



The Effect of Various Disinfection Methods on The Tensile Bond Strength of Soft Lining Material

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Abstract

Disinfection of dentures and resilient denture liners were preferred for cross-contamination treatment and better safety. Nevertheless, it has been found that these techniques affect the physical and mechanical properties of denture liners. Objective: To evaluate the impact of various disinfection methods on the tensile bond strength of acrylic soft liner. Material and Methods: 25 samples were made, then divided randomly into five groups (4 disinfection groups as well as a control group), after the daily disinfection procedure, distilled water was used to store the samples at room temperature. After 30 days, a universal testing device (Gester, China) was used to assess the tensile bond strength. The machine applied force to the specimens at a crosshead constant speed of 5 mm/minute until failure was recorded. Statistics software (SPSS) was used to analyze the measurements. Results: After 30 days of regular exposure to different disinfection methods, a greater mean value for bond strength showed in the control group while the lesser value was in the chlorhexidine group. No significant difference was found between the control and Protefix tablet groups. The sodium hypochlorite and microwave groups had no significant difference between them, but they were significantly different from the control, Protefix tablet, and chlorhexidine groups. the chlorhexidine group was significantly different from the control and other disinfected groups. Conclusion: All disinfected soft liners revealed a decrease in tensile bond strength, which was not significant with the protefix cleansing tablet but significant with the chlorhexidine, sodium hypochlorite, and microwave regimes.

Introduction:

Resilient denture liners can aid those who are unable to tolerate denture pressures because of thin, sharp, extremely resorbed ridges, large bony undercuts, and acquired or congenital palatal abnormalities (1). Resilient liners display concerns including bond strength deterioration, change in color, porosity, and decrease of resilience with the clinical application; some of these limitations increase microbial development and influence the liner's longevity, and also oral health conditions which include denture stomatitis (2,3). Constant denture cleaning is necessary for good oral health. Dentures provide a suitable habitat for fungal and bacterial pathogens including *Candida*, *Streptococci*, and other germs including respiratory pathogens (4). Denture liners' physical and mechanical properties have been reported to be affected by hygiene practices that cause plasticizer and soluble component loss (5). Therefore, the goal of this study is to determine the effect of various disinfection procedures on the tensile bond strength of permanent acrylic soft denture liner.

Materials and Methods

Specimens preparation

A total of 25 specimens were made, then divided into 5 groups based on disinfection groups. Metal dies with length, width, and height measurements of (40mm, 10mm, and 10mm) were invested in the silicon rubber foundation to produce a mold for molten wax to make wax blocks. The wax blocks were then invested in a dental stone with metal spacer dimensions (10mm, 10mm, and 3mm) separating two wax blocks for a resilient liner film. After the wax was eliminated, the mold for acrylic resin was created (6,7). The acrylic resin (Procryla, Presidential Dental, Germany) was mixed and packed on both sides of the spacer Fig. (1). After curing of resin (as a manufacturer's information) the spacer was removed. Then a soft liner (Vertex-Soft, Netherlands) was mixed according to the manufacturer's guidelines in a dry glass jar and packed in between the resin blocks, the two halves (upper and lower)

of the flask were closed, and to confirm even flow of the resilient liner, the hydraulic press was applied gradually for 5 minutes, after which the press was stopped, and the clamped flasks were transmitted to the water path for soft liner curing which based on manufacturer recommendations (70 °C for 1.5 hours, and then 100 °C for 30 minutes), the conventional flasking and packing procedures were followed in the processing of the sample (8), then the flask was unlocked and the specimens were taken out and finished by cutting any excess with a sharp blade (9). All of the specimens were split into five categories depending on their disinfection procedures.

Immersion and disinfection procedures of the samples

- Control group: The samples were soaked in distilled water.
- Sodium hypochlorite group: The specimens were soaked for 10 minutes each day in a 2% NaOCl solution. This concentration had been used for soft liner cleansing (10).
- Chlorhexidine group: The specimens were disinfected in a 2% chlorhexidine solution for 10 minutes per day. This concentration had been used for soft liner cleansing (10).
- Cleansing tablet group: One tablet (Protefix Active Cleanser, Flensburg-Germany) was dissolved in 200ml of warm water, about 35°C, and the samples were submerged for about 10 minutes/day for disinfection as per the manufacturer's instructions.
- Microwave irradiation group: The specimens were immersed in 200ml distilled water in a beaker and irradiated at a 540W for 3 min/day (wet irradiation), by a multi-power domestic microwave oven (11).

The specimens were stored at room temperature throughout the study (12). And to simulate 30 days of denture cleaning, the samples were disinfected daily, after that cleaned using tap water and stored in distilled water, with each disinfection cycle, new solutions of

denture cleanser were delivered, and distilled water was altered every day (13,14).

Tensile bond strength test:

All specimens were tested using a universal testing apparatus (Gester, China) at the crosshead constant rate of 5 mm per minute till recording the failure. The maximum tensile load before failure was documented for every specimen, and the tensile bond strength was assessed by this formula (14):

$$\text{Tensile stress (MPa)} = \frac{\text{Maximum tensile force (N)}}{\text{Bonded surface area (mm}^2\text{)}}$$

For each specimen, elongation curves of tensile strength were documented using the machine's computer software. The fracture modes were assessed visually, they were either an adhesive failure (complete separation happening at the acrylic-liner interface), cohesive failure (cracking and destruction inside the liner material), or a combination (mixed failures) (15). The percentage of the failure mode was calculated as follows: (failure type number/total number) × 100%

Results:

Table (1) displays descriptive statistics of the analyzed data in different disinfected and control groups of the acrylic soft liner. Such as (Mean value, Standard Error, Standard Deviation, maximum value, and minimum value). Results show the greater mean bond strength (3.62 MPa) in the control group while the lesser mean value in the 2% CHX group (2.60 MPa). Table (2) showed an analysis of variance that presented highly significant differences ($P < 0.01$) in the bond strength of disinfected soft liners in relation to the control.

Duncan's test of multiple ranges was presented in Fig. (2) which demonstrated

- Significant differences between the 2% CHX (2.60 MPa) group and the other four groups.
- 2% NaOCl group (2.95 MPa) and microwave group (3.04 MPa) had no

statistically significant difference between them, but they were significantly different from the control (3.62 MPa) and Protefix tablet (3.52 MPa) groups.

- No statistically significant differences were found between the control and Protefix tablet groups (3.62 MPa and 3.52MPa) respectively.

Analysis of the mode of failure

The failure mode percentage for tensile bond strength showed in Table (3) of a soft liner bonded with conventional acrylic blocks and were divided into 5 study groups. The failure mode for the specimens illustrated that the adhesive failure was predominant in the groups (control and Protefix tablet) while it was totally adhesive in 2% NaOCl, 2% CHX, and Microwave irradiation groups.

Discussion:

For maximum function, a strong connection must be formed between the soft liner and the denture foundation (16). Once liners detach from the acrylic resin surface, the possible space for bacterial activity and biofilm development is created; As a result, clinical problems with these polymers are frequently attributed to bonding failure (17).

In this study, the microwave irradiation and the chemical cleansers (2% NaOCl and 2% CHX) significantly reduced tensile bond strengths when compared to the control groups. While the decrease is slight and non-significant in the Protefix cleansing tablet. The outcomes of this study on the impact of NaOCl solution and Protefix tablet on tensile bond strengths were comparable with a previous study by (Mahboub *et al.*, 2017) (1), they found that 2.5% NaOCl solution significantly reduced the tensile and shear bond strengths as compared to the control and cleansing tablet groups. As well as the bond strengths of the cleansing tablet and control groups demonstrated no significant variations. Also, the findings agreed with the study by Narwal (2015) (18) who concluded that immersion in denture cleansers decreases the tensile bond

strength of lining materials bonded to denture base resin: irrespective of the type of denture cleanser used.

Various chemical components, including monomers and plasticizers, were released from the soft liners following immersion in distinct cleaning agents, and it was reported that the amounts of liberated components were different according to the type of cleansing agent (19). Moreover, it may also be suggested that the loss of components and plasticizers reduces bonding strength at bonded interfaces (1). Therefore, these observations might illustrate the lowering in bond strength of the acrylic soft liner in the present study after immersion in disinfectant solutions (Protefix cleansing tablet, 2% NaOCl, and 2% CHX) as compared to the control, and the bond strengths of these chemically different disinfectant groups were significantly different from each other. The findings from this study on the influence of NaOCl on tensile bond strength disagree with that of Nakhaei *et al.* (2019) (14) when they considered that ozone and two commonly used denture cleaners (NaOCl and Corega tablets) had no effect on the adhesive strength of a silicone soft liner to acrylic denture base material. However, there are differences between the two studies in the type of soft liner, immersion period, and NaOCl solution concentration. Also, in disagreement with Malheiros-Segundo *et al.* (2008) (20), they found an increase in tensile bond strength for lining materials following soaking in sodium perborate cleansing solution. However, different liner types, immersion periods, and cleansing solutions were used.

In the microwave disinfection group, the specimens were placed in 200ml of water, and increasing the temperature of the water reached the boiling temperature after 90 seconds of the disinfection cycle (11,21). As an outcome, it is probable that heating the denture acrylic resins during disinfection processes increased further polymerization and also residual monomer escape activities (22), leading to a drop in the tensile strength of the liner (23).

The failure mode of the specimens Table (3) explains that samples soaked in Protefix and distilled water exhibited predominantly adhesive failure type, and became totally adhesive in groups of 2% NaOCl, and 2% CHX, and Microwave irradiation. These results possibly indicate that a drop in bond strength influenced the failure mode that became an adhesive form, which is compatible with the findings of research by Mahboub *et al.* (2017) (1).

Conclusion:

All disinfected soft liners revealed a decrease in tensile bond strength, which was not significant with the protefix cleansing tablet but significant with the chlorhexidine, sodium hypochlorite, and microwave regimes.

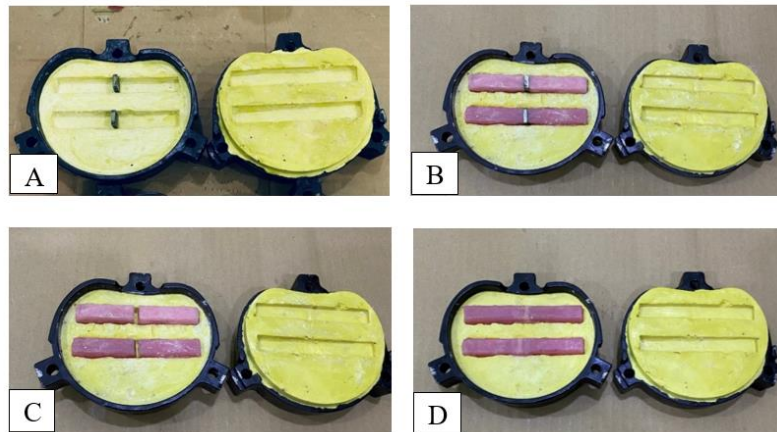


Fig. (1): Tensile bond strength sample preparation steps: A: After wax elimination. B: Acrylic resin blocks with spacers between them. C: Acrylic resin blocks after removing the spacer and before the soft-liner packing. D: After packing and curing the acrylic-based soft liner.

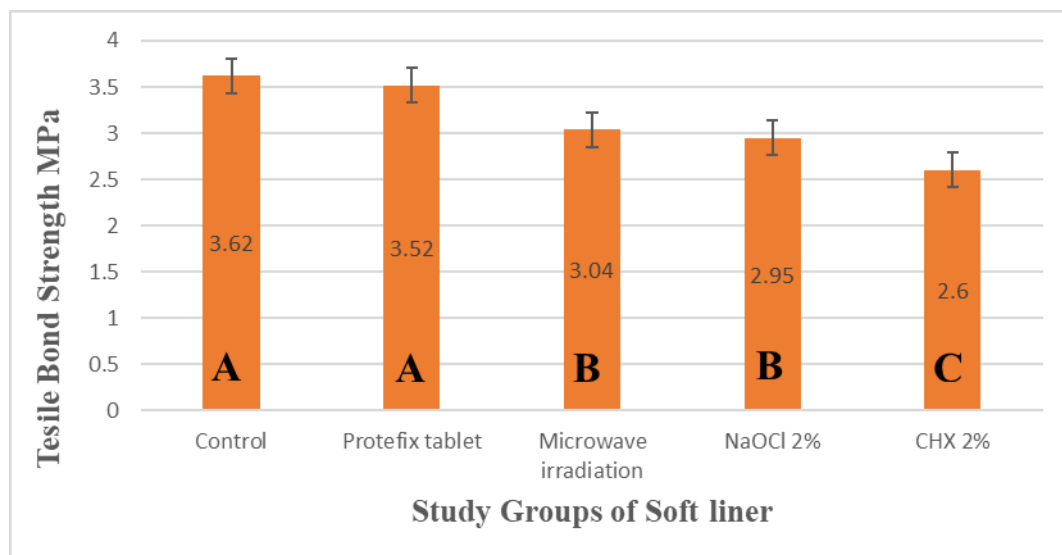


Fig. (2): Duncan’s multiple range test for tensile bond strength of vertex soft liner bonded with two blocks of a conventional heat cure acrylic among different methods of disinfection.

Table (1): Descriptive data of tensile bond strength for control and disinfected resilient liner.

Study groups	N.	Min.	Max.	Mean	Std. Error	Std. Deviation
Control	5	3.49	3.72	3.62	0.04159	0.09301
NaOCl 2%	5	2.84	3.02	2.95	0.03130	0.0700
CHX 2%	5	2.55	2.68	2.60	0.02676	0.05983
Protefix tablet	5	3.49	3.56	3.52	0.01463	0.03271
Microwave irradiation	5	2.88	3.12	3.04	0.04528	0.10124

N: Number of samples.

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

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Between Groups	3.536	4	.884	155.380	.000
Within Groups	0.114	20	.006		
Total	3.650	24			

df: Degree of freedom; F: F Value.

Table (3): Percentage of a mode of failure of tensile bond strength for disinfected soft-liner samples that were made of a soft liner bonded with conventional acrylic blocks.

Soft liner	N.	Adhesive %	Cohesive %
Control	5	60	40
NaOCl 2%	5	100	0
CHX 2%	5	100	0
Protefix tablet	5	80	20
Microwave irradiation	5	100	0
Total		88	12

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