

## The Effect of Microwave Irradiation and Some Denture Cleansers on The Bond Strength of Soft Liner to CAD/CAM-Milled Acrylic Resin

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### Abstract

Disinfection of dentures and denture liners was desired for cross-contamination prevention and improved safety. Nonetheless, it has been discovered that these procedures impact the physical and mechanical features of denture liners. To assess the impact of different disinfection procedures on the tensile bond strength of an acrylic-based soft liner with CAD/CAM-based acrylic denture resin. Material and Methods: 25 specimens were collected and randomly divided into five groups (sodium hypochlorite, chlorhexidine, cleansing tablet, microwave, and control groups), following the daily disinfection protocol, the samples were stored at room temperature ( $23\pm 2^{\circ}\text{C}$ ) in distilled water. After 30 days, the tensile bond strength was determined using universal testing equipment (Gester, China). The specimens were subjected to force by the machine at a steady crosshead speed of 5 mm/minute till the failure was recorded. The data were analyzed using statistics software (SPSS). Results: Showed that the control group had a higher mean value for bond strength, whereas the chlorhexidine group had a lower value. There was no significant difference between the control and cleansing tablet groups. However, they were significantly different from the microwave, CHX, and NaOCl groups. The NaOCl soft liner group is significantly different from all the other groups. No significant difference is found between microwave and CHX disinfected liner groups. Conclusion: The tensile bond strength of all disinfected soft liners decreased as compared with the control, which was not significant with the protefix tab but significant with the NaOCl, CHX, and microwave groups.

## Introduction:

Soft denture liners have proven to be an important means for both the dentist and the patient. They operate as shock absorbers due to their viscoelastic qualities, lowering and spreading pressure on the denture-bearing tissue and so improving patient comfort (1). Resilient liners exhibit issues such as bond strength weakening, discoloration, porosity, and declined resilience with clinical use; some of these drawbacks promote microbial colonization and impact the lifetime of the liner, as well as diseases of oral health such as denture stomatitis (2,3). Denture maintenance is important for adequate oral health. Dentures provide the environment for fungal and bacterial organisms such as *Candida*, *Streptococci*, and also other microorganisms like respiratory pathogens (4). The physical and mechanical features of denture liners have been observed to be influenced by hygienic practices that result in the loss of plasticizers and soluble components (5). The use of computer-aided design /computer-aided manufacturing technology in clinical dentistry is increasing. However, there has been little scientific investigation on the bonding qualities of denture liners to CAD/CAM-made denture polymers (6). As a result, the purpose of this research is to see how different disinfection processes affect the tensile bond strength of acrylic-based resilient liner attached to CAD/CAM-based PMMA polymer.

## Materials and Methods:

### Specimens preparation

A total of 25 samples were created and then separated into five groups based on disinfection groups. Metal dies with dimensions of (40mm in length, 10mm in width, and 10mm in height) were prepared to invest in the silicon rubber base to establish a mold for molten wax to construct wax blocks after solidification. After that, the wax blocks were placed in a dental stone with the metal spacer (10mm, 10mm, and 3mm in dimensions) dividing two wax blocks for a soft-liner film. The acrylic resin mold was created after the wax blocks were eliminated (7,8). The CAD/CAM-based PMMA polymer (NHT,

Latvia) was used to prepare the acrylic sample blocks by CAD/CAM machine (imes-icore, 250i, Germany) as shown in Fig. (1) using the software (Icam-v4.6). The acrylic samples that were prepared by the machine were still attached to each other by sprues except for the tested surface Fig. (2). These samples were separated and were finished by a dental disc burs leaving the testing surface (7). After wax elimination and removal of the spacer, the CAD/CAM-based acrylic samples were bonded with each other by a soft liner (Vertex-Soft, Netherlands) that was mixed in a glass jar according to the manufacturer's guidelines (1ml liquid to 2g powder), and incrementally packed into the space between the acrylic blocks by a clean metal mixing spatula, the flask was then enclosed under pressure and put in a water bath for curing depending on the manufacturer's recommendation (70 °C for 1.5 hours, then 100 °C for 30 minutes), the conventional flasking and packing procedures were followed in the processing of the sample (9). After a bench cooling for 20 minutes at room temperature (10), The samples were removed from the mold, and the unwanted margins were removed by a surgical blade (11). All of the samples were classified into 5 groups based on multiple disinfection procedures used.

### Disinfection processes of the samples

After 30 days, all 5 groups' specimens were evaluated, and the process was meant to be similar to the patients' everyday usage of dentures:

- Control group (Distilled water group): The specimens were submerged in distilled water.
- Sodium hypochlorite group: Soft liner specimens were submerged daily for 10 minutes in a 2 percent of NaOCl solution. 2% of sodium hypochlorite solution had been used to disinfect soft liners (12).
- Chlorhexidine group (CHX group): The samples were disinfected daily for 10 minutes in a 2 percent chlorhexidine solution. This percentage of chlorhexidine solution had been used to disinfect soft liners (12).

- Cleansing tablet group (Protefix group): One denture cleaning tablet (Protefix Active Cleanser, Flensburg-Germany) was prepared in 200ml of warm water (about 35 °C), for disinfection of the specimens, 10 minutes/day submerge was needed as directed by the manufacturer.
- Microwave irradiation group: The irradiation of the samples was done at a 540W for 3 min/day by a domestic multi-power microwave oven after they were immersed in 200ml distilled water in a beaker (13).

The storage of the samples was done at room temperature (14). After each disinfection cycle, the samples were washed with tap water and then kept in distilled water, new denture cleaner solutions were given for each disinfection cycle, and distilled water was replaced daily (15,16).

#### **Tensile bond strength assessment:**

A universal testing device (Gester, China) was employed to test the soft liner specimens Fig. (3) at a crosshead continuous speed of 5 mm/min until the failure is observed. For every specimen, the greatest tensile load before failure was stated clearly, and the tensile bond strength was estimated using this formula (16):

Tensile stress (MPa) = Highest tensile force (N) / Adhered surface area (mm<sup>2</sup>)

Tensile strength elongation curves were obtained for each specimen by using the machine's computer software. Visual examination revealed that the fracture patterns were either adhesive failure (total separation at the acrylic-liner contact), cohesive failure (cracking and destruction within the material of liner), or mixed failures (17). The failure mode percentage was obtained as follows: (failure category number/total number) ×100 percent.

#### **Results:**

Table (1) explains the descriptive analysis for the samples made of a soft liner bonded to two blocks of a CAD/CAM milled PMMA that showed a higher mean value of bond strength in the control group (3.31 MPa) while the lower mean value at

2% CHX group (2.59 MPa) after 30 days of daily disinfection. Analysis of variance (ANOVA) shown in Table (2) revealed highly significant variations in the bond strength ( $P < 0.01$ ) of disinfected soft liners compared to the control. Fig. (4) and Table (3) illustrated Duncan's various ranges test, which stated:

- The control group soft liner (3.31 MPa) is significantly different from all the groups except with Protefix tablet (3.27 MPa).
- The difference is not significant between the tablet soft liner group and the control group, while the tablet group soft liner is significantly different from the 2% CHX, 2% NaOCl, and microwave groups.
- Statistically, the 2% NaOCl soft liner group (2.94 MPa) is significantly different from all the other groups.
- There is no significant variance between the microwave disinfected soft liner (2.63 MPa) and the 2% CHX disinfected soft liner (2.59 MPa).

#### **Analysis of the Mode of Failure**

The percentage of a failure mode for tensile bond strength is revealed in Table (4). The type of failure for the samples revealed that adhesive failure was prevalent in the control group as well as the Protefix tablet group, but it became completely adhesive in the 2 % CHX, 2 %t NaOCl, and irradiated soft liner groups.

#### **Discussions:**

For optimal function, a strong connection between the soft liner and denture foundation is required (18). When liners strip away from the acrylic surface, a potential area for bacterial activities and biofilm growth is developed. Therefore, as the outcome, clinical problems that are associated with these polymers are commonly blamed on bonding failure (19). In this investigation, chemical cleaners (2% NaOCl and 2 % CHX) and microwave irradiation dramatically reduced tensile bond strengths compared with a control group. Whereas the decline

in the Protefix cleaning tablet is minor and insignificant. The findings of this investigation on the influence of sodium hypochlorite solution and Protefix cleansing tablet on tensile bond strengths agree with those of a previous study by (Mahboub *et al.*, 2017) (20), they discovered that 2.5 % Sodium hypochlorite solution reduced tensile bond strength significantly when compared to the control and cleaning tablet groups. Furthermore, there were no significant variations in the bond strengths of the cleaning tablet and the control groups. Also, the results corresponded with the findings of Narwal (2015) (21) who determined that immersing in denture cleaners reduces the tensile bond strength of the lining materials bound to denture base polymer: regardless of the kind of denture cleanser utilized. After immersing in different cleaning agents, several chemical compositions, like monomers and plasticizers, were liberated from the soft liners, and it was found that the quantities of released components varied depending on the kind of cleansing agent (22). Furthermore, it might be supposed that the lack of chemical components, as well as plasticizers, reduces bond strength at bonded surfaces (20). As a result, these findings may demonstrate the decrease in bond strength of the acrylic soft liner in the current research after immersion in disinfectant solutions (2% NaOCl, 2% CHX, and cleansing tablet) when compared with control, and the bonding strengths of these chemically distinct cleaning agent groups differed significantly from each other. The findings of this study on the influence of sodium hypochlorite on tensile bond strength disagree with the findings of Nakhaei *et al.* (2019) (10) they discovered that ozone and two popular denture cleansers (Corega tablets and Sodium hypochlorite) seemed to have no influence on the bond strength of a silicone-based resilient liner to denture base acrylic material. However, the kind of soft liner, sodium hypochlorite

concentration, and immersion period vary across the two investigations. Also, the data of this study disagree with Malheiros-Segundo *et al.* (2008) (23) who discovered an improvement in tensile bonding of lining materials following immersion in sodium perborate cleaning solution. However, various liner types, immersion durations, and cleaning solutions were employed. The specimens in the microwave disinfection group were put in 200ml of water, and the temperature of the water was increased until it reached boiling following 90 seconds of a disinfection period (13,24). As a result, it is possible that the heating of the acrylic polymers during the disinfection operations accelerated additional polymerization as well as residual monomer release activities (25), which will result in a drop in the liner's tensile strength (26). Table (4) explains the mode failure of the samples and showed that samples of distilled water group and Protefix tab group displayed predominantly adhesive failure, and became completely adhesive in the groups of sodium hypochlorite, chlorhexidine, and microwave oven. These findings may reflect that a reduction in bond strength influenced the failure mode which became an adhesive form, which is consistent with the findings of an investigation by Mahboub *et al.* (2017) (20).

## Conclusions

The tensile bond strength of all disinfected soft liners decreased as compared with the control, which was not significant with the protefix tab but significant with the NaOCl, CHX, and microwave groups.



Fig. (1): CAD/CAM machine used to prepare the acrylic samples.



Fig. (2): CAD/CAM manufacturing PMMA specimens.



Fig. (3): Universal testing machine for tensile strength.

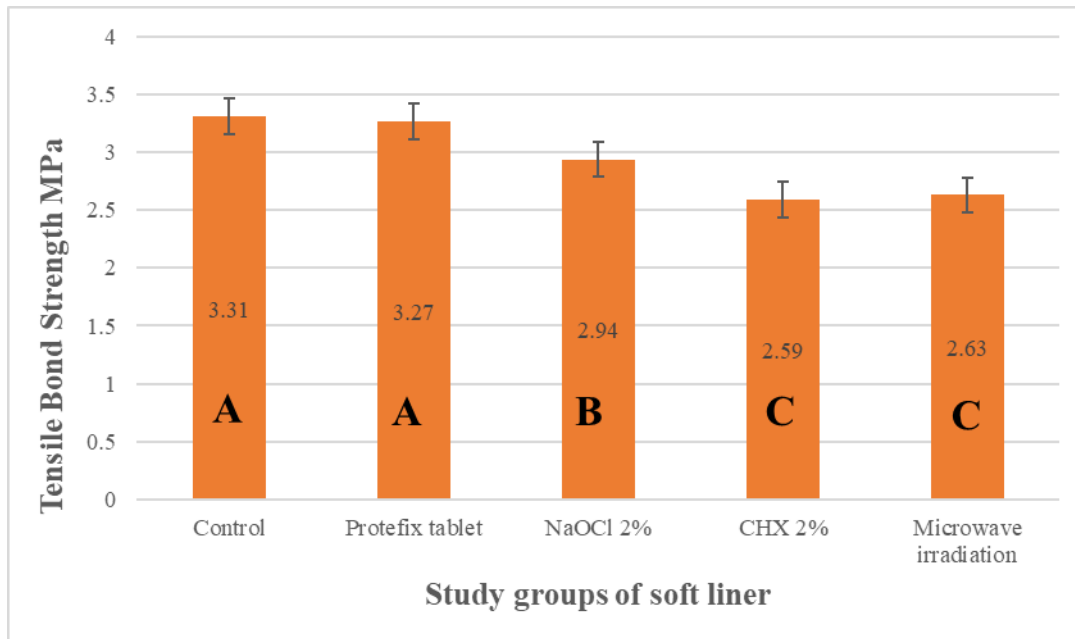


Fig. (4): Bar chart illustrates the mean value of tensile bond strength of each group.

Table (1): descriptive statistics for tensile bond strength (MPa) for control and disinfected soft-liner samples that bonded by two blocks of a CAD/CAM milled PMMA with different disinfection methods.

Study groups	N.	Min.	Max.	Mean	Std. Error	Std. Deviation
<b>Control</b>	5	3.19	3.44	3.3180	0.04294	0.09602
<b>NaOCl 2%</b>	5	2.90	3.04	2.9460	0.02502	0.05595
<b>CHX 2%</b>	5	2.52	2.65	2.5900	0.02702	0.06042
<b>Protefix tablet</b>	5	3.15	3.37	3.2720	0.04188	0.09365
<b>Microwave irradiation</b>	5	2.55	2.70	2.6320	0.02853	0.06380

N: Number of samples.

Table (2): ANOVA of tensile bond strength for disinfected and control groups

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
<b>Between Groups</b>	2.349	4	0.587	101.819	0.000
<b>Within Groups</b>	0.115	20	0.006		
<b>Total</b>	2.465	24			

df: Degree of freedom; F: F Value.

Table. (3): Duncan’s multiple range test for tensile bond strength of vertex soft liner bonded with two blocks of CAD/CAM-based acrylic among different methods of disinfection.

Source of Variance	N	1	2	3
<b>CHX 2%</b>	5	259.0000		
<b>Microwave irradiation</b>	5	263.2000		
<b>NaOCl 2%</b>	5		294.6000	
<b>Protefix tablet</b>	5			327.2000
<b>Control</b>	5			331.8000
<b>Sig.</b>		0.392	1.000	0.350

Means for groups in homogeneous subsets are displayed; Sig: Significance.

Table (4): Percentage of a mode of failure of tensile bond strength for disinfected soft liner samples that were made of a soft liner bonded with CAD/CAM-based acrylic blocks.

Soft liner	N.	Adhesive %	Cohesive %
Control	5	80	20
NaOCl 2%	5	100	0
CHX 2%	5	100	0
Protefix tablet	5	80	20
Microwave irradiation	5	100	0
Total		92	8

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