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Evaluation of the effect of hypochlorite cleanser on water sorption and solubility of flexible and conventional hot – cure – acrylic denture base. (A comparative study)

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Abstract

Background: One of the primary applications for thermoplastics flexible resins involved flexible partial dentures tooth born and combination flexible and chromium cobalt framework partial denture. There are certain to be many new clinical applications for thermoplastic resins in dentistry. The cleansers effect maturity of the sterilization of acrylic resin denture base; therefore, it using chemical or physical methods can minimize the risk of periodontal disease such as denture related stomatitis in denture users.

This study aims: to evaluate of the effect of hypochlorite cleanser on the water sorptsion and solubility of flexible and conventional hot – cure acrylic resin denture base. Compare the results on the water sorption and solubility between specimens.

Methods: Sixty of flexible and hot –cured acrylic resin specimens were prepared as following:

30 samples from hot – cure acrylic divided into two group 15 specimens immerse in the hypochlorite and 15 specimens immerse in the water. The process is cured in the water bath according to the conventional method. 30 specimens from flexible resin divided into two group 15 specimens immerse in the hypochlorite and 15 specimens immerse in the water. The process is cured in the plastic injection machine.

Results: showed highly significant differences among these groups. It showed that the hot – cured acrylic high water sorption and lower solubility and the flexible resin lower water sorption and high solubility.

Conclusion:

1. The comparison between the hot –cured acrylic and flexible resin denture base immersed in the hypochlorite and water on the water sorption is higher of the hot –cure acrylic and lower of the flexible resin.
2. The flexible resin denture base immersed in the hypochlorite and water is higher solubility compared with the hot –cured acrylic is lower solubility.

Keywords: Flexible resin, hot –cure acrylic, hypochlorite, water.

Introduction

Flexible dentures use a special flexible resin that prevents them from chafing the gums allows the wearer to chew properly. It also provides a soft

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base that prevents the gums from being rubbed raw. Some of the commercially available products are *Valplast, Duraflex, Flexite, Proflex, Lucitone* and *Impak* where as valplast and lucitone are monomers free. [1]

Flexible dentures have got various advantages over the traditional rigid denture bases. Translucency of the material picks up underlying tissue, making it almost impossible to detect in the mouth. No clasping is visible on tooth surfaces (when used in manufacturing of clear clasps), improving aesthetics. The material is exceptionally strong and flexible. Free movement is allowed by the overall flexibility. Complete biocompatibility is achieved because the material is free of monomer and metal, these being the principle causes of allergic reactions in conventional denture materials. Clinicians are able to use areas of the ridge that would not be possible with conventional denture and partial techniques. Patient can wear appliances that would normally not be comfortable. Flexible dentures will not cause sore spots due to negative reaction to acrylic resins and will absorb small amounts of water to make the denture more soft tissue compatible. Flexible dentures may be used as an alternate treatment plan in rehabilitating the anomalies such as ectodermal dysplasia. [2] While the disadvantage Flexible dentures generally not used for long-term restorations and is intended only for provisional or temporary applications. Flexible dentures tend to absorb the water content and will discolor often. Metal frame partial dentures remain the" standard" for long-term restorations. When grinding this prosthesis, proper ventilation, masks, and vacuum systems should be used and the procedure is technique sensitive. Extreme caution is necessary when processing to avoid skin contact with the heated sleeve, cartridge and furnace, heating bay, hot cartridge, injection insert, piston head adapter, hot flasks, and heat lamps. [3]

It is well documented that water sorption and solubility by flexible and hot-cure resins have a negative impact on their physical properties and may lead to harmful tissue reactions. The presence of residual monomer is often identified as the main cause for adverse tissue reactions. To optimize the polymerization reaction, the use of the proper powder/liquid ratio is recommended in the fabrication of a dental appliance. It is also recommended that a dental appliance should be soaked in water for at least 24 hours before delivery to a patient, in order to reduce the possible adverse effect. For flexible resins, associated with higher residual monomer levels than hot-cured resins, soaking the appliance at elevated temperatures (65ºC for 60 minutes), would reduce the residual monomer content more efficiently than at room temperature. This requires additional processing conditions from the technician or dentist. Changing the powder/liquid ratios, deliberately or not, may modify the residual monomer content of the final product. A relationship exists between the levels of residual monomer and water sorption. Also residual monomer leaching into the oral fluids may lead to adverse effects such as, oral tissue irritation or a delayed hypersensitivity reaction.[4]

The hot – cure acrylic resin show a larger variation of physical and mechanical properties with temperature. The primary use of polymers has been construction of prosthetic appliances such as denture base. However , they have been used for highly important application , such as artificial teeth , tooth restorations cements , orthodontic space maintainers and elastics , crown and

bridge facings , obturators for cleft palates , inlay patterns , implants , impression , dies , temporary crowns , endodontic fillings , and athletic mouth protectors.[5]

In human mouth dentures, prepare an optimal environment for adhesion and multiplication of both pathogenic and non pathogenic organisms. The increasing use of dentures has lead to a concomitant increase in the incidence of denture stomatitis. Management of denture related infections is challenging and infected dentures generally need to be disinfected. [6]

The increasing use of dentures in senile and institutionalized adults, who are prone to stomatitis and other infections, has caused increasing the denture related infections. [7]

The most important way to maintain healthy oral mucosa is proper cleaning and appropriate hygienic care of removable dentures. Though it is the responsibility of denture users, the dentists should inform patients about the various disinfectants used for plaque control. [8]

The aims of the study the evaluation and comparison of cleanser (hypochlorite) and water on the water sorption and solubility of flexible and conventional hot – cure acrylic denture base.

Materials and Methods

1- Pink heat-cure acrylic resin (Triplex hot Ivoclar vivadent, Liechtenstein).
2- Flexible acrylic resin (Germany). (figure 1,A)
3- Dental stone (type 3 model dental stone, elite models, Italy).
4- Silica gel (China).(figure 1,B)
5- Dental pumice (Steripim plus, Germany).
6- Distilled water (Al-mansore Co., Iraq).Hypochlorite (Iraq)
7- Separating medium (PD Pink color Siltom, Argentina)

Methods

Metal pattern preparation

The dimensions and shape of the metal pattern were made according to ADA specification No.12 (1999) Fig.(2).where the diameter is 50mm and thickness 0.5mm.

Sample grouping

Sixty specimens were prepared from flexible and hot – cure acrylic resin. The specimens were divided into (2) groups. Each group consisted of (30) specimens immerse in the hypochlorite and distill water.

Mold preparation of hot – cure – acrylic

During preparation of the mold, the conventional flasking technique was followed. The lower portion of the dental flask was filled with dental stone mixed according to the manufacturer instructions (w/p ratio is 25ml/100g); a layer of stone mix was placed on metal block to avoid trapping of air when inserting the metal block into the stone mix after coating with separating media (PD Pink color Siltom). After stone was set, both the stone and metal patterns were coated with separating media. The upper half of the flask was then positioned on top of lower portion and filled with stone, with vibration to get rid of the trapped air. Stone was allowed to harden for 60 minutes before the flask was opened. The metal patterns were invested each time when the specimens were to be prepared. The flask was then opened and metal patterns were removed from the mold carefully. [9]

Pink heat cured acrylic was mixed according to manufacturer's instructions (3:1) by volume. The liquid was placed in a clean and dry

mixing vessel followed by slow addition of powder. The mixture was then stirred with wax knife and left to stand in a closed container at room temperature until reaching the dough stage.

The packing process was performed while the acrylic is in dough stage. The resin was removed from its mixing jar and rolled, then packed into the mold previously coated with separating media with the aid of polyethylene sheet. The two halves of the flask were closed together and placed under the hydraulic press, and then the pressure was slowly applied to allow even flow of the dough throughout the mold space. The pressure was then released, the flask was opened and the over flowed material (flash) surrounding the mold space was removed with wax knife. A second trial closure was performed; the stone surface was again coated with the separating media, allowed to dry and the polyethylene sheet was removed. The two halves of the flask were finally closed until an intimate contact had been established and left under the press for 5 minutes then the flask was placed in a flask clamp thus maintaining undisturbed pressure during processing.

The curing was carried out by placing the clamped flask in a water bath and processed by heating at 74ºC for about an hour and half. The temperature was then increased to the boiling point for 30 minutes. [10]

After completing the curing, the flask was allowed to cool slowly at room temperature for 30 minutes. Followed by, complete cooling of the flask with tap water for 15 minutes before deflasking. The acrylic patterns were then removed from the mold.

Finishing and Polishing

An acrylic bur was used to remove all flashes of acrylic followed by 120-grain size sand paper with continuous water-cooling (to prevent over heating) in order to get smooth surface.

Polishing was accomplished using bristle brush and rag wheel with pumice using dental lathe polishing machine (low speed, 1500 rpm) till glossy surface was obtained, the final measurements of the samples were obtained using the vernier.

Preparation of flexible resin specimens

In this procedure, injection cast technique was used and the sprue designing was highly technique sensitive.

For preparation of the mold of the flexible resin specimens, it should be sufficient width of sprue was attached to the specimens and put four sprues in all specimens. [11]

Wax elimination was done by putting the flask in boiling water for 4 to 6 minutes to soften the wax. The bolts were loosened on the flask to remove the metal flask brackets and flask was opened. Boiling out procedure was completed and the wax was discarded. The flask was flushed with clean boiling water. The stone around the sprue was beveled with a knife. Flask margin were checked to ensure that both flask halves fit together with intimate metal contact. A thin coat of separating agent was applied to the mold and was allowed to dry completely. [12]

Using heat resistant gloves, the cartridge was inserted into the cartridge sleeve with the nozzle of the cartridge facing inwards. Injection insert was positioned on the bolt side of the flask and the opened flask was placed directly in a pre-heated oven maintained at 287C^{O}. Furnace timer was set for 25 minutes. After heating the flask assembly was placed in front of the Success plastic Injection machine.fig (3)

Cartridge sleeve and cartridge assembly were removed from the furnace, keeping the cartridge assembly horizontal while transporting it to the flask assembly on top of the flask so that the nozzle of the cartridge fitted into the opening of the injection insert. The narrow piston head was properly aligned with the cartridge sleeve. The piston was engaged by depressing the activation switch. After one minute of injection, the flask assembly was removed from the system and the cartridge assembly was disengaged from the flask assembly immediately. Finally, the used cartridge was removed using the knock out base and knock out rod and the cartridge sleeve was returned to the furnace. The flask assembly was cooled for five minutes before de-flasking after which the denture was retrieved.

The sprues were removed with a cut off disk. FRS was finished using normal procedures for acrylic. [13]

Water Sorption Test

A- Specimens preparation

From metal disc, 60 specimens of both hot and flexible resins denture base (30 for each) were prepared with dimensions of (50 ± 1mm in diameter and 0.5 ± 0.1 mm in thickness) according to (ADA specification No.12, 1999).

B- Test equipment and procedure

The samples were dried in a desiccators containing silica gel (figure4-A). The desiccators was stored in an incubator at a temperature of 37ºC ± 2ºC for 24 hours(figure4-B), removed to similar desiccators at room temperature for one hour, after which the samples were weighed using a digital balance. (Figure4- B). This cycle was repeated until the weight loss of each disk was not more than 0.5 mg in every 24 hour period; this was considered as condition mass according to (ADA specification No. 12, 1999). The samples were then immersed in distilled water at 37ºC ±1ºC for 7days. After that the samples were removed from the water with tweezers, wiped by a clean dry hand towel, until free from visible moisture, waved in the air for 15 seconds and weighed one minute after removed from the water.

The value for water sorption was calculated for each disc in (mg/cm^2) according to (ADA specification no.12, 1999) for denture base polymers water sorption:

$$\text{Water sorption } (mg/cm^2) = \frac{\textbf{Mass after immersion (mg) - Conditioned mass (mg)}}{\textbf{Surface area } (cm^2)}$$

Solubility Test

After the final weighing were described in the water sorption test, the samples were reconditioned to constant weight in the desiccators at 37ºC ± 2ºC as was done in the water sorption test previously. The value of solubility was determined for each sample according to the equation below:

$$\textbf{Solubility } (mg/cm^2) = \frac{\textbf{Conditioned mass (mg) - Reconditioned mass (mg)}}{\textbf{Surface area } (cm^2)}$$

Results

Water Sorption Test Results

Mean values, standard deviation (SD), standard error (SE), minimum and maximum are presented in (Table 1) and figure (5) for water sorption test.

The values of water sorption varied according to hypochlorite and water that are used. The highest mean water sorption value was obtained from the hot – cured acrylic immersed in the hypochlorite group (B) is (6.47E-03). While the lowest mean water sorption value was obtained from the flexible resin immersed in the water group (C) is (3.73E-03).

In Table (2) shows that the inferential statistics are t- test of the water sorption test. It appears that the comparison between the hypochlorite and water groups (A – B) of the hot – cured acrylic is high significant difference. While the comparison between the hypochlorite and water of the flexible resin groups (C – D) is non significant difference.

On way (ANOVA) with (LSD) of multiple comparison test, the results have shown that there was a high significant difference ($P<0.01$) among the groups of the hot – cured acrylic (A – B) and the flexible resin(C – D) immersed in the water and hypochlorite. Shown table (3)

Solubility Test Results

Mean values, standard deviation (SD) and standard error (SE) are presented in (Table 4) and (figure 6) for solubility test.

The values of water sorption varied according to hypochlorite and water that are used.The highest mean solubility value was obtained from the flexible resin immersed in the hypochlorite group (D1) is (3.93 E -03). While the lowest mean solubility value was obtained from the hot –cured acrylic immersed in the water group (A1) is (2.67 E-03).

In table (5) shows that, the inferential statistics are t- test of the solubility test of hot - cured acrylic and flexible resin. It appears that the comparison between the hypochlorite and water groups (A1 – B1) of the hot –cured acrylic is high significant difference. While the comparison between the hypochlorite and water of the flexible resin groups (C1 – D1) is significant difference.

In table (6) observe that, the inferential statistics (ANOVA) with (LSD) of multiple comparison of the solubility test, the results have shown that there was a high significant difference ($P<0.01$) among the groups the hot – cured acrylic (A1 – B1) and the flexible resin (C1 – D1) immersed in the water and hypochlorite.

Discussion

Thermoplastics used in dentistry have known a great diversification in the last years. Processing principles are similar to the injecting technology of chemoplastics. However, the main difference consists in chemical composition, liquefying temperature of grains, injecting pressure and the fact that thermoplastic resins are monocomponent.

In this study, hypochlorite is used as the cleanser of the denture bases on the water sorption and solubility of the hot and flexible -cured acrylic resins denture base.

The result in table (1), figure (5), the highest mean values from the hot – cured acrylic immersed in the hypochlorite group (B). While the lowest mean value was obtained from the flexible resin immersed in the water group (C). that related to water sorption of the materials represented the amounts of cleanser or water absorbed on the surface and into the

body of the material during fabrication, or while the materials is in service of water absorption is shown to obey the laws of diffusion, where there are two necessary physical parameters diffusion coefficient and equilibrium concentration. This is results agreement with (Hatrick, et.al 2003, Takashashi et. al, 2009; Fu CC. et. al, 2009).

The mean values for water sorption by hot and flexible acrylic denture base resins immersed in the hypochlorite and water are within the limits given by ADA specification No.12, (1999), the gain in weight by the resin must not be greater than 0.7 mg/cm^2.

Statistically are t- test of the water sorption of hot –cured acrylic and flexible resin. It appears that the comparison between the hypochlorite and water groups (A – B) of the hot – cured acrylic is high significant difference. While the comparison between the hypochlorite and water of the flexible resin groups (C – D) is non significant difference as shown Table (2). This may be related to that the hot – cured acrylic resin tended to have inherently high water sorption values.

This phenomenon is explained by the water absorption occurring among the molecular chains due to the high hydrophilicity of the numerous amide bonds forming the main chains of the polyamide resin. This explanation agreed with (Phillips, 1989; AL-Musawi, 2005). While the flexible resin denture base materials could be adjusted to a level as low as that in popular industrial materials such as nylon. Such an adjustment would result in strong hydrogen bonding between amide groups and a reduction in attachment areas for water molecules; therefore, the amount of water sorption in flexible resin would decrease to the same level as nylon. This is agreement with (Kaplan et.al, 2008; Colan et.al; 2008).

In the table (3) showed that, the inferential statistics are (ANOVA) and (LSD) (least significant difference) of the water sorption test. It appears that the high significant difference ($P<0.01$) comparison between all groups hot – cured acrylic and flexible resin immersed in the hypochlorite and water.

This is investigated Arikan et.al; 2005, they are studied the physical properties of the acrylic resin and obtain to the higher water sorption of the hot – cured acrylic resin and lower water sorption of the flexible resin. This is related to the composition of the polymerized acrylate, its base component is methyl- metacrylate. These materials are developed to chemical reaction between the hot – cured acrylic and hypochlorite or water. The certain of the composition of thermoplastic flexible are a resin derived from diamine and dibasic acid monomers. This is the lowest contact angle against water or hypochlorite. It is presumed that the differences of molecular weight or cross- linking agents will influence the water sorption of flexible resin. This is supported with (Lai et.al; 2003, Phoenix et.al; 2004).

From table (4), figure (6), the highest mean solubility value was obtained from the flexible resin immersed in the hypochlorite group (D1). This could be related to losing more weight due to lower degree of polymerization of flexible resin and the presence of higher contents of residual acid monomer which make higher solubility. This explanation agreed with (Antonelli et.al, 2001; Low LG., 2004).

While the tested specimens of hot – cured acrylic resin immersed in the water group (A1), it appear that lowered mean values of solubility. This is probably due to the loss of molecular weight of the hot –cure acrylic and the loss of the cross-linked

between the molecular which lead to lower of solubility. This is result supported with (Craig et al., 1996; Craig and Powers, 2002; AL-Musawi, 2005).

In the table (5) showed statistically are t- test of the solubility test of hot - cured acrylic and flexible resin. It appears that the comparison between the hypochlorite and water groups (A1 – B1) of the hot –cured acrylic is high significant difference ($P<0.01$). While the comparison between the hypochlorite and water of the flexible resin groups (C1 – D1) is significant difference ($P<0.05$). This is state that the polymer is cross - linked, it cannot dissolve but only swell as solvent penetrates the material. The solvent matches that of the polymer, the chain conformation is most expanded, resulting in a maximum viscosity. When the loss of viscosity is result loss molecular weight of the hot – cured acrylic and higher difference between the groups (water, hypochlorite) of solubility test. This is agreement with (Price CA. 1994; John et.al; 2001; Low LG., 2004).

On other hand, the flexible resin contain the larger intermolecular attractive forces associated with them, the escaping tendency of larger molecules weight will be increase solubility between flexible resin and (water, hypochlorite). This is explanation agreed with (Fitton et.al, 1994; Arikan et.al, 2005)

From table (6) it showed are the statistically (ANOVA) with (LSD) of multiple comparison of the solubility test. It observed that, there was a high significant difference ($P<0.01$) among the groups hot – cured acrylic (A1 – B1) and flexible resin (C1 – D1). This is related to the Intermolecular forces can be a big help for a polymer chain, when the hot – cured acrylic immersed the hypochlorite and water, they form strong hydrogen bonds. This strong less binding holds are crystal together, which lead to the higher difference between groups of the solubility test. They pointed that (John et.al, 2001; Takahshi et.al, 2009)

While the flexible resin is result the higher difference between groups. This is investigated Yokoyama et.al; 2004. They are studied the Molecular weight, intermolecular bonding forces of the flexible resin and obtain to the chain flexibility controlled by molecular weight, the Chain flexibility is depended on the structure and composition of the resin that make up the flexible matrix that attached to main chain which lead to the higher difference of the solubility of the flexible resin immersed hypochlorite and water. This is supported with (Fitton et.al, 1994; Negrutiu M., 2001).

Conclusion

Within the limitations of this study, the following conclusion could be withdrawn:

1- The comparison between the hot –cured acrylic and flexible resin denture base immersed in the hypochlorite and water on the water sorption is higher of the hot –cure acrylic and lower of the flexible resin.
2- The flexible resin denture base immersed in the hypochlorite and water is higher solubility compared with the hot –cured acrylic is lower solubility.

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A B

Figure (1): A- Flexible acrylic resin capsule B- Silica gel

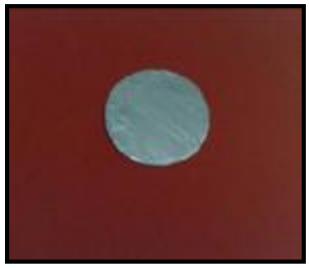

Figure (2): Metal Patterns of water sorption and solubility

Figure (3): plastic injections machine

A B

Figure (4): A- Samples drying in desiccators over silica gel. B- Digital electronic balance.

Figure (5): Bar chart show mean values for water sorption (mg/cm^2) of Hot and flexible Resins denture base as influenced by hypochlorite and water.

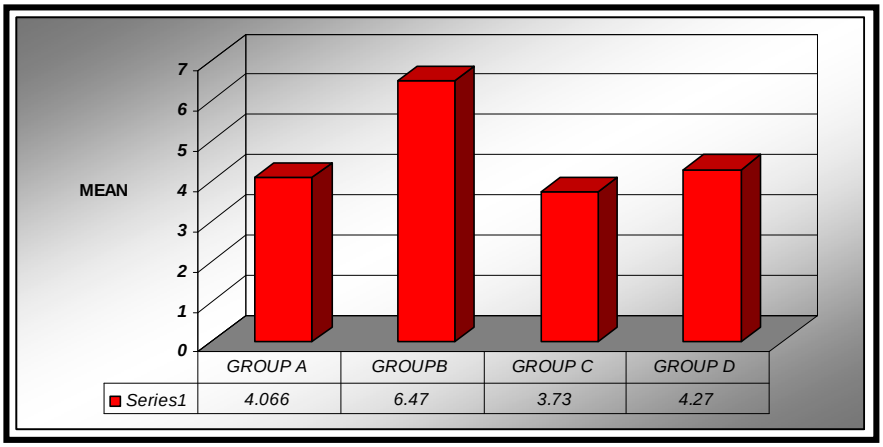

Figure (6): Bar chart show mean values for solubility (mg/cm^2) of Hot and flexible resins denture base as influenced by hypochlorite and water

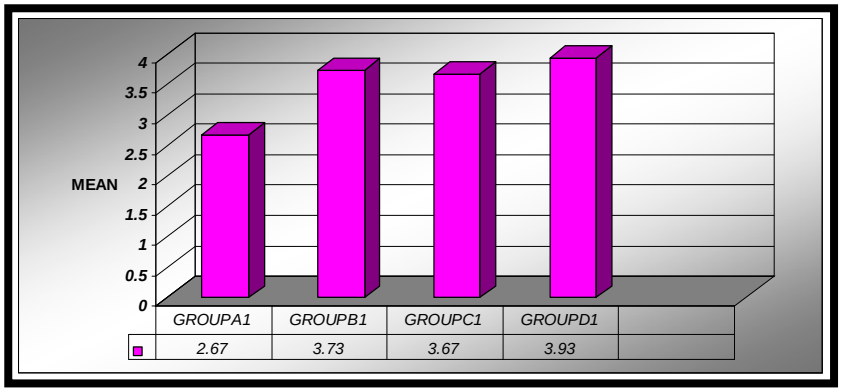

Table (1): Descriptive statistics for water sorption (mg, cm2) among studied groups. (Hot –cure A, Hot – cure B, Flexible C, Flexible D)

Groups	Mean	St.d deviation	St.d Error of mean	Mini.	Maxi.
Hot-cured A	4.066E-03	2.2509E-03	5.8119E-04	0.001	0.006
Hot- cured B	6.47E-03	1.55E-03	4.01E-04	0.002	0.008
Flexible resin C	3.73E-03	2.34E-03	6.05E-04	0.001	0.006
Flexible resin D	4.27E-03	2.43E-03	6.28E-04	0.001	0.007

Table (2): T- test of the water sorption of the hot –cure acrylic and flexible resin.

Groups	t	P- Value	C.S
Hot – cured A – B	3.450	P< 0.01	HS
Flexible resin C – D	0.570	P>0.05	NS

Table (3): LSD least significant difference for water sorption of hot and flexible

Groups		Hot-cured acrylic		Flexible resin	
		Water A	Hypochlorite B	Water C	Hypochlorite D
Hot - cured acrylic	Water A		HS	HS	HS
	Hypochlorite B	HS		HS	HS
Flexible resin	Water C	HS	HS		HS
	Hypochlorite D	HS	HS	HS	

Table (4): Descriptive statistics for solubility (mg, cm2) among the studied groups. (Hot-cured A1, Hot – cure B1, Flexible C1, Flexible D1)

Groups	Mean	St.d deviation	St.d Error of mean	Mini.	Maxi.
Hot-cured A1	2.67 E- 03	7.24 E-04	1.87 E-04	0.002	0.004
Hot- cure B1	3.73 E- 03	1.10 E-03	2.84 E-04	0.002	0.005
Flexible resin C1	3.67 E -04	9.00 E - 04	2.32 E -04	0.002	0.006
Flexible resin D1	3.93 E -03	1.03 E - 03	2.67 E -04	0.002	0.006

Table (5): T- test of the solubility of the hot –cure acrylic and flexible resin.

Groups	t	P- Value	C.S
Hot – cured A1 – B1	3.096	P< 0.01	HS
Flexible resinC1 – D1	1.000	P< 0.05	S

Table (6): LSD least significant difference for solubility of hot and flexible –cured

Groups		Hot-cured acrylic		Flexible resin	
		Water A1	Hypochlorite B1	Water C1	Hypochlorite D1
Hot - cured acrylic	Water A1		HS	HS	HS
	Hypochlorite B1	HS		HS	HS
Flexible resin	Water C1	HS	HS		HS
	Hypochlorite D1	HS	HS	HS	