

Comparative Evaluation of Physical Properties of Commercially Available Silicone-Based Soft Denture Liners and Acrylic-Based Soft Denture Liners

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Abstract

Elastic materials used in dental prosthetics to line removable dentures should be characterized by biocompatibility toward oral tissues, shape, and color stability; resistance to abrasion; and durability of the junction between the lining and the denture. The resilient lining materials present problems during clinical use, such as weakening of bond between lining and denture loss of resiliency, color alterations, and porosity. This review was aimed to compare and evaluate the physical properties of soft denture liners acrylic and silicone based and to determine which denture liners would be best suited for clinical usage. A review protocol was structured on the basis of the guidelines proposed by the PRISMA statement and Centre for Reviews and Dissemination. Overall, the results indicated that silicone-based soft denture liners performed significantly better than acrylic-based soft denture liners when compared for color stability, surface hardness, tensile bond strength, water sorption, and solubility, concluding that silicone-based soft liners would be better for long-term clinical use.

Keywords: Acrylic, bond strength, color stability, denture liner, silicone, surface hardness

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INTRODUCTION

Complete denture bases are fabricated from rigid acrylic resin, because they should have adequate mechanical and physical properties capable of withstanding biting and chewing forces, thus preventing distortions and fractures.^[1] However, certain parts of the alveolar ridge are sensitive to the pressure of hard prosthetic materials, due to thin overlying mucosa.^[2] In such cases, it is necessary to line the inner surface of denture base with a soft material similar to mucosa to compensate for the lost thickness and viscoelastic behavior of the mucosa.^[3] Soft lining materials are able to form an absorbing layer on the part of denture in contact with the oral mucosa, and this allows less traumatic transmission of occlusal forces.^[2] These properties make soft denture lining materials useful for treating patients with ridge atrophy or resorption, bony undercuts, bruxing tendencies, congenital or acquired oral defects, xerostomia, and dentures opposing natural dentition.^[4] The result is that wearing the complete prosthesis becomes more comfortable for the patient. Soft denture lining materials have been

used in dentistry for more than a century with the earliest soft liners being natural rubbers. One of the first synthetic resins developed in 1945 as a soft liner was a plasticized polyvinyl resin, followed by the introduction of silicones in 1958.^[5] Contemporary elastic materials are used for short- and long-term application in the oral cavity and are divided into acrylic and silicone types.^[2]

Elastic materials used in dental prosthetics to line removable dentures should be characterized by biocompatibility toward oral tissues, shape and color stability; resistance to abrasion; and durability of the junction between the lining and the denture.^[6] It has been seen that rougher surfaces enhance the adhesion of microorganisms onto resilient lining materials and may allow fungal growth.^[7]

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Denture plaque control using mechanical and chemical methods is essential for the maintenance of good oral hygiene of denture wearers.^[8] However, mechanical cleansing (brushing) is not advisable for soft denture liners, since it can damage the resilient lining.^[9] The solutions used for denture cleaning can be divided according to their chemical composition such as alkaline peroxide, alkaline hypochlorites, acids, disinfectants, and enzymes.^[10] They are dispensed in powder or tablets forms.^[11]

This review was aimed to determine and compare the effect of various denture cleansers and other physical stresses on the water sorption and solubility, tensile bond strength, shear bond strength, surface hardness, surface roughness, and color changes of acrylic- and silicone-based soft denture liners and to determine which denture liners would be best suited for clinical usage.

MATERIALS AND METHODS

A review protocol was structured on the basis of the guidelines proposed by the PRISMA statement^[12,13] and Centre for Reviews and Dissemination.^[13] The review was carefully designed under the following headings as stated in the checklist of items to include when reporting a systemic review or meta-analysis.

Eligibility criteria

The language chosen is English following the specifications of the journal. The following review has not been reviewed/published by any other journal.

Information sources

Studies reporting the impact of denture cleansers on soft denture liners were identified by searching electronic databases and scanning reference lists of articles.

Search strategy

The search was applied to MEDLINE, EMBASE, Web of Science, PubMed, and PubMed Central. Supplemental hand search was conducted, where the reference lists and citations of the relevant articles were reviewed.

Study selection

The study selection was carried out independently by the first two authors who adhered to the predefined eligibility criteria.

Data collection process

Data collection was done for comparative evaluation of physical properties of silicone- and acrylic-based soft denture liners under the following criteria: surface roughness, water sorption and solubility, tensile bond strength, shear bond strength, surface hardness, surface roughness, and color changes.

Data items

A total of 176 studies were collected for the purpose of this review, out of which 36 studies were finalized carefully keeping in mind the parameters of the review.

Risk of bias in individual studies

Any disagreements between the two reviewers regarding the inclusion of studies were resolved by discussion. A consensus method was adopted by the third author when dispute persisted. Publications were identified as being relevant through the initial screening of titles and abstracts followed by screening of the full text.

Analysis of the results of the included studies

Araújo and Basting^[1] performed an *in situ* evaluation of surface roughness and micromorphology of two soft liner materials for dentures at different time intervals. Forty-eight rectangular specimens of each of the two soft liner materials were fabricated: a silicone-based material (Mucopren Soft) and an acrylic resin-based material (TruSoft). The specimens were placed in the dentures of 12 participants and evaluated at: 0, 7, 30, and 60 days. They came to the conclusion that silicone-based material showed lower surface roughness values and a smoother surface than the acrylic resin-based material, thereby making it preferred when selecting more appropriate material, due its tendency to promote less biofilm buildup.

El-Hadary and Drummond^[5] evaluated two soft denture lining materials with distinct chemical compositions (silicone-based soft liner-Luci-Sof and a plasticized acrylic resin soft liner-PermaSoft) to determine and compare their water sorption, solubility, and tensile bond strength. The study results concluded that on the basis of lower water sorption and solubility and higher tensile bond strength, Luci-Sof might provide a better clinical success.

Pinto *et al.*^[14] did an *in vitro* study to evaluate the effect of varying amounts of thermal cycling on bond strength and permanent deformation of two resilient denture liners bonded to an acrylic resin base. Plasticized acrylic resin (PermaSoft) or silicone (Softliner) resilient lining materials were processed to a heat-polymerized acrylic resin. Specimens were divided into nine test groups ($n = 10$) and were thermal cycled for 200, 500, 1000, 1500, 2000, 2500, 3000, 3500, and 4000 cycles. With regard to failure type, the soft liner groups presented adhesive failure (100%) regardless of specimen treatment. PermaSoft groups presented adhesive (53%), cohesive (12%), or a combined mode of failure (35%). For the deformation test, there was no significant difference among the soft liner specimens. However, a significant difference was observed between control and PermaSoft specimens after 1500 or more cycles.

Choi *et al.*^[15] conducted a study with the purpose to measure the tensile bond strength and durability of various combinations of three different resilient denture liners bonded to three different poly (methyl methacrylate) denture base materials. The tensile bond strength of three resilient denture liners, namely Ufi Gel SC, Silagum-Comfort, and Vertex Soft, combined with heat-polymerized (Vertex Rapid Simplified), autopolymerized (Vertex Self-Curing), and computer-aided design and computer-aided manufacturing (IvoBase) denture base resins were tested by using a universal testing

machine (total $n = 138$). Half of the specimens were thermocycled between 5°C and 55°C for 1500 cycles before testing. After testing, modes of failure and interface surfaces were examined using light microscopy and scanning electron microscopy, respectively. Thermogravimetric analysis was carried out to analyze the differences in content between the three different denture base acrylic resins. Silicone-based resilient denture liners produced the highest tensile bond strength to all denture bases tested.

Sudhapalli and Sudhapalli^[16] evaluated the influence of different exposure times of a commonly used denture cleanser on sorption and solubility of four soft liners, i.e., long-term and short-term acrylic liners and long-term and short-term silicone liners. Each of these was divided into four groups: first control group: all liners were kept in artificial saliva for entire period of the study and the second group: liners were immersed daily in cleanser for 1 h and then transferred to artificial saliva for rest of the day. Similarly, samples of the third and fourth groups were immersed in cleanser for 4 and 8 h, respectively, and transferred to artificial saliva. Sorption and solubility tests were conducted and statistical analysis was done. One-way ANOVA followed by *Post hoc* Tukey's test for pair-wise comparisons was done. Overall, silicones were performed better than acrylics. Long-term silicone was most stable. Short-term acrylic was the most unstable.

Rajaganesh *et al.*^[17] conducted this study to comparatively evaluate the shear bond strength of two chairside soft relining materials, namely autopolymerizing-plasticized acrylic resin liner and a silicone-based liner bonded to heat-polymerized polymethyl methacrylate denture base resin and to analyze the mode of interfacial bond failure. Forty test specimens were prepared by bonding plasticized acrylic- and silicone-based soft liner to heat-polymerized acrylic resin blocks. Twenty specimens, ten from each group, were subjected to thermal cycling and later to shear bond strength testing. The debonded specimens were then qualitatively analyzed for the mode of failure using scanning electron microscopy. The results concluded that the silicone-based soft liner showed higher shear bond strength to heat-polymerized acrylic resin than acrylic-based soft liner both before and after the thermal cycling.

Ergun and Nagas^[18] compared the color stability of three acrylic-based hard liners (Ufi gel hard, Dura-Liner II, Tokuso Rebase) and two silicone-based soft liners (Ufi gel permanent, Molloplast B) using the colorimeter. Color measurements were made before and after distilled water and aging. Data were statistically analyzed using nonparametric Kruskal–Wallis and Mann–Whitney U-tests. The results indicated that the most discolored liner material was Dura-Liner II after aging and the least discolored material was Ufi Gel permanent after distilled water. Based on the results of the study, they devised the conclusion that, silicone-based liner materials are considered to be more color stable than acrylic-based liner materials.

Mese and Guzel^[7] evaluated the effect of storage duration on the tensile bond strength and hardness of a definitive acrylic resin-based heat-polymerized (Vertex Soft), interim acrylic resin-based autopolymerized (Coe-Soft), definitive silicone-based heat-polymerized (MolloplastB), and definitive silicone-based autopolymerized (Mollosil Plus) resilient liner onto denture base acrylic resin. Specimens were stored for 1 day, 1 week, or 1, 3, or 6 months in water at 37°C. The results indicated that there were significant differences both in the hardness and bond strength values of resilient liner materials. The definitive silicone-based heat-polymerized (Molloplast B) resilient liner had significantly higher bond strength and lower hardness values than the others.

Ueda *et al.*^[19] investigated the influence of chemical and mechanical cleaning on the surface morphology of the silicone soft relining material. Three plate-shaped specimens were prepared for each group (control, hard, and soft) by laminating a 1.5-mm-thick silicone soft relining material. The control group specimens were stored in water, and the hard and soft group specimens were cleaned with hard and soft bristle denture brushes, respectively. Abrasion testing with a toothbrush and immersion testing with an enzyme-containing peroxide denture cleanser were performed, simulating a period of approximately 4 months. Their study results led to the conclusion that chemical cleaning using the enzyme + neutral peroxide denture cleanser did not roughen the surface of the silicone soft relining material.

Mutluay and Tezvergil-Mutluay^[20] evaluated the changes in surface properties and softness of soft relining materials after cyclic loading in water. Three polysiloxane (Silagum AM Comfort, Molloplast B, and Mollosil Plus) and two acrylic-based (Vertex Soft and Astron LC Soft) proprietary soft relining materials and a vinyl polysiloxane (Imprint 2 Garant) as the reference impression material were evaluated. A control group from each material was only subjected to water immersion. Nondestructive cyclic loading was carried out with a strain of 16.6% and a frequency of 1.6 Hz 200,000 times in distilled water at 37°C. The specimens were then duplicated and compared with the controls using roughness measurements, detail reproduction, and scanning electron microscope. Shore A hardness values before and after cycling were also measured. Polysiloxane-based materials preserved their softness, surface texture, and surface smoothness better under cyclic loading compared to acrylic resin-based plasticized materials.

Mohammed *et al.*^[21] conducted a study to evaluate the effect of commercially available denture cleansers on surface hardness and roughness of acrylic- and silicon-based denture liners at various time interval. Two autopolymerizing denture liners, Kooliner (acrylic) and GC reline soft (silicon) were tested with two commercially available denture cleansers such as Polident and Efferdent Plus. A total of 120 specimens were prepared, and all the specimens were divided into six groups based on the relining materials and denture cleansers used.

Surface hardness and surface roughness were tested using Shore A durometer and profilometer, respectively, at the end of day 1, 7, 30, and 90. The results revealed that the average surface hardness and surface roughness were lower in silicon liner material than acrylic liner material.

Leite *et al.*^[22] evaluated the color stability and hardness of two denture liners obtained by direct technique (DT) and indirect techniques (ITs), after thermal cycling and immersion in beverages that can cause staining of teeth. Seventy disc-shaped specimens processed by DT and ITs were made from Elite Soft (silicone-based soft denture liner) and Kooliner (acrylic-based hard denture liner) denture liners and were stored in water, coffee, tea, soda, and red wine for 36 days. The values of color change, Shore A hardness (Elite Soft), and Knoop hardness (Kooliner) were obtained. The thermal cycling promoted the color change only for Kooliner in the IT. Immersion in the beverages did not promote color change for Elite in both techniques.

Niarchou *et al.*^[23] conducted this study with the purpose to evaluate hardness and color stability of some visible light polymerized and autopolymerized soft reliners after exposure in different denture-cleansing treatments. Six soft denture reliners (two autopolymerized silicones, one autopolymerized acrylic, and three visible light polymerized ones) were exposed to four cleansing treatments. Hardness was measured with a Shore A durometer, and color changes were evaluated by a tristimulus colorimeter. Sofreliner showed the smallest hardness change and Light Liner the greatest. Versasoft and Sofreliner seem to have the lowest color change for every cleansing treatment examined, whereas Light Liner and Eversoft presented the greatest. Silicone-based materials demonstrated the smallest changes in both hardness and color, either when using water or with any of the other cleansing treatments.

Saraç *et al.*^[24] aimed to investigate the color stability of soft denture liners and the effectiveness of denture cleansers on soft denture liners colored by food colorants in different time periods. A plasticized acrylic resin soft liner (Viscogel) and a silicone-based soft liner (Mollosil) were used in this study. From each material, 30 specimens were prepared in a Teflon mold 15 mm in diameter and 3 mm thick. The prepared specimens were stored in distilled water for 24 h at 37°C. Initial color measurements of the specimens were made using a small-area colorimeter. Color difference (Delta E) values were calculated, and the derived data were analyzed using repeated-measure analysis of variance for three-way classification and Bonferroni multiple comparison tests ($\alpha = 0.05$). They concluded that silicone-based soft denture lining material was more resistant to staining.

Rao *et al.*^[25] determined the effect of denture cleansers on resiliency of the soft liner. Two soft liners (Molloplast B and Refit) and two denture cleansers (Clinsodent and Fittydent) were taken. The samples were tested with Hounsfield tensometer. They came to the conclusion that greater the

softness and better the elastic recovery of the denture soft liner, more effective would be its performance clinically. Silicon-based material, such as Molloplast B, rebounds quickly and would seem preferable to a material that is acrylic based.

Salloum^[26] evaluated the viscoelastic properties of acrylic and silicone lining materials. This study investigated and compared viscoelastic properties of two resilient denture lining materials. Tested materials were laboratory processed; one of them was silicone-based liner product (Molloplast B) and the other was plasticized acrylic resin (Vertex™ Soft). Twenty cylindrical specimens (10–20 mm in length, 11.55 mm in diameter) were fabricated in an aluminum mold from each material for creep and stress relaxation testing (the study of viscoelastic properties). Statistical study of Young's moduli illustrated that Vertex™ Soft was softer than Molloplast B. On the other hand, the results explained that the recovery of silicone material was better than of acrylic one.

Murata *et al.*^[27] studied the properties of soft denture liners. They implied that the clinical success of the materials depends both on their viscoelastic properties and on durability. Acrylic resins and silicones are mainly available for permanent soft liners. The acrylic permanent soft liners demonstrate viscoelastic behavior, whereas silicone permanent soft liners demonstrate elastic behavior. The improvement in masticatory function is greater in dentures lined with the acrylic materials than in those lined with silicone products. However, the acrylic materials exhibit a more marked change in viscoelastic properties and loss of cushioning effect over time than silicones. They concluded that from the standpoint of durability, the silicones are preferred.

Iwasaki *et al.*^[28] aimed to investigate the effect of long-time immersion of soft denture liners in 37°C water on viscoelastic properties. Six silicone-based and two acrylic resin-based soft denture liners were selected. Cylindrical specimens were stored in distilled water at 37°C for 6 months. Viscoelastic properties, which were instantaneous and delayed elastic displacements, viscous flow, and residual displacement, were determined using a creep meter and analyzed with two-way analysis of variance and Tukey's comparison ($\alpha = 0.05$). The observed viscoelastic properties of three from six silicone-based liners did not significantly change after 6-month immersion, but those of two acrylic resin-based liners significantly changed with the increase of immersion time.

DISCUSSION

The use of soft denture liners is an important advent in the treatment of complete and partial denture patients. Their use for patient comfort and the treatment of atrophic ridge, bony undercuts, bruxism, xerostomia, and dentures opposing natural teeth has been known to be clinically beneficial. Unfortunately, even the best materials available today do not last more than a year or two in service.^[29] Denture lining materials are generally classified into short-term soft liners (tissue conditioners) and long-term soft liners.

Short-term soft liners or tissue conditioners are commonly used as temporary liners. Materials available as permanent soft liners include plasticized acrylics, silicone rubber, plasticized vinyl polymers and copolymers, hydrophilic polymers, polyphosphazene fluoropolymers, fluoroethylene, and polyvinyl siloxane addition silicones. Currently, the most commonly used materials are plasticized acrylics and silicone rubber, which are either chemically or heat polymerized.^[30] Silicone rubber material is composed of dimethylsiloxane polymer, which is a viscous liquid, cross-linked to provide good elastic properties. These materials excel in their resiliencies, whereas acrylic soft resin materials are acrylic copolymers to which plasticizers may be added. These materials may absorb water, swell, and harden because of plasticizer leaching.^[22] This hypothesis is supported by Pahuja *et al.*^[31] who studied the effect of different chemical disinfection methods on the increase in surface hardness of soft denture liners and came up with the conclusion that acrylic-based soft liners showed significantly higher increase in surface hardness than silicone-based soft liners.

The present review aimed at evaluating and comparing two kinds of commercially available denture liners to determine which would yield better properties under physical stresses and prove to be more beneficial for long-term clinical use. In the following review, articles were chosen on the basis of their relevance to compare the physical properties of silicone-based denture liners to acrylic-based denture liners. With the data gathered from various studies consulted for the purposes of the article, observations were made that silicone-based soft liners constantly performed better than acrylic-based denture liners. Silicone-based soft liners showed lower surface roughness values, less water sorption, better tensile bond strength, decreased surface hardness, and better color stability over a period of time than acrylic-based soft liners. This is also supported by Brozek *et al.*^[2] who determined the effect of storage in disinfectants and artificial saliva on a series of commercial soft lining materials for dentures. It was observed that the acrylic materials became less elastic on storage for up to 28 days, whereas the silicone materials showed no change in elastic properties, irrespective of cleansing treatment. Similar results were obtained by Mancuso *et al.*^[32] tested hardness and color stability of liner materials based on acrylic resin and silicone after 2000 thermal cycles. It was concluded that hardness and color stability of silicone soft liners were less affected than acrylic resin-based liners.

The soft denture liners are meant to function with denture in the oral cavity. The nutrient-rich environment of the oral cavity does not fully matches the *in vitro* nature of the various studies consulted for the purpose of this review. Therefore, the behavior of denture lining materials in this study may only partially predict clinical performance. Despite increasing the use of soft liners in prosthetic dentistry and the importance of cleansing to prevent cross-contamination, factors such as absorption and solubility, roughness, bond strength,

color stability, and viscoelastic properties need to be further investigated.

CONCLUSION

In the above article, physical properties of soft denture liners were reviewed under water sorption and solubility, tensile bond strength, shear bond strength, surface hardness, surface roughness, and color changes. Under all these parameters, it was observed that silicone-based soft liners performed better than their acrylic-based counterparts in all the studies. Therefore, it is safe to say that silicone-based soft denture liners are better suitable to long-term clinical usage.

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Conflicts of interest

There are no conflicts of interest.

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