

Effect of Denture Cleansers on Tensile Bond Strength of Soft Liners to Denture Base Resin

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Abstract

Background and Aim: Optimal bond strength between soft liners and denture base resin is an important requirement for application of these materials. This study aimed to determine the effect of 2.5% sodium hypochlorite (NaOCl) and Corega denture cleanser solutions on tensile bond strength of Acropars, Molloplast-B, GC soft liner and Mollosil soft liners to denture base resin.

Materials and Methods: In this in-vitro experimental study, 30 specimens of each of the 4 soft liners according to the manufacturer's instructions were processed between two blocks of polymethyl methacrylate. Specimens were divided into 3 groups and after immersion in 2.5% sodium hypochlorite and Corega solutions were subjected to tensile bond strength testing using Universal Testing Machine (Zwick Roell, Z50, Germany) with a crosshead speed of 5 mm/min. Data were analyzed with two-way ANOVA, Tamhane's post hoc test and Fisher's exact test.

Results: The mean tensile bond strength of all three testing positions was 3.27 ± 1.04 , 0.93 ± 0.35 , 0.71 ± 0.31 and 0.28 ± 0.11 MPa for Acropars, Molloplast-B, GC soft liner and Mollosil, respectively. Type of soft liner material had a significant effect on the tensile bond strength of soft liner to denture base resin ($p < 0.0001$) but type of cleansing solution had no significant influence on tensile bond strength of specimens.

Conclusion: The 2.5% sodium hypochlorite and Corega solutions had no significant effect on tensile bond strength of soft liners to denture base.

Key Words: Cleansing solutions, Tensile strength, Acrylic resins, Denture liners

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Introduction

Long-term use of denture causes significant changes in its supporting structures and can lead to constant pain and discomfort especially in the mandible of patients. Additionally, resorption of the edentulous alveolar ridge leads to the formation of a sharp and thin alveolar ridge crest bearing too much pressure that causes severe problems for the patient and necessitates the need for improvement of denture quality and comfort.

Soft liners have extensive applications in patients who cannot tolerate conventional hard bases. Soft lining materials have remarkable capabilities in healing the inflamed tissues [1-2], distributing and spreading the functional loads exerted on denture areas [3-4], improving denture fit and retention between tissue and denture base [5] and cushioning functional forces [6-7]. Soft denture liners are offered in two forms of silicone-based and acrylic-based and both types are

available in heat-cure and self-cure [6-8]. Optimal properties of soft lining materials include their strong bond to denture base, peri- and post-operative dimensional stability, long-term elasticity, minimal water sorption, color stability, easy application, tissue compatibility, pleasant odor and low cost [7-8]. Despite numerous advantages, high porosity of soft liners increases plaque accumulation, colonization of *Candida* strains and development of denture stomatitis [9]. On the other hand, failure of bond between soft liners and denture base is a major complication of using these materials. This complication provides a potential surface for bacterial growth, plaque accumulation and calculus formation [4, 10]. None of the mentioned optimal properties of soft liners would be efficient if the bond between the liner and denture base is lost. In order to prevent debonding, a minimum of 4.5 kg/cm² bond strength is required. Water sorption or loss by the soft liner, application of surface primer and composition of denture base are among the factors affecting the bond strength of soft lining materials to denture base resin [11]. Absorption or loss of soluble components may lead to bond failure between the soft liner and denture base acrylic resin. Reduced bond strength may also result from immersion in water or cleansing agents and subsequently increased stiffness and changed viscoelastic properties of the soft liner or pressure created at the bond interface [12]. Among the two methods of mechanical and chemical plaque control, application of chemical cleansing agents is the method of choice for plaque control in dentures and soft liners especially in the elderly with movement limitations [12]. However, their long-term application may have damaging impacts on the physical properties of soft liners due to the loss of soluble compounds and plasticizers and water sorption [13]. Soft lining materials also undergo chemical changes over time due to being in service and storage in water or chemical cleansers [10]. Therefore, selection of a cleansing agent should be done carefully in order to prevent or decrease change in soft liner properties. In a 6-year study on soft liners, it was demonstrated that in 43.4% of cases, the reason for replacement of soft liner was inadequate bond of soft liner to resin due to incorrect processing procedures and improper home care such as soaking in bleach or Mersene. In 20% of cases, the soft liner

had been separated from the denture base; which can be prevented by proper usage. Staining of soft liners was observed in 45% of cases and a correlation was found between the immersion in bleach (sodium hypochlorite) and wrinkling and fading of soft liners. Liners that were clinically unserviceable and required replacement had excessive wrinkling due to immersion in bleach-type cleansers [14]. Several studies have investigated the effect of storage in cleansers on stiffness and color change of soft liners [7, 8, 13, 15-17]; however, studies evaluating the effect of cleansing agents on the bond strength of soft liner to denture base are scarce [12, 16, 18, 19]. Therefore, this study was designed to determine the effect of denture cleansing agents on tensile bond strength of acrylic- and silicone-based heat-cure and self-cure soft liners to denture base.

Materials and Methods

In this in-vitro experimental study, 10 specimens of each of the 4 understudy soft lining materials namely Acropars (Marlic Co., Iran), Molloplast-B (Detax-GmbH & Co., KG, Ettlingen, Germany), GC soft liner (GC Corporation, Tokyo, Japan) and Mollosil (Detax-GmbH & Co., KG, Ettlingen, Germany) were evaluated after immersion in 2.5% sodium hypochlorite (NaOCL) and Corega (RosenDarman Co.) solutions.

In order to match the specimens, two brass spacers were prepared measuring 3x10x70 mm for acrylic resin and 3x10x10 mm for the soft liners. Specimens were fabricated using flasking as follows: First, Vaseline was applied to the flask and the prepared dental stone was poured into the lower part of the flask using a vibrator. A large spacer was placed in the middle of the flask. The brass spacer was placed in a way that half of it was embedded in the stone and the other half was out to be placed in the upper part of flask. Dental stone was then poured into the upper part of the flask and the flask was pressured for 20 minutes. The two halves were then separated and the large spacer was removed. Dental stone was then cleaned with hot water and a cleansing agent and a biofilm coat was applied to the two halves. A small spacer was placed in the middle of the rectangular space created by the large spacer.

Polymethyl methacrylate acrylic resin (Meliodent,

Heraeus Kulzer, Berkshire, UK) was mixed according to the manufacturer's instructions and after reaching the doughstage, was packed at both sides of the small spacer. Heat-curing of the acrylic resin was carried out according to the manufacturer's protocol. Afterwards, the following 4 soft liners were used according to the manufacturer's instructions. Acropars soft liner was prepared according to the manufacturer's instructions and placed in the space created by the spacer. The flask was pressed for 10-15 minutes and the excess soft lining material was removed. The flask was then placed in cold water. Specimens were stored in boiling water for 30 minutes. Afterwards, they were taken out and polished.

For Molloplast-B samples, primer was applied to the acrylic surface, soft liner was placed in the respective space created by the spacer, flask was pressed for 15-20 minutes, flask was opened and the excess Molloplast-B material was removed, heat-curing of the material was carried out according to the manufacturer's instructions, the flask was allowed time to cool down, samples were extracted from the flask and polished.

For GC soft liner and Mollosil specimens, empty spacer space was filled with the GC soft liner or Mollosil, a smooth surface was placed over it; 30 minutes later, specimens were taken out, excess material was removed with a sharp knife and a surgical blade, all specimens were stored in distilled water for three months and then randomly divided into 12 groups of 10; out of which, 4 groups of 10 were considered as the control groups that were tested without storage in cleansing agents. The remaining 8 groups were divided into two groups. In the first group, specimens were immersed in 2.5% sodium hypochlorite solution (NaOCL) for 96 times (12 days, 8 times a day, each time for 5 minutes). The second group specimens were immersed in Corega solution for 96 times (12 days, 8 times a day, each time for 15 minutes). Eventually, samples were subjected to tensile bond strength testing in Universal Testing Machine (ZwickRoell, Z50, Germany) with a cross-head speed of 5 mm/min.

Maximum tensile bond strength values of specimens were recorded in MPa. Furthermore, mode of failure in specimens was determined using stereomicroscope. Images were taken of the fracture site

under the stereomicroscope at 20x magnification. Cases where the fracture occurred within the soft lining material or acrylic resin were considered as cohesive failure. Failure at the soft liner/acrylic resin interface was considered as the adhesive failure and fractures of both mentioned types were considered as the mixed failure.

Two-way ANOVA was carried out to assess the effect of these two variables on the bond strength. Tamhane's post-hoc test was used for pair-wise comparison of soft liners and Fisher's exact test was applied to evaluate the failure mode in different groups.

Results

The mean and SD of tensile bond strength of Acropars, Molloplast-B, GC soft liner and Mollosil at baseline (without immersion in denture cleansing agents), after immersion in 2.5% NaOCL and after immersion in Corega solution are demonstrated in Table and Diagram 1. The results of two-way ANOVA revealed that type of soft liner had a significant effect on the tensile bond strength of soft liner to denture base ($p < 0.0001$); whereas, type of denture cleanser had no effect in this regard ($p = 0.71$). Also, the effect of interaction of soft liner material and type of cleansing agent on the tensile bond strength of specimens was not significant either ($p = 0.24$). The results of pair-wise comparison of groups are demonstrated in Table 2. The modes of failure in different groups are demonstrated in Table 3. Fisher's exact test indicated no statistically significant difference in modes of failure between different groups.

Discussion

Achieving adequate bond strength between the soft liner and denture base is critically important in prosthodontic treatments because if the soft liner material is separated from the denture base, the gap area is not easily cleanable leading to consequent microbial plaque accumulation and functional impairment of prosthetic parts [12].

The present study evaluated the effect of 2.5% NaOCL and Corega solutions on bond strength of different soft liners to denture base.

Study results showed that the effect of type of cleansing agent or the interaction of type of cleansing agent and soft liner material on the tensile

Table 1. The mean and SD of tensile bond strength of various soft liners after immersion in denture cleansers

Cleanser \ Soft liner	Base liner	Sodium hypochlorite	Corega
Acropars	3/03 ± 0/87	3/16±1/15	3/63±1/10
Molloplast-B	0/87±0/35	1/13±0/40	0/79±0/13
GC soft liner	0/75±0/33	0/62±0/23	0/76±0/36
Mollosil	0/37±0/10	0/24±0/08	0/25±0/08
Total	1/25±1/16	1/29±1/29	1/36±1/46

Table 2. Pair-wise comparison of different soft lining materials in terms of tensile bond strength

Soft lining material	Soft lining material	Mean difference	SD	P.V
Acropars	Molloplast-B	2/34	0/20	0/0001
	GC soft liner	2/56	0/20	0/0001
	Mollosil	2/99	0/19	0/0001
Molloplast-B	GC soft liner	0/22	0/08	0/066
	Mollosil	0/65	0/06	0/0001
GC soft liner	Mollosil	0/43	0/06	0/0001

Table 3. Mode of failure in different soft liners after immersion in denture cleansers

Soft liner	Cleanser	Adhesive	Cohesive	Mixed
Acropars	Baseline	8	2	-
	Sodium hypochlorite	9	1	-
	Corega	10	-	-
Molloplast-B	Baseline	6	4	-
	Sodium hypochlorite	4	5	1
	Corega	8	2	-
GC soft liner	Baseline	10	-	-
	Sodium hypochlorite	10	-	-
	Corega	9	1	-
Mollosil	Baseline	10	-	-
	Sodium hypochlorite	10	-	-
	Corega	10	-	-

bond strength was not statistically significant. Insignificant effect of cleansing agents on the tensile bond strength of soft liners to denture base indicates the compatibility of the understudy cleansing agents with these materials.

Corega is a commercial denture cleanser with a formulation similar to that of Polident. It is commercially available in the market in the form of tablets. This cleansing agent contains the following constituents:

Sodium carbonate, potassium caroate, citric acid, sodium carbonate peroxide, sodium bicarbonate, sodium benzoate, PEG-180, sodium lauryl sulfoacetate, subtilisin, PBP, aroma, CL44090

Corega is effective for biofilm removal [20] but has no significant effect on surface roughness of denture base resin [2]. Similar to our study results, other studies could not show the significant effect of denture cleansing agents on bond strength of soft liners to denture base acrylic resin [12, 19, 22]. Sodium hypochlorite is a disinfecting agent with antibacterial and antifungal properties that can be used as a cleansing agent for immersion of dentures. It is odorless and tasteless and has no harmful effect on skin. Due to its alkaline pH, sodium hypochlorite is effective for disintegration of microbial plaque and prevents calculus formation by affecting the plaque matrix. This solution removes

stains and dissolves organic compounds. Sodium hypochlorite is often used as a home cleansing agent at low concentrations of about 0.5%. At this concentration, NaOCL destroys *Candida albicans* but has no significant effect on denture surface roughness [23, 24]. Furthermore, 1% concentration of sodium hypochlorite can disinfect the surface of acrylic resin and destroy the microorganisms that have penetrated the surface [25]. A 5.25% concentration of sodium hypochlorite has no significant effect on surface roughness of denture base materials either [21]. But, concentrations higher than 5.25% lead to discoloration (fading) and roughness of denture surface [26].

This cleansing agent is readily available and easy to use. However, causing metallic corrosion and fading of the acrylic resin are among the main disadvantages of NaOCL. Additionally, it may leave an unfavorable taste or odor if used at high concentrations. In such cases, after immersion in NaOCL, denture may be soaked in another cleanser or rinsed with water [24].

In the current study, 2.5% NaOCL had no significant effect on the bond strength of soft liner to denture base. Therefore, considering the mentioned advantages for low concentrations of this solution, its 2.5% or lower concentrations may be recommended to patients using soft liners without adversely affecting the bond strength; especially because in contrast to commercial denture cleansers, this solution is easily available and does not impose high costs on patients.

The results of this study showed that different soft lining materials had a significant effect on tensile bond strength of soft liners to denture base.

The highest tensile bond strength was observed in Acropars soft liner; which is consistent with the results of other studies [12, 27].

High tensile bond strength of Acropars soft liner is due to its optimal bond with polymethyl methacrylate. Considering the fact that chemical composition of Acropars soft liner is similar to that of denture base polymer, chemical bonds form between the acrylic liner and denture base polymer (28, 29). Molloplast-B soft liner ranked second in terms of tensile bond strength. This soft liner, similar to other silicone soft lining materials, requires the use of a bonding agent for adhesion to cured acrylic resin.

In various studies, bond strength of Molloplast-B soft liner ranked second after the acrylic heat-cure soft liners but at the same time, was reported to be greater than that of other soft lining materials; which is in agreement with our study results [12, 19, 27].

Small differences observed in the results of various studies may be explained by different sample sizes, type of acrylic resin, and different methodologies of studies.

Similar to the majority of previous studies, the minimum tensile bond strength in the present study belonged to Mollosil soft liner. In contrast to other studies, the amount of bond strength in Mollosil in the current study was not within the clinically acceptable range [12, 18].

Some researchers have demonstrated that a minimum of 0.45 MPa tensile bond strength is required for the soft liners in order to be used in the clinical setting [10]. Considering this criterion, Acropars, Molloplast-B and GC soft liner had the highest requirements for clinical service in a decreasing fashion but Mollosil soft liner did not meet the required criterion and could not measure up for this purpose.

Variable bond strengths of soft liners may be due to their physical properties and chemical characteristics such as their ability to bond with acrylic resin. Acrylic-based resin materials form a molecular structure after preparation and application that penetrates into the surface of similar compounds. This mechanism explains the results of the present study and similar investigations [30].

In conclusion, this study, similar to previous ones [4, 12, 29, 31, 32], demonstrated that the bond strength of acrylic soft liners was greater than that of silicone types. Also, heat-cure soft liners had higher bond strength than self-cure types.

This study did not evaluate the effect of duration of storage in disinfecting agents; however, it seems that the lower soft liner bond strength values obtained in this study in comparison to the corresponding investigations may be attributed to the longer duration of immersion of samples in distilled water (3 months).

The majority of studies evaluating the effect of duration of immersion in water or cleansers have indicated that by increasing the duration of storage, the bond strength between denture base and

soft liner decreases, which is due to the dissolution and disintegration of soluble components [4, 12, 33, 34].

The bond strength values in the present study, with consideration of 3-month immersion, were lower than the rates in Mese et al, study [12]. This difference may be attributed to the type of acrylic resin and the cross-head speed of applied tensile force.

Reduced bond strength of soft liners due to increased water storage may be explained by the fact that acrylic soft liners become stiffer over time due to the release of plasticizers [35, 36]. Reduced bond strength is attributed to the swelling and pressure formation at the bond interface or the changed viscoelastic properties of the soft liners that make them stiffer and transfer the external forces to the bonding interface [11].

In Molloplast-B, decreased bond strength over time may be attributed to high water sorption due to its filler content [11].

Considering the increased solubility of silicone-based soft lining materials following immersion in water, there is a possibility that sodium hypochlorite solution leads to the efflux of fillers from the silicone by increasing the solubility of soft liners [8].

Despite our expectations for the mode of failure to be adhesive in acrylic and cohesive in silicone soft liners, the present study results demonstrated that the majority of failures in soft liners were of adhesive type (Table 3). It means that the tensile strength of each of the understudy soft liners was greater than the tensile bond strength of the denture base to soft liner. This finding is in contrast to the results of previous studies [11, 12, 27].

Generalization of the present study results to the clinical setting should be done with utmost caution considering its in-vitro design. Also, it should be noted that the final decision regarding the applicability of different materials in the oral environment should be made following the conduction of accredited in-vivo clinical examinations in order to recommend or not recommend their application. Further investigations are also warranted to study other physical and mechanical characteristics of soft liners such as their surface roughness, solubility, water sorption and stiffness after immersion in denture cleansers. Long-term effect of immersion in denture cleansing agents on the physical and

mechanical properties of soft liners needs to be further evaluated as well.

Conclusion

The present study evaluated the effect of denture cleansing agents on the bond strength of soft liners to denture base and revealed that immersion of different soft lining materials in 2.5% NaOCL and Corega solutions had no significant effect on the tensile bond strength of denture base to soft liners. Also, 2.5% sodium hypochlorite solution may be used as an alternative to Corega. On the other hand, type of soft liner had a significant effect on the mentioned tensile bond strength.

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