PRODUCT INVESTIGATIONS

e-ISSN 1643-3750
© Med Sci Monit, 2023; 29: e941793
DOI: 10.12659/MSM.941793

Received: 2023.07.16
Accepted: 2023.08.21
Available online: 2023.09.06
Published: 2023.10.12

Comparative Analysis of Properties in Chairside Silicone Denture Liners versus Heat-Cured Molloplast-B: An In-Depth In Vitro Evaluation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDE 1 Mahdi Mutahar
DFG 2 Nasser M. Al Ahmari
DFG 2 Saeed M. Alqahtani
BFG 2 Thrya S. Gadah
DFG 3 Abdulkarim H. Alshehri
EG 3 Hafiz A. Adawi
FG 2 Mansoor Shariff
FG 3 Fuad A. Al-Sanabani
EF 3,4 Mohammed M. Al Moaleem

1 Dental Academy, University of Portsmouth, Portsmouth, United Kingdom
2 Prosthetic Department, College of Dentistry, King Khalid University, Abha, Saudi Arabia
3 Department of Prosthetic Dental Science, College of Dentistry, Jazan University, Jazan, Saudi Arabia
4 Faculty of Dentistry, University of Ibn al-Nafis for Medical Sciences, Sana'a, Yemen

Corresponding Authors: Mahdi Mutahar, e-mail: mahdi.mutahar@port.ac.uk, Mohammed M. Al Moaleem e-mail: drmoaleem2014@gmail.com
Financial support: None declared
Conflict of interest: None declared

Background: We investigated the bond strength, tensile strength, and water absorption properties of 4 widely used chairside silicone long-term denture soft lining materials and compared properties with those of heat-cured silicone material.

Material/Methods: Four chairside materials (GC Reline Soft, Mucopren Soft, Sofreliner Soft, and Elite Soft Relining) and a heat-cured silicone material (Molloplast B) were investigated. For tensile and shear bond strength and tensile strength, samples were prepared according to the manufacturers' instructions and the testing machine used. For water absorption, IOS 1567 was followed to prepare specimens. Bond strengths were measured using a Lloyd Instruments materials testing machine. Ten specimens for each test were prepared for each soft liner, except for water absorption and solubility tests, for which only 5 specimens were prepared. ANOVA, Bonferroni, and Kruskal-Wallis tests were used to compare values of materials and assess changes over time.

Results: There was strong evidence of differences in the properties between materials. GC Reline Soft showed comparable tensile bond (1.4±0.6 MPa), shear bond (1.1±0.4 MPa), tensile strength (5.44±0.98), water absorption (0.92±0.2 μg/mm^3), and solubility values (0.3±0.2 μg/mm^3) to that of Molloplast B (1.4±0.4; 1.6±0.5; 4.53±0.9 MPa, 1.7±0.3, and 1.0±0.3 μg/mm^3, respectively). The water solubility of Sofreliner Soft was significantly lower (1.5±0.8 μg/mm^3) than that of Molloplast B.

Conclusions: There were significant differences between some properties of 4 chairside denture soft lining materials and that of Molloplast B, which had higher shear and tensile bond strength than chairside denture silicone soft lining materials but had the highest water solubility.

Keywords: **Absorption • Denture Liners • Shear Strength • Solubility • Tensile Strength**

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/941793

4540 5 5 28

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Background

The success of a denture is predicated on ideal comfort, aesthetics, and suitable function. Many denture wearers experience soreness behind the denture base due to chronic pain caused by complete dentures. The chronic pain is produced by soft tissue of the denture bearing area being sandwiched between a denture and an alveolar ridge [1,2].

Denture soft lining materials are frequently used in managing edentulous patients therapeutically, primarily to create the intaglio surface of the denture, thereby assisting in healing injured tissues by acting as a temporary or long-term cushion for irritated tissue [3-5]. Denture soft lining materials line the denture, which can help distribute forces more evenly to the soft tissues during chewing and reduce severe mechanical stress on the mucosa [6,7]. They are most advantageous in treating patients with atrophy/resorption, spicules, bruxism, inherited oral abnormalities, and xerostomia-like conditions [8].

Denture soft lining materials have been used in dentistry for more than a century, and the first were made of natural rubber. Plasticized polyvinyl resin is the earliest artificial resin, created as a soft liner in 1945, and was replaced in 1958 by silicones. Plasticized acrylic, silicones, vinyl polymers, and hydrophilic materials are all available as permanent denture soft lining materials. Plasticized acrylics and silicones, which can be chemically or heat polymerized, are currently the most frequently used materials [9]. Silicone denture soft lining materials are present in 2 polymerizing forms: heat-polymerized silicone materials and auto-polymerized silicone materials. Molloplast B is heat-polymerized silicone composed of vinyl-terminated poly-dimethylsiloxane and silica fillers. There are numerous silicone-based denture soft lining materials that are currently commercially available. The properties of Molloplast B, a heat-processed silicone-based denture soft lining material, have been extensively studied, and Molloplast B has been found to be the optimum soft lining material among many others for clinical purposes [10]. However, although chairside silicone-based denture soft lining materials are commercially available resilient denture lining materials, there is little or no information about their properties.

Chairside denture soft lining materials are auto-polymerized silicone materials that are polymerized under conditions similar to those of conventional laboratory-processed dentures but can also be used as chairside-processed silicone soft liners, being applied directly at chairside and polymerized in the patient's mouth. This minimizes the time needed for the denture to be produced in the laboratory, as in the case of heat-cured silicone, avoiding the considerable inconvenience of the patient being without the denture [6-9]. Sofreliner Soft, GC Reline Soft, Mucopren Soft, and Elite Soft Relining are examples of these chairside denture soft lining materials [11].

These elastic materials that line removable dentures for dental prostheses need to be biocompatible in the oral cavity and must have color stability, abrasive resistance, and durability with the denture base. A bond failure between the liner and denture base is a major issue while using resilient denture liners. Water absorption, solubility, and denture base composition are all factors that influence the binding with denture liners and bases [12]. Also, rougher surfaces have improved microbe adhesion and might promote microbial growth [9].

The most serious problems with all available denture soft lining materials are the inadequate bond strength, loss of softness over time, water absorption, poor tear strength, colonization of *Candida albicans*, and poor color stability [13,14]. The need for relining removable partial dentures is common, and the problem is that there is little information available of the properties of the commercially available chairside denture soft lining materials. Previous studies of chairside silicone soft lining materials have usually included only a small number of materials and limited number of tests [1,3,9,14-16]. Thus, the present study aimed to evaluate the bond strength properties of 4 chair-side silicone lining materials (GC Reline Soft, Mucopren Soft, Sofreliner Soft, and Elite Soft Relining) and compare their properties with those of a heat-cured silicone lining material, Molloplast B. We hypothesized that chairside denture silicone soft lining materials would have better properties than Molloplast B.

Materials and Methods

Study Design

This in vitro study used 4 chairside addition-cured vinyl polysiloxane materials (Sofreliner Soft, GC Reline Soft, Mucopren Soft, and Elite Soft Relining) and 1 heat-cured silicone material (Molloplast B). **Table 1** shows the 5 denture soft lining materials used in this study with their types, constituents, and manufacturers. The vinyl polysiloxane materials were supplied as 2-paste cartridge systems. Molloplast B was supplied as a single-component silicone. All materials were used according to the manufacturers' directions. These 4 widely used chairside soft liners were investigated for bond strength, tensile strength, and water absorption properties. Ten specimens for each test were prepared for each soft liner, except for the water absorption and solubility test, for which only 5 specimens were prepared.

Specimens Preparation and Testing for Shear Bond Strength

Ten shear bond specimens were prepared for each soft lining material. The specimens were prepared by investing a glass block sized 50×10×3 mm in a 50%/50% stone and plaster mix

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Table 1. Five silicone long-term denture soft lining materials, their types, constituents, and manufacturers.

Material	Type	Chemical components	Manufacturer
Sofreliner	Autopolymerized silicone	Polyorganosilovane silicone resin powder silica, amorphous	Tokuyama Corp., Tokyo, Japan
GC Reline Soft	Autopolymerized silicone vinyl Polysiloxane	Silicone dioxide vinyl dimethyl polysiloxane hydrogen polysiloxane	GC Dental Products, Kasugai, Aichi, Japan
Mucopren Soft	Autopolymerized silicone	Vinyl polysiloxane, platinum catalyst, and others	Kettenbach GmbH, Eschenburg, Germany
Elite Soft Relining	Autopolymerized silicone	Poly vinylsiloxane platinum-based catalysers	Zhermack SpA 45021 Badia Polesine (Rovigo), Italy
Molloplast B	Heat-cured silicone-based	Hydroxyl terminated polydimethylsiloxane, fumed silica fillers, methyl triacetoxysilane, dibutyl tin dilaurate, poly methyl methacrylate	Detax, GMBH, Ettlingen, Germany

using a conventional dental flasking technique with Stellon Q-20 acrylic (Dentsply Ltd, Surrey, UK). After polymerization, flasks were disassembled and the acrylic resin block, sized 30×60×6 mm, was removed from the flask.

A pattern measuring 10×10×3 mm was inserted between acrylic blocks and invested in a 50%/50% stone and plaster mix using conventional dental flasking, creating space for the denture liner. Separating medium (sodium alginate) was applied to the stone surfaces before adding the plaster side of the dental flask, enabling flask opening. After investment setting, wax was removed by boiling, leaving 1 acrylic block in the stone and the other on the plaster side. Both acrylic blocks were cleaned with ethyl alcohol, primed, and treated with separating medium where the soft liner attaches. The spaces previously occupied by the wax pattern were filled with denture soft liner materials. The soft liner was then packed into the spaces formerly occupied by the spacers. The specimens bonded measured 50×10×10 mm, with 10×10×3 mm of soft lining material (**Figure 1A**). All chairside silicone soft liners were cured at room temperature. Molloplast B was cured in a water bath for 7 h at 70°C with a boiling point of 3 h at 100°C terminally, and stored at room temperature after removing from molds.

Each shear test specimen was placed in the Lloyd Instruments testing machine (Lloyd Instruments is a trademark of AMETEK Sensors, Test & Calibration, England). The load cell was 1 kN. Clamps held each specimen, while the constant rate of separation was 5 mm/min, according to ISO 527(1983). The specimens bonded measured 50×10×10 mm, with 10×10×3 mm of soft lining material. All the specimens were tested on the same day, and the room temperature during the test was 22±10°C. The results of the shear bond strength (MPa) test were calculated from the load given by the Lloyd Instruments testing machine.

Specimen Preparation and Testing for Tensile Bond Strength

Ten specimens of each of the denture liners were prepared for tensile bond strength testing by investing a glass block sized 30×60×6 mm in a 50%/50% stone and plaster mix, as described above. The acrylic resin block was then trimmed using a silicon carbide paper disc (320 grit) in a lapping unit (Kemet International City). The trimmed and finished acrylic resin block, measuring 30×60×6 mm, was cut into 10 strips, each measuring 30×6×6 mm. They were covered with Vaseline to facilitate their hard removal from the stone and then invested in 50%/50% stone and plaster mix to create molds measuring 30×6×6 mm each. Each acrylic strip was then cut into halves, and 3 mm was trimmed from each middle surface. Acrylic resin strips were replaced in exactly the same positions as the original using labels or marks, leaving a 6-mm gap in the middle for soft lining material. All acrylic surfaces were primed, and separating medium was put on all plaster/stone surfaces to facilitate their removal and avoid any damage to the middle soft lining material during removal. The soft liner was then packed into the previously trimmed 6×6×6-mm spaces. The specimens were acrylic resin blocks measuring 27×6×6 mm, with 6×6×6 mm of soft lining materials (**Figure 1B**). All denture soft lining materials were cured as described above.

Each tensile test specimen was placed in the Lloyd Instruments testing machine. Two clamps held each specimen and the tensile separating force was applied with the constant rate of 5 mm/min, according to ISO 527(1983). The specimens were acrylic resin blocks of 27×6×6 mm, with 6×6×6 mm of soft lining materials. All specimens were tested on the same day, and the room temperature during the experiment was 22±10°C. The results of the tensile bond strength were in (MPa=N/mm^2) and were calculated from the load given in the Lloyd Instruments testing machine.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

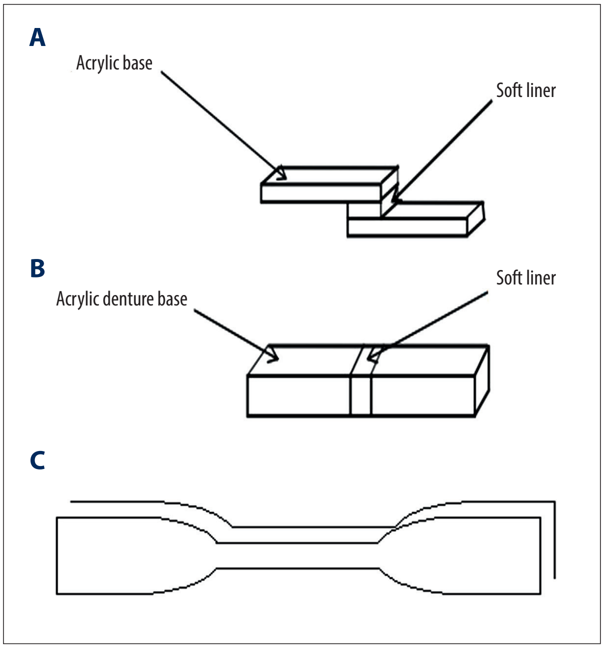

Figure 1. Diagrammatic representation of a specimen of shear bond strength (**A**), tensile bond strength specimen (**B**), and tensile strength specimen (**C**).

Specimen Preparation and Testing for Tensile Strength

Ten dumbbell-shaped specimens were prepared for each material using gypsum molds, which were made by using the plastic pattern. The size of each specimen was 25×2×2 mm (**Figure 1C**). The patterns of 25×2×2 mm were invested in a 50%/50% stone and plaster mix in a conventional dental flasking technique to create molds of the same shape, into which soft lining material was packed. The soft liner was then packed into the spaces previously formed by the plastic pattern. The same procedure was used for all chairside silicone liners. Testing of specimens was conducted on a Lloyd Instruments tensile machine connected to a compatible computer. Each tensile test specimen was placed in 2 clamps that held each specimen, and the tensile separating force was applied with the constant rate of 20 mm/min. The rate of deformation has an effect on the value of tensile strength. There was a preload of 5 N. All the specimens were tested on the same day, and the room temperature during the experiment was 22±10°C. The results of the tensile strain properties were calculated from the load given by the Lloyd Instruments testing machine, using the following equation: T=F/A, where T=tensile strength (N/mm^2); F=force at failure (N); A=original cross-sectional area (mm^2).

Specimen Preparation and Testing of Water Absorption and Solubility

Five samples were prepared for each soft lining material, and each was processed according to its manufacturer's instructions and prepared according to IOS 1567. The specimens' dimensions were 50 mm in diameter and 0.8±1 in height. Each soft liner was cured according to its manufacturer's instructions. They were then removed and stored until the time of testing. The tested prepared specimens complied with ISO 1567 (1999). Then, prepared specimens were submerged in distilled water for 7 days and 2 h at 37±1°C for 23±1 h and then conditioned according to ISO 1567 until they achieved a constant weigh to an accuracy of 0.2 mg, which was recorded as (m1). The volume of each specimen was calculated using the mean of 3 diameter measurements and the mean of 5 thickness measurements. The thickness measurements were taken in the center and at 4 equally spaced locations around the circumferences.

The conditioned specimens were then immersed in distilled water for 7 days ±2 h at 37±1°C, before they were removed with polymer-coated tweezers, wiped with clean absorbent papers until free from visible moisture, waved in the air for 15±1 s, and weighed 60±10 s after removal from the water. This was recorded as (m2). In a desiccator, all specimens were dried once again until a constant weight was reached and recorded as (m3). In accordance with IOS 1567: 1999(E) guidelines, water absorption was calculated as (m2 - m3) divided by the specimen's volume (V). The volume (V) was determined using the formula $V=\varpi r^2h$, where ϖ is approximately 3.142. The radius (r) was obtained from the average of 3 diameter measurements, and the thickness (H) of the specimens was calculated as the average of 5 thickness measurements.

Statistical Analysis

Data obtained from the tests were analyzed with Stata/IC v. 10.1 (Stata Corp LP, College Station, TX, USA). Repeated-measures ANOVA was used to compare mean values of tests for the 5 different materials, to assess changes over time, and to detect any differences between wet and dry specimens. A corrected Bonferroni test was used to determine differences between materials at 2 time points. *P* values of 0.05 or less were considered statistically significant. The shear bond strength, tensile bond strength, tensile strength, energy absorption (resilience and stiffness), and water absorption and solubility results for the 5 different materials were compared using the StatGraphic-Plus package V5.0 system (Manugistics Inc., Rockville, MD, USA). Initially, using a one-way ANOVA, summary statistics were calculated (including mean, standard deviation, standard skewness, and standard kurtosis). The Kruskal-Wallis test (comparing medians) established if statistically significant differences existed between the materials in each test.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

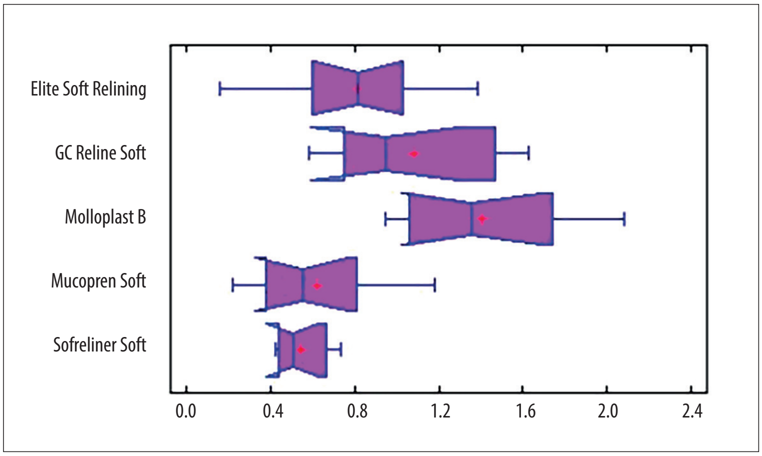

Figure 2. Shear bond strength values of the 5 materials.

Table 2. Shear bond strength mean values (MPa) and standard deviations for 5 silicone long-term denture soft lining materials (n=10).

Materials	Shear Bond Strength MPa	Mode of failure		
		Adhesive	Mixture	Cohesive
Mucopren	0.6±0.3	10	0	0
GC Reline Soft	1.1±0.4	0	6	4
Sofreliner	0.6±0.1	0	5	5
Elite	0.8±0.4	5	2	3
Molloplast B	1.4±0.4	0	10	0

Results

Shear Bond Strength

The box-and-whisker plots in **Figure 2** show the differences between the materials. There was no discernible difference between GC Reline Soft and Molloplast B in terms of shear bond strength ($P>0.05$). The shear bond strength of Molloplast B was significantly greater than that of the other materials ($P<0.05$). GC Reline Soft had greater shear bond strength than did Elite Soft Relining, Mucopren Soft, and Sofreliner Soft. The shear bond strength of GC Reline was substantially higher than that of Sofreliner Soft ($P<0.05$; **Figure 2**).

Shear bond strength values are given in **Table 2**. The greatest values were for Molloplast B and GC Reline, with 1.4 MPa and 1.1 MPa, respectively, and the differences between them were significant ($P=0.03$). Mucopren and Sofreliner had the lowest values, at 0.6 MPa. Elite had an intermediate value, which was significantly lower than that of Molloplast B but not significantly different from that of GC Reline. While Mucopren and Sofreliner had the lowest values, the value of Sofreliner was not significantly higher than that of Mucopren: 0.9 MPa and 0.8 MPa, respectively.

Tensile Bond Strength

The box-and-whisker plots in **Figure 3** show the differences between the materials. The difference in tensile bond strength between Molloplast B and GC Reline Soft was not statistically significant ($P>0.05$). Molloplast B had a substantially greater tensile bond strength than did the other materials ($P<0.05$). The tensile bond strength of GC Reline Soft differed significantly from that of Mucopren Soft ($P<0.05$), but did not differ significantly from that of Elite Soft Relining or Sofreliner Soft ($P>0.05$). **Figure 3** demonstrates that there were no statistically significant differences among the tensile bond strengths of Mucopren Soft, Sofreliner Soft, and Elite Soft Relining. The values of tensile bond strength of the 5 denture liners are shown in **Table 3**. Molloplast B and GC Reline had the greatest values, at 1.6 MPa and 1.4 MPa, respectively, and Mucopren demonstrated the lowest value, at 0.7 MPa; there was a significant difference between them. Elite Soft Relining was in the same position among all materials for tensile bond strength as it was for shear bond test, with its value differing significantly from that of Molloplast B and GC Reline.

Tensile Strength

The box-and-whisker plots in **Figure 4** show the differences between the materials. The tensile strength value of Mucopren Soft was significantly higher than that of the other materials

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

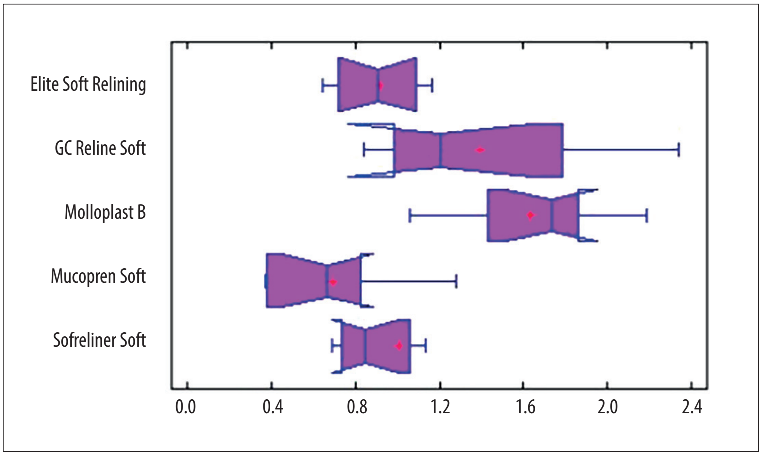

Figure 3. Tensile bond strength values of the 5 materials.

Table 3. Tensile bond strength mean values (MPa) and standard deviations for 5 silicone long-term denture soft lining materials (n=10).

Materials	Mean±SD (MPa)	Mode of failure		
		Adhesive	Mixture	Cohesive
Mucopren	0.7±0.3	10	0	0
GC Reline Soft	1.4±0.6*	1	3	6
Sofreliner	0.8±0.3	0	6	4
Elite	0.9±0.2	10	0	0
Molloplast B	1.6±0.5*	0	0	10

* Indicates statistical significance; SD – standard deviation.

(P<0.05). In comparison with the value of other materials, the value of Sofreliner Soft was significantly lower (P<0.05). The tensile strength of GC Reline Soft was significantly greater than that of Elite Soft Relining (P<0.05) but not significantly different from that of Molloplast B (P>0.05). Although tensile strength value of Molloplast B was higher than that of Elite Soft Relining, the difference was not statistically significant (P>0.05; **Figure 4**). Tensile strength values are listed in **Table 4**. The value of Molloplast B (4.5 MPa) was significantly lower than that of Mucopren (8.4 MPa) and not significantly lower than that of GC Reline (5.4 MPa). In contrast, Molloplast B had a relatively higher value than did Elite, with no significant difference, at 4.5M Pa and 4.3M Pa, respectively, while its value was significantly different than that of Sofreliner (2.17 MPa).

Water Absorption and Solubility

The box-and-whisker plots in **Figure 5** show the differences in the water solubility values of the materials. Molloplast B and Elite Soft Relining had greater water solubility values than the other materials. The difference was significantly greater than that of GC Reline Soft and Sofreliner Soft (P<0.05) but not significantly different than that of Mucopren Soft (P>0.05). GC Reline Soft had a lower water solubility value than the other materials. Differences in water solubility with Elite Soft Relining, Sofreliner Soft, and Molloplast B were statistically significant (P<0.05) but not significantly different than that of Mucopren Soft (P>0.05). The difference in water solubility values between Mucopren Soft and Sofreliner Soft was statistically significant (P>0.05; **Figure 5**).

Water absorption and solubility values are shown in **Table 5**. GC Reline showed the lowest water absorption (0.92±0.2 μg/mm^3), and the differences between this value and the values of the other materials were statistically significant, except for that of Softliner (1.5±0.8 μg/mm^3). The highest water absorption values were for Elite and Mucopren, at 1.85 μg/mm^3 and 1.84 μg/mm^3, respectively. Molloplast B was intermediate in value (1.7 μg/mm^3). In contrast, the water solubility properties of the 5 materials exhibited different approaches. GC Reline had the least soluble ingredients (0.3 μg/mm^3). Molloplast B had the highest (1.0 μg/mm^3), followed by Elite (0.97 μg/mm^3). Regarding solubility, the difference between the highest 2 values (Molloplast B and Elite) and the lowest (GC Reline) was statistically significant. The value of Softliner was intermediate (0.5μg/mm^3), which was not significantly different from that of GC Reline but was significantly different from that of Elite and Molloplast. The value of Mucopren (0.6 μg/mm^3) was not significantly different from any of the 5 materials.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

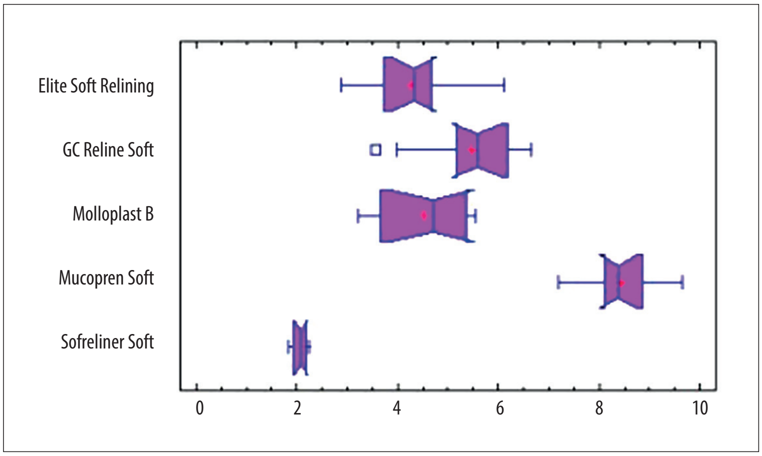

Figure 4. Tensile strength values of the 5 materials.

Table 4. Tensile strength mean values (MPa) and standard deviations for 5 silicone long-term denture soft lining materials (n=10).

Material	Tensile strength mean values N/mm² (MPa)	Standard deviation (N/mm²)
Molloplast B	4.53	0.90
Mucopren	8.43	0.68
GC Reline	5.44	0.98
Sofreliner	2.17	0.41
Elite	4.36	0.89

Table 5. Water absorption and solubility values (mean±SD) for 5 long-term denture soft lining materials using ISO 1567: 1999 (E) in (µg/mm³).

Material	Water absorption (µg/mm³) (M_2-M_3/V)	Water solubility±S (µg/mm³) (M_1-M_3/V)
Mucopren	1.8±0.00	0.6± 0.00
GC Reline	0.92±0.2*	0.3±0.2
Sofreliner	1.5±0.8	0.5±0.2
Molloplast B	1.7±0.3	1.0±0.3
Elite	1.85±0.7	0.97±0.4

* Indicates statistical significance.

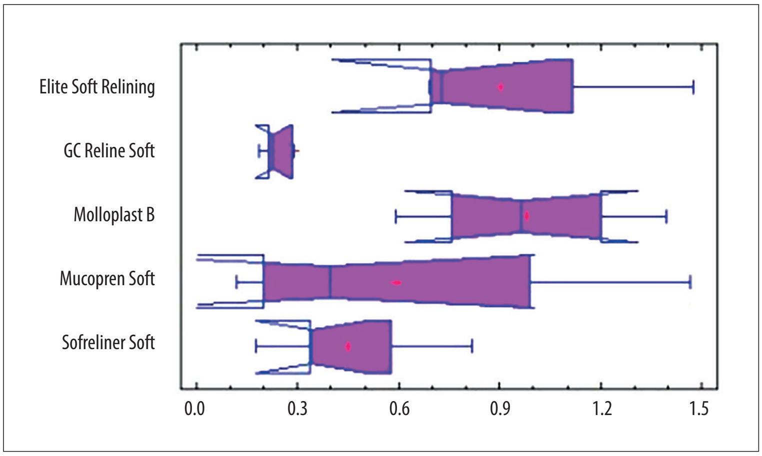

Figure 5. Water solubility values of the 5 materials.

Discussion

Denture liners can be helpful for patients who have bruxism, residual ridge resorption, nonresilient mucosa, and severe undercutting in some areas [17]. In this study, 4 commonly used vinyl polysiloxane materials (Sofreliner Soft, GC Reline Soft, Mucopren Soft, and Elite Soft Relining) and 1 heat-cured silicone material (Molloplast B) were examined for their bond strength, tensile strength, water absorption, and solubility.

Molloplast B was chosen for comparison as a heat-cured soft lining material because it has been widely studied and is well recognized for its good clinical performance. The physical tests were chosen to provide a broad range of information on the

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

materials. Those tests can help predict the behavior of the materials in the clinic. Tensile testing was the most reliable method to assess the bond strength of liners because it provides data on bond strength relative to material strength [5].

In our study, we examined shear bond strength values among denture liners and found that auto-polymerized liners, ie, Mucopren and Sofreliner, had the lowest values of all the tested denture liners. The highest values were for GC Reline and Molloplast B. In their study, Kreve et al investigated how well 2 types of chairside soft relining materials, plasticized acrylic resin liner and silicone-based liners, held up under shear. Results showed that before and after thermal cycling, silicone-based soft liners had greater shear bond strength than did acrylic-based soft liners [10,13,18].

We also examined the tensile bond strength values of 5 the materials, and Molloplast B (heat-cured material) and GC Reline (polyvinylsiloxane material) had the greatest values, with no significant differences between them. This finding was contrary to that of a study conducted by Białożyt-Bujak et al in 2021, which showed that the Flexacryl Soft acrylic liner had the highest bond strength and the acrylic substance Villacryl Soft had the lowest. Decreasing tensile bond strength over time suggests issues with water absorption, dissolution, increasing hardness, and internal tensions at the relining-denture plate junction [4,19]. The aging of the materials in the aqueous environment, which leads to a change in hardness and a progressive rise in water absorption and solubility, is responsible for this [6].

The finding in our study was similar to that of Madan et al, who found that the greatest results among silicone materials were obtained for the Molloplast B material. Furthermore, they also discovered that bond strength values of Molloplast B were much higher, vulcanizing at higher temperatures [20]. In 2020, Pahuja et al conducted a systematic review and meta-analysis examining the effects of storage time on the hardness and tensile strength of bonds of a definitive silicone-based heat polymerized (Molloplast B) liner, silicone-based auto polymerized (Molosil Plus), an interim acrylic resin-based heat polymerized (CoeSoft), and a silicone-based heat polymerized (Vertex Soft) resilient liner. Results showed that hardness and bond strength values varied significantly among the resilient liner materials. The heat-polymerized silicone-based robust liner (Molloplast B) offers substantially higher binding strength and less hardness [21]. Similar results were also found in a study conducted in 2015 by Choi et al [8]. Three distinct robust liners were bonded to 3 different poly (methyl methacrylate) denture foundation materials in a study evaluating the tensile bond strength and endurance of materials. Using a standard testing procedure, the tensile bond strength of the 3 resilient denture liners, Ufi Gel SC, SilagumComfort, and Vertex Soft, in combination with heat- and auto-polymerized (Vertex Rapid Simplified, Vertex SelfCuring), computer-aided design and computer-aided manufacturing (IvoBase), and heat- and auto-polymerized (Vertex SelfCuring) denture base resins was evaluated. The strongest tensile bond among all evaluated denture liners was achieved for the silicone-based robust denture liners. A recent study conducted by Dutta et al in 2023 compared the tensile bond strength of a heat-polymerized silicone-based resilient material following a brief immersion in 2 distinct denture cleaning solutions made of sodium perborate monohydrate, clinsodent, and water for differing amounts of time and concluded that the tensile bond strength values of soft-liner specimen differed significantly after immersing in water and a pair of distinct denture solutions for cleaning during the periods of immersion [22].

In our study, the tensile strength of Molloplast B was significantly lower than that of Mucopren and not significantly lower than that of GC Reline. This finding was similar to that of Białozyt-Bujak in 2021, which showed that GC Reline Soft and acrylic-based materials demonstrated significant increases in hardness among tested silicones in 3 months [4]. Palla et al conducted a systematic review on soft denture lining materials in 2021 to investigate effects of soft denture liners on masticatory performance and muscle activity of edentulous patients wearing complete dentures. They concluded that soft denture liners gave denture wearers greater masticatory ability, compared with traditional denture base materials, indicating a higher tensile strength of soft liners [23]. In 2021, Almuraikhi et al assessed the tensile binding strength of a soft liner to denture base resin with various surface treatments. These acrylic resinous blocks were divided into 3 groups: control, methyl methacrylate monomer surface treatment, and phosphoric acid surface treatment. Samples treated with methyl methacrylate monomer for soft lining denture base resins showed significantly higher tensile bond strengths than those attained by using other surface treatment techniques [24]. As per a literature review conducted by Yankova et al in 2021, resilient lining materials showed lower tensile and shear strength values than strong acrylic resins [9]. The ability of resilient lining materials to adhere to poly methyl methacrylate is influenced by the type of polymerization used. Higher shear strength is demonstrated by cold-curing silicones cross-linked by heat, such as SilagimComfort and Ufi Gel P [25,26]. In 2023, Jayakrishnan et al investigated the tensile bond strength of 2 different denture liners that had been altered by the addition of antifungal agents. Their findings revealed that neither of these liner materials had significantly different tensile bond strengths when fluconazole antifungal agent had been added, but that there were significant changes when the miconazole antifungal agent was added to the denture base resin [27].

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]

Also, we demonstrated that for water absorption and solubility values, GC Reline showed the lowest water absorption, and the difference between these values and those of the other materials was statistically significant. The highest water absorption values were for Elite and Mucopren. GC Reline had the least soluble ingredients (0.3 µg/mm^3). Molloplast B had the highest, followed by Elite. The value of Mucopren was not statistically significant different from any of the 5 materials. This finding was similar to the study conducted by Chauhan et al in 2021, which demonstrated a greater percentage of solubility and absorption with an acrylic-based soft liner than with silicone-based liners. Also, there were notable variations in water absorption and hardness values of the resilient liner material; however, the water absorption values for the heat-cure acrylic, self-cure silicone, and self-cure acrylic products varied [6]. The results can have been affected by the polymerization mode, material chemistry, and composition. A similar result was found by Pahuja et al in 2020 in a systematic review comparing the water absorption, solubility, and tensile binding strength of 2 soft denture liners with different chemical compositions (silicone-based soft liner, LuciSof, and a plasticized acrylic resin soft liner, PermaSoft). LuciSof had greater therapeutic success due to decreased water absorption and solubility and higher tensile bond strength [21]. These results were also supported by Sudhapalli et al [28], who investigated the effect of varied denture cleanser exposure times on the absorption and solubility of 4 soft liners, namely long-term and short-term acrylic liners. They concluded that silicones outperformed acrylics in terms of overall performance. Long-term silicone denture liners proved to be most stable, whereas acrylic denture liners were most unstable in the short term. Iwasaki et al [14] investigated the impact of different immersion durations on the viscoelastic properties of soft denture liners in 37°C water. However, their findings yielded contradictory results. The viscoelastic characteristics of 2 acrylic resin and 6 silicone soft denture liners were measured, and the viscoelastic properties of 3 of 6 silicone-based liners did not significantly change following a 6-month immersion.

There are several limitations for this study. First, it was conducted in the laboratory; therefore, caution should be taken when applying and interpreting its results in the clinical situation. Second, to study the response of a denture soft lining material to deforming forces in the mouth, it would be appropriate to use dynamic cyclic forces to simulate mastication forces experienced in the clinic rather than a compression test, as was used in this study. The compression set test does not represent mastication forces due to the great energy input directed at the soft liner within long duration of load, which gives the material a poor recovery response compared with that of dynamic and cyclic behavior under mastication forces. In addition, this study had a limited sample size and was an in vitro rather than in vivo study. Further research is required to measure color stability, flexural strength, viscoelastic properties, and thermocyclic properties of soft liner denture materials.

Conclusions

Molloplast B was better in terms of tensile and shear bond strength, apart from Sofreliner. On the other hand, Molloplast B failed to show better tensile strength properties than GC Reliner and Mucopren, or better water absorption and solubility properties than any of the tested chairside denture soft lining materials. This means, under the limitation of this study, some chairside denture long-term soft lining materials, such as GC Reline, could have important properties that are comparable to those of Molloplast B.

Acknowledgments

We would like to express our gratitude to Robert Jagger for his assistance, guidance, and insightful advice during this endeavor.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

References:

1. Nakhaei M, Dashti H, Ahrari F, et al. Effect of different surface treatments and thermocycling on bond strength of a silicone-based denture liner to a denture base resin. J Contemp Dent Pract. 2016;17(2):154-59
2. Akin H, Tugut F, Mutaf B, Guney U. Investigation of bonding properties of denture bases to silicone-based soft denture liner immersed in isobutyl methacrylate and 2-hydroxyethyl methacrylate. J Adv Prosthodont. 2014;6(2):121-25
3. AlHamdan EM. Soft Denture liner and microbial disinfection with contemporary and conventional agents. Photodiagnosis Photodyn Ther. 2022;38:102768
4. Białożyt-Bujak E, Wyszyńska M, Chladek G, et al. Analysis of the hardness of soft relining materials for removable dentures. Int J Environ Res Public Health. 2021;18(18):9491
5. Brahmandabheri N, Duggineni C, Chitturi R, et al. Effect of surface treatments on the tensile bond strength of heat cure silicone soft liner to an acrylic resin denture base in a simulated oral environment – a comparative SEM study. J Dr NTR Univ Health Sci. 2022;11(1):57-63
6. Chauhan MS, Trivedi R, Singh PR, et al. Assessment of the water sorption and hardness of silicone and acrylic-based soft liners at different time period: An in vitro study. Int J Cur Res Rev. 2021;13(05):2
7. Azpiazu-Flores FX, Schricker SR, Seghi RR, et al. Adhesive strength of 3 long-term resilient liners to CAD-CAM denture base polymers and heat-polymerized polymethyl methacrylate with thermocycling. J Prosthet Dent. 2022 [Online ahead of print]

8. Choi JE, Ng TE, Leong CKY, et al. Adhesive evaluation of three types of resilient denture liners bonded to heat-polymerized, autopolymerized, or CAD-CAM acrylic resin denture bases. J Prosthet Dent. 2018;120(5):699-705
9. Yankova M, Peev T, Yordanov B. Basic problems with the use of resilient denture lining materials: Literature review. J IMAB. 2021;27(2):3723-30
10. Garcia RM, Léon BT, Oliveira VB, Del Bel Cury AA. Effect of a denture cleanser on weight, surface roughness, and tensile bond strength of two resilient denture liners. J Prosthet Dent. 2003;89(5):489-94
11. Kreve S, Dos Reis AC. Denture liners: A systematic review relative to adhesion and mechanical properties. ScientificWorldJournal. 2019;2019:6913080
12. Iwasaki N, Yamaki C, Takahashi H, et al. Effect of long-time immersion of soft denture liners in water on viscoelastic properties. Dent Mater J. 2017;36(5):584-89
13. Mese A, Guzel KG. Effect of storage duration on the hardness and tensile bond strength of silicone- and acrylic resin-based resilient denture liners to a processed denture base acrylic resin. J Prosthet Dent. 2008;99(2):153-59
14. Azpiazu-Flores FX, Schricker SR, Seghi RR, et al. Adhesive strength of 3 long-term resilient liners to CAD-CAM denture base polymers and heat-polymerized polymethyl methacrylate with thermocycling. J Prosthet Dent. 2022 [Online ahead of print]
15. Khan G, Roghani K, Muhammad N, et al. Advancements in polymeric denture lining materials. In Applications of Polymers in Surgery: Materials Research Forum LLC. 2022;175-94
16. Muddugangadhar BC, Mawani DP, Das A, Mukhopadhyay A. Bond strength of soft liners to denture base resins and the influence of different surface treatments and thermocycling: A systematic review. J Prosthet Dent. 2020;123(6):800-6.e6
17. Krishnappan PL, Jaiesh R, Swaminathan TN. Comparative evaluation of heat-polymerized and auto-Polymerized Soft Liners with Regard to Transverse Bond Strength, Peel Bond Strength and Water Sorption: An in vitro study. Int J Prosthodont. 2014;4(3):61-67
18. Kreve S, Dos Reis AC. Denture liners: A systematic review relative to adhesion and mechanical properties. ScientificWorldJournal. 2019;2019:6913080
19. Madan N, Datta K. Evaluation of tensile bond strength of heat cure and autopolymerizing silicone-based resilient denture liners before and after thermocycling. Indian J Dent Res. 2012;23(1):64-68
20. Faiza M. Evaluation of the effect of lemongrass essential oil on *Candida albicans* adhesion on heat cured acrylic based soft lining material. J Med Chem Sci. 2023(7):1684-95
21. Pahuja RK, Kaura S, Roy N. Comparative evaluation of physical properties of widely used silicone-based soft denture liners and acrylic-based soft denture liners. Indian J Dent Sci. 2020;12(1):56-61
22. Dutta DA, Nidawani DP, Singh DR, Poduval DS. Evaluate and compare the hardness and tensile bond strength of a silicone soft lining material, after short term immersion in two different denture cleansing solutions and water over varying time periods. Saudi J Oral Dent Res. 2023;8(3):110-15
23. Palla ES, Karaoglani E, Naka O, Anastassiadou V. Soft denture liners' effect on the masticatory function in patients wearing complete dentures: A systematic review. J Dent. 2015;43(12):1403-10
24. Almuraikhi T. Assessment of tensile bond strength of a soft liner to the denture base resin with different surface treatments: An in vitro study. J Contemp Dent Pract. 2022;23(6):613-17
25. Park SJ, Lee JS. Effect of surface treatment on shear bond strength of relining material and 3D-printed denture base. J Adv Prosthodont. 2022;14(4):262-72
26. Rajaganesh N, Sabarinathan S, Azhagarasan NS, et al. Comparative evaluation of shear bond strength of two different chairside soft liners to heat processed acrylic denture base resin: An in vitro study. J Pharm Bioallied Sci. 2016;8(Suppl. 1):S154-S59
27. Surapaneni H, Ariga P, Haribabu R, et al. Comparative evaluation of tensile bond strength between silicon soft liners and processed denture base resin conditioned by three modes of surface treatment: An invitro study. J Indian Prosthodont Soc. 2013;13(3):274-80
28. Sudhapalli S, Sudhapalli S. Time dependent effect of a denture cleanser on the sorption and solubility of four soft liners – an invitro study. J Clin Diagn Res. 2016;10(4):ZC100-3

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS]