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# Evaluation the Effect of Different Methods of Disinfection on Tensile Strength and Bond Strength of Soft Denture Lining Materials

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**الخلاصة**

**الأهداف:** هدف الدراسة هو تقييم تأثير طريقتين مختلفتين لتطهير الطقم على قابلية التمدد و قوة الارتباط لنوعين مختلفين للمواد المبطنة للطقم لفترتين من الوقت (١٤ و ٣٠ يوم ). **المواد وطرائق العمل:** حضرت مائتا عينة من مادتي (Vertex ,Molloplast–B) المبطنة للطقم لتقييم تأثير طرق التطهير بالغمر في المحاليل المطهرة الكيميائية و التي شملت ( الماء المقطر، اللعاب المصنع، محلول ملحي عالي التركيز و محلول الخل المخفف) وطريقة التطهير باستخدام المايكروويف على قابلية التمدد و قوة الارتباط للمواد المبطنة للطقم. **النتائج:** إن نتائج القياسات أعلاه قد أُخضعت لاختبار تحليلات أحادية الاتجاه للتباين و اختبار دنكن المتعدد المدى لتوضيح فيما إذا كان هناك أي اختلاف معنوي بين المجموعات التجريبي عند مستوى احتمالية ٥%. **الاستنتاجات:** اظهرت النتائج ان هناك تاثير معنوي لطرق التطهير على قيمة قابلية التمدد و قوة الارتباط لمادتي التبطين و كذلك اظهرت النتائج ان اعلى قيمة لقابلية التمدد و قوة الارتباط لمادة (Vertex)بعد الفترتين (١٤ و ٣٠ يوم ) كانت لمجموعة التطهير بالمايكروويف، بينما كانت اعلى قيمة لقابلية التمدد و قوة الارتباط لمادة(Molloplast–B) هي لمجموعة الغمر في الماء المقطر و ان اقل قيمة كانت لمجموعة الغمر في محلول الخل المخفف لكلا المادتين. و اظهرت النتائج ان التطهير بالمايكروويف له اقل تأثير وان تأثير طرق التطهير المختلفة يزداد بازدياد فترة التطهير.

## ABSTRACT

**Aims**: Aim of the study to evaluate the effect of two different disinfection methods for two periods of time on tensile strength and bond strength of soft denture lining materials (Vertex and Molloplast-B). **Materials and methods** : The effect of two disinfection methods ,first chemical disinfection method (which include artificial saliva , saturated salt and vinegar solution), and second microwave method on two physical properties the tensile and bond strength of soft denture lining materials for two periods of times (14 and 30 days) was evaluated, two hundred samples were prepared, one hundred samples to each property test . ANOVA and Duncan's multiple range test were performed to determine the significant difference among the tested groups at $p \leq 0.05\%$ . **Results**: The result showed that the highest value of tensile and bond strength of Vertex after 14 and 30 days were achieved with the microwave group, while for Molloplast -B highest value achieved with the control distilled water group. The lowest value was achieved after immersion in vinegar group for both soft lining material. A significant difference between the two soft lining materials among all disinfection methods at $p \leq 0.05$**.Conclusions :** The results appeared that the chemical disinfection and microwave disinfection methods have a significant effect on the tensile strength and bond strength of both vertex and Molloplast –B soft ling materials for two periods of time. Microwave disinfection has less effect than the chemical disinfection on the properties. The effect of disinfection increase significantly with increasing period of time .

**Keywords:** soft lining material, disinfection, tensile, bond strength

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## INTRODUCTION

Soft denture lining materials have become important in dental prosthetic treatment, because of their capability of restoring health of inflamed and distorted mucosa, normally used to interface a hard prosthesis surface and the oral tissues that in contact.[1] Soft denture lining materials include silicone elastomer and plasticized acrylic resin [2] both groups are available in auto-or heat-cured forms. These materials are polymerized at room temperature or at higher temperatures. [2-4] Inadequate cleaning of dentures in elderly leading to plaque formation on the surface of dentures is a common problem among denture wearers and can lead to denture stomatitis.[5] The daily use of chemical denture cleansers

can affect the properties of both denture acrylic resin and resilient liners.[6] The use of microwave energy to disinfect dentures has been suggested to overcome the problems associated with denture cleaning.[1] This study aims to evaluate the effect of two different disinfection methods on the tensile strength and bond strength of soft denture lining materials.

## MATERIALS AND METHODS

**Mould Preparation :**

The conventional flasking technique for complete denture was followed in the mould preparation. [7] For Vertex (Vertex-Dental B.V, Netherland), the powder-liquid ratio was mixed according to the manufacturer's instructions .The soft acrylic denture material dough was placed in the mould of flask for packing and curing.[8] For soft denture lining material Molloplast-B (DETAX DIN EN)was made as a paste material and placed in the mould of flask for packing and curing. Curing was carried out according to the manufacturer's instructions by placing the clamped flask in a thermostatically controlled water bath. Polymerization in boiling water at 100C for approximately 2 hours.[7]

**Disinfection methods:**

The disinfection methods were performed for the two different soft ling materials (Vertex and Molloplast-B )for two periods of time (14 days and 30 days) as in the followings:

1. The samples (control group) were soaked in distilled water only at 37$^{o}$C. [9]
2. The samples group of artificial saliva were soaked in distilled water for 8 hours per day at 37$^{o}$C, then were immersed in artificial saliva at 37$^{o}$C in incubator (for 16 hours). Artificial saliva was of the following composition: NaCl, 0.400 g; KCl, 0.400 g; $CaCl_2H_2O$, 0.795 g; $NaH_2PO_4$, 0.69 g; $Na_2S\bullet 9H_2O$, 0.005 g; urea 1.0 g; distilled water, 1000 ml. The pH was then adjusted to 7 or 9 with NaOH or HCl, and the volume made up to one liter of distilled water. [10] The usage of artificial saliva to produce a setting solution similar to the oral medium.
3. The samples group of saturated salt were soaked in distilled water for 8 hours per day at 37$^{o}$C, then half an hour per day in saturated salt solution [18] and finally the samples were immersed in artificial saliva at 37$^{o}$C in an incubator for (15 and half hours) per day. [8] Saturated salt solution was prepared by the addition of 40gm of salt to each 100ml distilled water.
4. The samples group of vinegar solution were soaked in distilled water for 8 hours per day at 37$^{o}$C, then half an hour per day invinegar solution(acetic acid): $CH_3COOH$ [11] and finally the samples were immersed in artificial saliva at 37$^{o}$C in an incubator for (15 and half hours) per day. [8] Five (ml) of vinegar was diluted in 100 ml of distilled water. Acetic acid used as household denture cleanser.[11]
5.The samples group of microwave were irradiated with Domestic microwave oven (LG, Korea). The recommended microwave energy for sterilization is about 650 W for 6 min. [12], samples then soaked in distilled water for 8 hours per day at 37$^{o}$C, and finally were immersed in artificial saliva at 37$^{o}$C in an incubator for (15 and half hours) per day.[8] The disinfection solutions and solution of artificial saliva were prepared and changed every .[8]

The PH values of the prepared solutions were measured by using PH meter device(PHILIPS, GE, and type PW 94, England) .The PH value of the solutions were : Distilled water (7.000), artificial saliva (7.315), saturated salt solution (7.100)m and vinegar (2.603).

**1.Tensile Strength Test:**

One hundred samples were prepared for tensile strength test , five samples to each sub-division group .A dumbbell-shaped specimen was prepared in dimensions of 75x12.75x2.5±0.03 mm in length, width and depth respectively, while the dimensions of the tensile bar of each specimen are 35mm x 3mm x 2.5±0.03 mm length, width and depth respectively [13] as shown in Figure (1).

Figure (1): A dumbbell-shaped specimens for tensile strength test

Water storage for 48 hours at 37°C before testing the specimens [7,13] then the specimens were disinfected according the recommended plane.

The tensile strength was tested using a Textile Tensile testing machine(Kyoto, Japan) The specimens were placed under tension until fracture occurred. The force at failure was recorded in Newton (N) and the true tensile strength value was calculated by the following formula (American Dental Association): [13]

$$T.S\ (MPa.) = \frac{F\ (N)}{A\ (mm^2)}$$

F=Force at Failure (N).

A=Area of Cross Section at Failure ($mm^2$)

**2. Bond Strength Test:**

A split metal mold was used in this study to prepare one hundred samples of the acrylic denture base cylinders (one hundred pairs cylinders). This mold having five cylindrical holes, each hole is 20 mm height and 12.65_+0.03 in diameter, [14] (Figure 2).

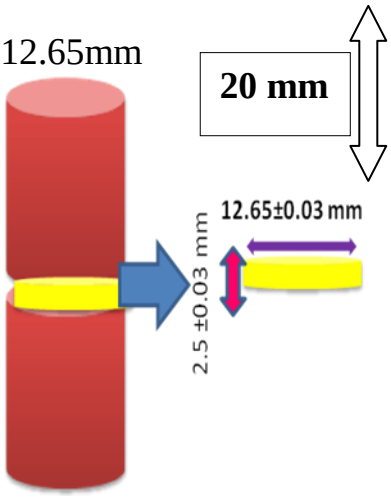


Figure (2): Pair of acrylic cylinders+ Rounded metal spacer

Powder and liquid of heat cured polymethyl methacrylate(Respal Dental, Italy) was proportioned and mixed according to the manufactures instructions. The mold was packed with dough acrylic resin material and curing was accomplished in a thermostatically controlled water bath according to the manufactures instructions. Roughening of surface of acrylic denture base cylinder was accomplished with the aid of acrylic bur no. (0.32) that used to standardize method of roughening. Each cylinder was roughened through moving the bur above it horizontally, in one direction and at a speed of 50000cycle/minute. Each cylinders were roughened by a new bur.[15] Dental flask with dental stone was used to prepare mold for the specimens of all types of soft denture lining materials used in this study.

Rounded metal spacer of 2.5 mm thickness and 12.65 mm in diameter was fixed to the roughened surface of a pair of acrylic cylinders. This specimen was used as a standard specimen to prepare the mold,[15] Figure(2).Pair of acrylic cylinders were placed in the mold (with it is roughened surface). An adhesive were applied to the roughened acrylic surface according to the group. Primo adhesive (DETAX DIN EN, Germany ) of Molloplast lining material was applied as one layer using fine brush .While, Vertex soft denture lining material is acrylic based soft liner ,liquid was used to treat the roughened acrylic surface. Lining materials placed in

the space created by the metal spacer, (Figure 3). The specimens were disinfected according to the recommended plane.

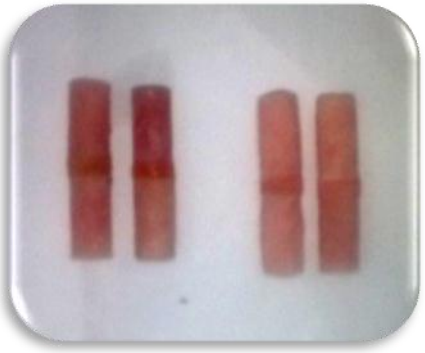

Figure (3) : Two Pairs of acrylic cylinders with Vertex and Molloplast–B lining materials placed in the space (2.5 mm thickness)

The specimens were disinfected according to the recommended plane. A universal testing machine (Zweigle, Semiautomatic strength tester MILANO) was used to measure the tensile bond strength between the acrylic denture base and soft denture lining materials in unit of Mega-Pascal (MPa) which was calculated based on the load (F) in Newton (N) at circular surface area (S) in $mm^2$ :

BS (MPa)= F/S (Abid Al-Kadder)[15] F(N)= Load (Kg)× 9.8

(S)= circular surface area in $mm^2$

Statistical Analysis: Student T- test, One-way analysis of variance (ANOVA) and Duncan's multiple range test were performed to determine the significant difference among the tested groups at $p \leq 0.05\%$.

## RESULTS

**1.Tensile Strength Test:** The result in (Table1). Showed that the highest value of tensile strength of Vertex material after 14 and 30 days was achieved with the microwave group (0.096520 *MP*a, 0.095620 *MP*a). The lowest value after 14 and 30 days was achieved after immersion in vinegar group (0.0804 *MPa*, 0.0672 *MPa*).

Table (1): Mean (*MPa*) and standard deviation of tensile strength of Vertex and Molloplast-B soft denture lining materials after 14 and 30 days among different methods of disinfection at $p \leq 0.05$ .

| Solutions | Materials | No. | After 14 days | | After 30 days | |
|---|---|---|---|---|---|---|
| | | | Mean MPa | S.D ± | Mean MPa | S.D ± |
| **Distilled water** | Vertex | 5 | 0.0895 | 0.0071 | 0.08878 | 0.0109 |
| | Molloplast-B | 5 | 0.00976 | 0.0022 | 0.0094 | 0.0025 |
| **Microwave** | Vertex | 5 | 0.096520 | 0.0003 | 0.09562 | 0.0186 |
| | Molloplast-B | 5 | 0.00914 | 0.0016 | 0.0069 | 0.0010 |
| **Artificial saliva** | Vertex | 5 | 0.09196 | 0.0044 | 0.08512 | 0.0062 |
| | Molloplast-B | 5 | 0.00878 | 0.0004 | 0.007 | 0.0001 |
| **Salt** | Vertex | 5 | 0.08318 | 0.0014 | 0.076 | 0.0031 |
| | Molloplast-B | 5 | 0.00858 | 0.0005 | 0.00592 | 0.0006 |
| **Vinegar** | Vertex | 5 | 0.0804 | 0.0187 | 0.067 | 0.0040 |
| | Molloplast-B | 5 | 0.00742 | 0.0014 | 0.00676 | 0.0010 |

No.=Number of samples S.D= Standard deviation MPa =mega pascal

The results also showed that the highest value of tensile strength after 14 and 30 days for Molloplast -B material was achieved with the control distilled water group (0.00976 *MPa*, 0.0094 *MPa*), while the lowest value after 14 days was achieved with immersion in vinegar (0.00742 *MP*a) and with salt after 30 days (0.00592 *MP*a). ANOVA analysis of tensile strength (Table 2), Revealed that there was a statistically significant difference in tensile strength of Vertex materials after 14 and 30 days at $P \leq 0.05$.

Table(2):ANOVA of tensile strength of Vertex and Molloplast –B soft denture lining materials after 14 and 30 days among different methods of disinfection

| | | After 14 days | | | | | After 30 days | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **SS** | df | **MS** | **F** | ***P*** value* | **SS** | **Df** | **MS** | **F** | ***P*** value* |
| **Vertex** | **Between Groups** | 0.001 | 4 | 0.000 | 2.528 | 0.043 | 0.0025 | 4 | 0.001 | 5.773 | 0.003 |
| | **Within Groups** | 0.002 | 20 | 0.000 | | | 0.0025 | 20 | 0.000 | | |
| | **Total** | 0.003 | 24 | | | | 0.0050 | 24 | | | |
| **Molloplast-B** | **Between Groups** | 0.000 | 4 | 0.000 | 1.756 | 0.177 | 0.000 | 4 | 0.000 | 4.784 | 0.007 |
| | **Between Groups** | 0.000 | 20 | 0.000 | | | 0.000 | 20 | 0.000 | | |
| | **Total** | 0.000 | 24 | | | | 0.000 | 24 | | | |

For Molloplast materials there was no statistically significant differences in tensile strength after 14 days while after 30 days of immersion there was a statistically significant difference in tensile strength among all tested groups. Duncan's Multiple Range Test (Table 3)

Table (3): Duncan's Multiple Range Test of tensile strength after 14 and 30 for both Vertex and Molloplast-B soft denture lining materials among different methods of disinfection at $p \leq 0.05$ .

| **Disinfection methods** | **Periods of time for disinfection** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **After14 days (Materials) MeanMPa*** | | | | | **After30 days (Materials) MeanMPa*** | | | |
| | No | Vertex | G | Molloplast | G | Vertex | G | Molloplast | G |
| **Distilled water** | 5 | 0.0895 | ab | 0.00976 | a | 0.08878 | bc | 0.0094 | bc |
| **microwave** | 5 | 0.096520 | b | 0.00914 | a | 0.09562 | c | 0.0069 | c |
| **Artificial saliva** | 5 | 0.09196 | ab | 0.00878 | a | 0.08512 | bc | 0.007 | ab |
| **Salt** | 5 | 0.08318 | a | 0.00858 | a | 0.076 | ab | 0.00592 | a |
| **vinegar** | 5 | 0.0804 | a | 0.00742 | a | 0.067 | a | 0.00676 | ab |

*means with different letters indicate significant difference at $p \leq 0.05$.

For Vertex after 14 days of immersion showed that there were no statistically significant differences in tensile strength at $p \leq 0.05$ among all disinfection groups, except that among microwave, salt and vinegar groups. After 30 days of immersion revealed that there were no statistically significant difference in tensile strength between control group and other tested group for Vertex, except that between the control group and vinegar group and among microwave, salt and vinegar groups

of disinfection.The result showed that there was no statistically significant difference in tensile strength of Molloplast-B after 14 daysat $p \leq 0.05$. While after 30 daysof immersion revealed that there were no statistically significant differences among control group and other tested group, except that between the control distilled water group and salt group of disinfection.

The strength of the filler-polymer bond will have an influence on tensile properties. During disinfection the soft denture liner absorbs a certain amount of water by the filler lead to a considerable amount of dimensional change and result in decrease in tensile and shear stress in the intermolecular chain, this result agreed with AL-Athel*et al*., and others.[16,1]

For the microwave disinfection method, the water in which the materials were placed to reach the boiling temperature. Therefore, it is likely that the heating of the acrylic resins during the disinfection procedures may have enhanced the further polymerization and residual monomer release processes [17]. These will lead to decrease the tensile strength of the liner.

Clear vinegar is considered as acidic solvent. This property of the solution leads to the softening of the surface layer of acrylic resin material and decreases interchain forces and this will allow the water molecules to penetrate the material so, this factor will affect on the strength of the polymer, these agreed with Khalil. [11]

The salt leads to plasticization, which results in disentanglement crazing andbrittle the polymers, which is a reflection of its interaction with the polymer and lead to decrease the yield and tensile strength.[18]

**2.Bond Strength Test:** The results in Table (4). Showed that the highest value of bond strength after 14 and 30 days for Vertex soft denture lining material immersion was achieved with the microwave group (1.344 *MPa*, 1.216 *Mpa*) while the lowest value was achieved with vinegar (0.692 *MPa*, 0.5888*MPa*) respectively.

Table (4): Mean and standard deviation of bond strength of Vertex and Molloplast-B soft denture lining materials after 14 and 30 days among different methods of disinfection at $p \leq 0.05$.

| Solutions | Materials | | After 14 days | | After 30 days | |
|---|---|---|---|---|---|---|
| | | | Mean MP | S.D ± | Mean MP | S.D ± |
| **Distilled water** | Vertex | 5 | 1.165 | 0.2145 | 1.1412 | 0.4162 |
| | Molloplast-B | 5 | 0.2124 | 0.0970 | 0.1832 | 0.0510 |
| **Microwave** | Vertex | 5 | 1.34400 | 0.4456 | 1.216 | 0.4033 |
| | Molloplast-B | 5 | 0.15980 | 0.0844 | 0.1402 | 0.1012 |
| **Artificial saliva** | Vertex | 5 | 1.2 | 0.1224 | 0.97162 | 0.0376 |
| | Molloplast-B | 5 | 0.1596 | 0.0805 | 0.1554 | 0.0999 |
| **Salt** | Vertex | 5 | 0.701 | 0.2029 | 0.6 | 0.0905 |
| | Molloplast-B | 5 | 0.1586 | 0.0922 | 0.1316 | 0.1106 |
| **Vinegar** | Vertex | 5 | 0.692 | 0.0641 | 0.5888 | 0.0280 |
| | Molloplast-B | 5 | 0.149 | 0.0637 | 0.1396 | 0.0489 |

No.=Number of samples S.D= Standard deviation

The highest value of bond strength after 14 and 30 daysimmersion for Molloplast-B soft denture lining material was achieved with the control distilled water group(0.2124 *MPa*, 0.1832 *Mpa*). The lowest value was achieved with vinegar 14 days and with salt after 30 days immersion (0.149 *MPa*, 0.1316*Mpa*) respectively. ANOVA analysis of bond strength (Table 5) Revealed that there was a statistically significant difference in bond strength of Vertex soft denture lining materials after 14 and 30 days at $P \leq 0.05$.

Table(5): ANOVA of bond strength of Vertex and Molloplast-B soft denture lining materials after 14 and 30 day among different methods of disinfection at $p \leq 0.05$

| | | After 14 days | | | | | After 30 days | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **SS** | **dF** | **MS** | **F** | ***P*** value* | **SS** | **dF** | **MS** | **F** | ***P*** value* |
| **Vertex** | **Between Groups** | 1.839 | 4 | 0.460 | 7.536 | 0.001 | 1.750 | 4 | 0.437 | 6.314 | 0.002 |
| | **Within groups** | 1.220 | 20 | 0.061 | | | 1.386 | 20 | 0.069 | | |
| | **Total** | 3.059 | 24 | | | | 3.135 | 24 | | | |
| **Mol-loplast-B** | **Between Groups** | 0.013 | 4 | 0.003 | 0.449 | 0.772 | 0.008 | 4 | 0.002 | 0.279 | 0.888 |
| | **Between Groups** | 0.142 | 20 | 0.007 | | | 0.150 | 20 | 0.007 | | |
| | **Total** | 0.155 | 24 | | | | 0.158 | 24 | | | |

*P** value ≤ 0.05,Statistically Significant differences, df =Degreeof freedom MS=Mean square ;Ss=Sum of square

For Molloplast soft lining materials there was no statistically significant difference in bond strength after 14 and 30 days for all disinfection methods. Duncan's Multiple Range Testfor Vertex (Table 6)

Table (6) :Duncan's Multiple Range Test ofbond strength after 14 and 30 days for both Vertex and Molloplast-B soft denture lining materials among different methods of disinfection

| **Disinfection methods** | **Periods of time for disinfection** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **After14 days (Materials) MeanMPa*** | | | | | **After30 days (Materials) MeanMPa*** | | | |
| | No | Vertex | G | Molloplast | G | Vertex | G | Molloplast | G |
| **Distilled water** | 5 | 1.165 | b | 0.2124 | a | 1.1412 | b | 0.1832 | a |
| **microwave** | 5 | 1.34400 | b | 0.15980 | a | 1.216 | b | 0.1402 | a |
| **Artificial saliva** | 5 | 1.2000 | b | 0.1596 | a | 0.97162 | ab | 0.1554 | a |
| **Salt** | 5 | 0.701 | a | 0.1586 | a | 0.6 | a | 0.1316 | a |
| **vinegar** | 5 | 0.692 | a | 0.149 | a | 0.5888 | a | 0.1396 | a |

*means with different letters indicate significant difference at $p \leq 0.05$

Showed that Vertex after 14 and 30 days for the microwave group has a greatest value than other disinfected groups because, these samples when irradiated by microwave for the first and second time this process result in complete the polymerization of the acrylic resin and improve the bond with the resilient liner. [22] These results disagree with Baysan*et al*.[23], in that microwave energy at a medium setting for 5 minutes he reported that microwave energy processing did not compromise the adhesion of the resilient lining material to polymethyl methacrylate (PMMA).

## CONCLUSIONS

The results appeared that the chemical disinfection and microwave disinfection methods have a significant effect on the tensile strength and bond strength of both vertex and Molloplast –B soft ling materials. Microwave disinfection has less effect than the chemical disinfection on the properties. The effect of disinfectionincrease significantly with increasing period of time from 14 to 30 days.

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