, 7, 8)

Table (5): ANOVA for Comparison of indentation hardness among time intervals.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	80.039	3	26.680	0.672	0.571
Within Groups	4605.622	116	39.704		
Total	4685.661	119			

Table (6): ANOVA for Comparison of tensile strength among time intervals.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	190.864	3	63.621	105.997	0.000*
Within Groups	69.625	116	0.600		
Total	260.489	119			

Table (7): ANOVA for Comparison of torsional strength among time intervals.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	25.229	3	8.410	12.595	0.000*
Within Groups	77.457	116	0.668		
Total	102.687	119			

Table (8): ANOVA for Comparison of water sorption among time intervals.

SOV	SS	df	MS	F–value	*p*–value
Between Groups	9.370	3	3.123	72.205	0.000*
Within Groups	5.018	116	0.043		
Total	14.388	119			

Demonstrated that there was no significant difference at $p \leq 0.05$ in the indentation hardness of flexible resin among different time intervals and there was significant difference at $p \leq 0.05$ in the tensile strength, torsional strength and water sorption of flexible resin among time intervals.

DISCUSSION

This research demonstrated that there was no significant difference at $p \leq 0.05$ in

the indentation hardness among protifex tablet, flexible denture cleanser, and saturated salt at different times. This agreement with Abdulrahman,[11] who concluded that the denture disinfectant had no effect on the hardness of flexible resin material. There was a significant difference at $p \leq 0.05$ in the indentation hardness among previous disinfectants, microwave and distilled water. This result indicated that the chemical disinfectant increased the hardness of flexible resin while the microwave irradiation decrease the hardness of flexible resin. The results of the present study was similar to a study done by Pavarina *et al* .,[17] It was explained that the absence of any effect of immersed solutions on the surface hardness of the acrylic denture teeth could be attributed to the cross-linking of the materials. The present experiment also found that the immersion of nylon material in denture cleanser caused more surface hardness compared to immersion in distilled water. It is already known from the study of Yu-lin Lai *et al* .,[18] that nylon material was the most hydrophilic with the largest water uptake. Water can also act as plasticizer, Microwave irradiation reduce the hardness might be caused by the effect of temperature (boiling water) on the plasticizer of flexible resin. Figure (3) and Table (2) showed a comparison of indentation hardness among time intervals (2 days, 1week, 1 month and 2months). This study demonstrated that there was no significant difference at $p \leq 0.05$ in the indentation hardness among time inter vale. This is in disagreement with Chhnoeum,[19] who concluded that denture cleanser affected the surface hardness of Vitaflex significantly after 60 cycles of immersion. The possible explanation of this finding should be done with caution. It may be due to different strategies of experiment of those authors. Figure (5) and Table (4) showed a comparison of tensile strength among time intervals (2days, 1week, 1 month and 2months). This study demonstrated that there was a significant difference at $p \leq 0.05$ in the tensile strength among time intervals. This decrease in the tensile strength may be due to the formation of foci of stress concentration due to breakdown of the interface of bond between the nylon matrix. When there is a breakdown of this interface, the stresses developed under load will not be effectively distributed throughout the material; the interface will act as a primary source of fracture, leading to the subsequent disintegration of the resin.[20] Tensile strength of flexible resin was significantly decrease by storage time. There was significantly difference between time interval. This result may caused from water absorption and solubility of the material. When denture base materials are stored in a solution. They absorb water and release soluble components. The absorption behavior of denture base materials depended upon the balance between water uptake and loss of plasticizers which are leached out. At equilibrium, it is assumed that most or all soluble matters have been dissolved and denture base materials are saturated with water [21]. This difference may have been the most hydrophilic of flexible resin. It was the result of the amide groups along the chain of polyamide[22] and result to the highest water uptake and leached out of plasticizers. The tensile strength of flexible resin was also significantly affected by storage, this result may have been the higher potassium and sodium ionic concentration of denture disinfectants solution compared to the distilled water[23] lead to higher release of soluble component and plasticizers. Valplast exhibited the lowest tensile strength. The low maximum load exhibited by nylon means that it is less rigid than acrylic resin. Results of (Figure 6 and Table 5) showed a comparison of torsional strength among disinfectants. This study demonstrated that there was no significant difference at $p \leq 0.05$ in the torsional strength among disinfectants. The interpretation of these results may be due to the fact that all disinfectants are solutions and have the same effects on torsional strength of flexible resin material. Figure (7) and Table (6) showed a comparison of torsional strength among time intervals (2 days, 1week, 1 month and 2 months). This study demonstrated that there was no significant difference at $p \leq 0.05$ in the torsional strength between 1 and 2 months but there is a significant difference among 2 days, 1 week and (1 and 2 months), but this result disagreed with Ana *et al.*,[24]

who concluded there was no statistically significant difference between results of torsional strength for 2 days versus 30 days, depending on the nature of the polymer, whether it is amorphous or crystalline, linear, branched or cross linked. The response to torsion varies. This study demonstrated that there was no significant difference at $p \leq 0.05$ in the water sorption among distilled water and disinfectants. This is due to the fact that all the flexible resin specimens treated with solutions contain water. Figure (9) and Table (8) showed a comparison of water sorption among time intervals (2day, 1weeks,1 month and 2 months). This study demonstrated that there was no significant difference at $p \leq 0.05$ in the water sorption between 1 and 2 months, but there was a significant difference at $p \leq 0.05$ among 2days , 1week and (1 and 2 months). This significant increase of the water sorption of the flexible resin specimens may be due to the presence of the voids occurred in the body of the specimens, and as the absorbed water stays in gaps among the inter polymeric chains, make the magnitude of these inter polymeric gaps determines the amount of water to be absorbed [25]. On the other hand, the presence of these polymers disturbs the crystallinity of the nylon matrix; all these factors increased the amount of the uptake of water by the flexible resin specimens [26].The acidic pH of the solution leads to an increase in the diffusion rate of the water into the acrylic resin specimen[27]. Also this agreed with Sunitha [28], who concluded during the comparison between the individual control groups and disinfectant groups for water sorption, a significant difference was observed in the disinfectant group, this may be due to the increase in storage time, which means that the longer exposure of the flexible resin surfaces to the strong chelating activity of the sodium citrate which is a component of commercial denture cleanser may lead to roughened acrylic surface which in turn increases and accelerates the water sorption process.

CONCLUSION

From the results of this experimental investigations, the following conclusions can be mentioned:

- In comparison among disinfectants, there was no statistically significant difference at $P \leq 0.05$ in tensile strength, torsional strength and water sorption properties, while there was a significant difference in indentation hardness .
- There was no significant difference at $P \leq 0.05$ in indentation hardness among different time of immersion cycles (1 week, 1 month and 2 months), while there are a significant difference in tensile strength, torsional strength and water sorption properties after 1 and 2 months of immersion cycle.
- The microwave irradiation had significantly lowest effect on the indentation hardness of flexible denture base material.

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