Evaluation of some properties of four silicon based soft denture reliner materials

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ABSTRACT
Background: Lining materials have been widely used for prosthodontics rehabilitation. One unresolved problem is the easy adherence of Candida to these materials because roughness of a porous surface, inadequate adhesion of silicon to acrylic denture base is the most problem of the silicone soft liner material. Although silicone soft liner materials have more stability when compared with acrylic based type of soft liner material but they still show several disadvantages like the material have susceptibility to water absorbed of solvents and particular water and loss of soluble components and this lead to effect the strength of bond and change viscoelasticity of material. The purpose of this study was to compare among four silicone based soft liner materials (permaflex and Molloplast, Ufi Gel SC and permafix) in invitro investigations properties shear bond, water sorption and solubility and surface roughness test.

Materials and methods: Seventy two specimens of 4 silicon based soft lining material, 24 for each material, 6 for each test, the specimens of shear bond strength test were subjected to tension in instron machine with speed rate was 0.5 mm/minute to measure shear bond strength by N/mm. The surface roughness samples were measured by using profilometer device. The final test of this study was water sorption and solubility according to ADA specification No. 12 (1999) All data were collected and analyzed by ANOVA and LSD tests; the finding showed the permaflex had high shear bond strength followed by Molloplast, Permafix respectively and the least bond strength was for Ufi Gel.

Results: Surface roughness test showed the same mean value among most of the materials. For water sorption and solubility test the permaflex had the lowest value and followed by Molloplast and was not significant change between permafix and Ufi Gel SC.

Conclusions: indicated that permaflex shows better properties when compared with other soft liner materials and that hot cure polymerizing soft liner material showed proper properties when compared with auto polymerizing soft liner material.

Keywords: Denture liner, silicon based. (J Bagh Coll Dentistry 2011;23(36-42).

INTRODUCTION
The accuracy of denture fit is an important factor in the retention of denture. The base of the denture is largely responsible for providing the prosthesis with retention, stability and support by being closely adapted to the oral mucosa. However, the process of bone resorption is the irreversible and may lead to an inadequate fit of the prosthesis (1,2).

Relining is the procedure used to re-surface the tissue side of denture with a new base material, producing an accurate adaptation to the denture foundation area (3).

Relining materials were classified by McCabe JF1987 into:
1- Hard reline material.
2- Tissue conditioners.
3- Soft liners.

Soft or resilient liners were also classified by Philips; 1982 into plasticized acrylic resin and silicon Rubber, both of these liners can be found in self cured or laboratory processed liners.

The use of soft denture liners is an important adjunct in the treatment of complete and partial denture patient, particularly those who are medically compromised (3). The use of these materials act as a cushion for the denture bearing mucosa through absorption and redistribution of forces transmitted to the stress bearing area of the edentulous ridge, they are capable of restoring health to the inflamed mucosa (4).

Soft denture liners have several problems associated with their use such a loss of softness, water sorption, colonization of Candida Albicans and adhesion failure between liner and denture base, therefore, frequent clinical evaluation and periodic replacement of soft denture liner are needed. (5,3)

The denture base is defined as "The part of denture that rests on foundation tissues and to which teeth are attached. Acrylic plastic has been the most widely used and accepted among all denture base material and it is estimated that it represent 95% of the plastic in prosthodontics (6), because it meets most of the requirements for clinically acceptable denture base material (7).

Acrylic is composed of a chain of methacrylate molecules linked together to give polymethylmethacrylate (PMMA). As indicated
Denture reline is indicated when the denture still retains proper vertical dimension, centric occlusion relation ship and esthetic appeal. When the denture lacks one of these features in addition to compromised fit of the denture base, re- fabrication of the denture should be contemplated 8,14.

Relining material can be classified as:
1. Hard reline material
   A. Mouth - cured type
   B. processed type:
      I) Heat activated
      II) Chemically activated
      III) Light activated
2. Tissue conditioners
3. Soft denture liners
   A. Plasticized acrylic type
   B. Silicones type

Soft denture liners
Soft denture liner materials have been used in dentistry for more than a century, with the earliest soft liners being natural rubbers 10.

The ISO in 1999 defined soft denture lining material as a soft resilient material bonded to the fitting surface of a denture to reduce trauma to the supporting tissues. Soft liners are used when patient can not tolerate the hard denture base and also used to improve retention of an ill fitting denture, they can absorb the impact force during mastication, and disperse the mastication force widely over the alveolar ridge by interposing between the denture and mucosa 5,16.

These materials are able to compensate the reduced thickness of mucosal tissue and reduce the stresses directed to the basal seat area 17.

Many kinds of materials have been introduced to the dental profession such as plasticized acrylic, vinyl polymers and copolymers, fluoroelastomer, silicon rubber and natural rubber 1,18.

Types of soft denture liners
Acrylic based denture soft liners, chemically activated soft liners, Heat activated soft liners, Hydrophilic soft denture liners Silicon soft
denture liners
Disadvantages of soft lining materials
1- Bonding failure
2- Loss of resiliency and softness
3- Debris accumulation and candida albicans growth
4- Weakening of the denture

MATERIALS AND METHODS
The materials were used in this study are listed as follows: Permanent soft liners:

Four permanent soft denture lining materials were used in the study: Ufi Gel SC (room temperature curing silicon), permaflx kohler (cold cure silicon) Molloplast B (heat cure silicone), and permaflex® (heat cure silicone). They are silicones based chemical structure with different curing methods. They were evaluated for: (figure 2)

1. Shear bond strength and.
2. Roughness surface test.
3. Water sorption and solubility.

Shear bond Strength
Twenty Four specimens were prepared for shear bond strength, six specimens for each group.

Each specimen consists of two heat-cured acrylic blocks with dimensions of (3 inch*l inch*3 6 inch length, width, depth respectively) with stopper of depth about 3 mm 17.

One block of acrylic was put over the other block leaving a space between them of dimensions (1 inch*l inch *3 mm length, width, depth respectively). The thickness of the handle of acrylic specimen is 5 mm, this thickness is important to have good clamping of the specimen by Instron machine and the force was directed parallel to each other.

A. Preparation of acrylic specimen
Metal plate patterns were constructed with dimension of 3*1*3/16 Inch (length, width, depth) respectively. The metal plates were coated with separating medium and allowed to dry then invested in the lower portion of denture flask that was filled with dental stone mixed according to manufacture instruction, P/L ratio 100 g/30ml, after setting of stone, both stone and metal pattern were coated with separating medium (cold mould seal), then the upper half of flask was positioned properly, and filled with stone mixture under vibration allowing for the air bubbles to rise up. The flask was well covered and left for stone setting, after an hour the flask was opened and the standard specimens was drawn out.

B. Final Specimens Preparation
The block of the metal plate pair was invested
in heavy but flexible silicone impression material. The block with the silicon mould was invested in freshly mixed dental stone poured in the lower half of giant flask. Investing steps were followed as previously mentioned (2.3.2.1. c). After setting of the stone, the flask was opened and the metal block was removed leaving space, one of matching pairs of prepared resin plate were fit back into the silicon mold where then soft liner was put as will be mentioned later on the surface that was prepared for and then conditioning the other matching pair on it covering the flask for packing of soft liner to produce final specimen.

1- Preparation of acrylic specimens

Several brass patterns were constructed in a form of disc with fifteen mm diameter and four mm thickness Figure (3)

The brass patterns were coated with separating medium and allowed to dry. The lower portion of the dental flask was then filled with dental stone (mixed according to the manufacture instructions), and the patterns were invested into the stone mixture, they were inserted to one half of their depth. After setting; both the stone and the brass surfaces were coated with separating medium. The upper half of the flask was then opened, the brass patterns were removed, and the two halves of the mould were coated with separating medium to be ready for packing the acrylic.

RESULTS

Shear Bond Test

Figure 4 showed the mean and standard deviation (SD) values shear \( \rho \) bond strength for each liner material data for easier comparisons, the highest mean value of shear bond strength were shown for permaflex (0.402 N/mm\(^2\)), followed by Molloplast B (0.375 n/mm\(^2\)) then permafix (0.328 n/mm ) and the lowest mean value for shear bond strength were shown for Ufi Gel SC (0.300 N/mm\(^2\)).

One way analysis of variance (ANOVA) for shear bond strength showed in Table (1) the highly significant differences among the liner materials (P value \( \leq 0.01 \)) so the least significant difference "LSD" of multiple comparison test for shear bond strength of soft liner material at Table (3.3) showed:

a) Significant difference between permaflex and Molloplast \( (p<0.05) \)

b) Highly significant \( (p<0.01) \) between (permafix and Ufi Gel SC, permaflex and permafix, permafix and JVlolloplast, Ufi Gel SC and permaflex and finally between Ufi Gel SC and Molloplast).

Sorption Test

The approach used in this study, was according to ADA specification which is calculated in mg/cm\(^2\).

Table 2 and Figure 5 showed the mean value and standard deviation for sorption test of liner material.

The lowest water sorption mean value was shown for permaflex (0.2208 mg/cm\(^2\)) followed by Molloplast B (0.2628 mg/cm\(^2\)) and then by permafix (0.3157 mg/cm\(^2\)) and the highest value for Ufi Gel SC (0.3554 mg/cm\(^2\)).

The ANOVA test at Table (2) showed the F value equal to 16.417 and there was highly significant difference among groups \( (p<0.01) \).

At Table (3), the LSD test the least significant difference for sorption test between liner material showed that there is highly significant difference \( (p<0.01) \) \( (p=0.00) \) between permafix and permaflex, Ufi Gel SC and Molloplast, and finally between Ufi Gel SC and permaflex. There is no significant difference \( (p>0.05) \) between Ufi Gel SC and permaflex \( (p=0.068) \).

Finally there was significant difference between permafix and Molloplast \( (p=0.05) \) and between Molloplast B and permafix \( (p=0.044) \), \( (p<0.05) \).

DISCUSSION

Soft denture reline materials have been used in dentistry for more than a century; these materials play an important role in modern prosthodontics, many of these materials have been used with varying levels of success, but limitations were existed including volumetric changes, abrasion, color instability and water sorption and solubility besides the problem of adhesion.

A desirable objective of these materials is the low sorption and solubility, high bond strength to underline denture base and low surface roughness \(^{(10)}\).

In present study, four commercial brands of silicon resilient liner were compared for their bond strength to heat polymerized acrylic resin, their water sorption and stability and finally their surface roughness.

Shear Bond Strength Test

Shear bond test is considered as appropriate method for testing bond strength of lining material since the forces that lining material is clinically exposed to, are more closely related to shear.

It is important to measure adhesion bond instead of cohesions strength of resilient liner to assess interfacial separation under oral condition,
otherwise, cohesive rupture of resilient liner give as only limited information on strength of liner material (1).

As result obtained by the study tables (1) showed that there was significant differences in mean values of shear bond strength among the liner material.

Permaflex ® showed highest bond strength, this thought is, that Permaflex based on a new co-polyester poly (butylenes succinate-co-ethylenesuccinate-co-ethyleneterphthalate), (PBEST) the incorporation of such terphthalate aromatic rings into polymer chain improve bonding because this co polyester contain two ester functioning group at Para position (JiiigMfO/4rt5), the acrylic denture base also contains ester group. This make the interaction between these two similar groups is more available. Terephthalate this type of material does not require an adhesive when it is cured in conjunction with an acrylic denture base material, this material actually is silicone co-polyester that contain component capable of bonding to acrylic resin.

Although permaflex and Molloplast are heat cured materials, they had different polymerization periods; permaflex was processed for 2 hours in boiling water while Molloplast was processed for 11/2 hours in boiling water following the manufacture's directions. This is different period of processing and different pressure applied resulted in amore complete polymerization reaction combined with permaflex and this might be lead to improve bonding.

Molloplast had high value shear bond strength when compared to other two material, Molloplast b are PDMS bearing vinyl end group (as Figure (4), the adhesive supplied with Molloplast B, is 3-methacryloxy propyl trimethoxy silane that used to increase interfacial strength between fiber and resin.

The methacrylate end of the adhesive was bound chemically to PMMA resin (denture base material) while the silicone end with soft lining material. As such, there would be both addition reactions through vinyl group as well as physical forces between similar groups (methacrylates).

Also the results showed that the permafix had higher shear bond when compared with Ufi Gel SC. although this, materials are cold cure silicon, hydroxyl terminated but there are different in filler and additive composition and amount that reflect this difference.

Table (4) showed that hot cure silicon had high shear bond strength / where was compared with cold cure silicon materials and this might be due to higher degree of polymerization with slower rate of it could be achieved with heat polymerization resin, so enough time is available for the monomer to attack material and better bond is gained .this is agreed with Amin et al. (12).

Because of vesicoelastic proprieties of these materials so with heat and pressure the flowing of these materials increased leading to flow of material inside rough surface of acrylic denture base and increase the mechanical adhesion.

Surface Roughness

The surface roughness is measured of finer surface irregularities in surface texture. Ra: is rated as arithmetic average deviation of surface valleys and peaks expressed in micro mter or micro inches.

Anon significant difference in surface roughness among (permaflex, Molloplast, permafix) were noticed (Table5), highly significant difference was showed with Ufigelsc and other material and this might due To that ufigelsc was processed at room temperature, mixing and loading might lead to in complete polymerization of material that lead to formation of micro pocket within structure, and this might lead to high surface roughness.

The present of monomer and impurities within structure of Ufigelsc might contributed to this value of Ra of ufigelsc and finally this might due to different size particles of polymer powder of these silicones material

Water sorption and solubility

The approached that was used in this study was according to ADA specification which was calculated in mg cm.

Tables (6) Fig (5, 6) showed that permaflex had a lower value for water sorption and solubility might due to incorporation of stable aromatic benzene ring into polymer chain that give polymer an additional stability.

Molloplast B had low water sorption and solubility when was compared with permafix and Ufi Gel SC and this because the material is vinyl terminated that had low polarity towered water. Pure Silicon has very low water absorption, it has been suggested that filler present in these materials are responsible for water absorption characteristic (Anusavice, 1996 and Bradin, 1983). the improved bonding of filler to resin occur by acryloxyalkyl sialin as showed by (Wright, 1981) and due to complete polymerization of these material and cross linking by mode of polymerization lead to less unreacted monomer and impurities, more dense material, therefore less water absorption and less material leached out to soluble.
Permafix and Ufi Gel SC are silicone-hydroxyl terminated so this material has polarity towered water because of some intermolecular interaction (like dissolved like) (Sileberg 1982), therefore, lead to more water sorption and solubility. The cold curing silicone (Permafix and Ufi Gel SC) showed higher water sorption and solubility when compared with hot curing silicone material, this might due to that this material processed at room temperature, the process of mixing and loading may leave micro pocket within structure of material besides the intermolecular spaces present within structure of material, into which the water may be absorbed. Also this material are like silicone type impression material that cross linked with condensation reaction that by products material may be produced that have low molecular weight which lead to more solubility of this material.

REFERENCES
Table 1: Mean distribution of shear bond strength (N/mm²) among studied groups.

<table>
<thead>
<tr>
<th>Studied groups</th>
<th>No.</th>
<th>Mean (N/mm²)</th>
<th>S. D</th>
<th>S.E</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ufi Gel SC</td>
<td>6</td>
<td>0.300</td>
<td>0.0288</td>
<td>0.0117</td>
<td>0.2480</td>
<td>0.3216</td>
</tr>
<tr>
<td>Permafix</td>
<td>6</td>
<td>0.328</td>
<td>0.0110</td>
<td>0.0044</td>
<td>0.3200</td>
<td>0.3480</td>
</tr>
<tr>
<td>Molloplast B</td>
<td>6</td>
<td>0.375</td>
<td>0.0081</td>
<td>0.0033</td>
<td>0.3680</td>
<td>0.3856</td>
</tr>
<tr>
<td>Permaflex</td>
<td>6</td>
<td>0.402</td>
<td>0.0072</td>
<td>0.0029</td>
<td>0.3928</td>
<td>0.4080</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

Table 2: The ANOVA test for sorption test between and within studied groups.

<table>
<thead>
<tr>
<th>ANOVA Test</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>P-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>0.0627</td>
<td>3</td>
<td>0.0209</td>
<td>16.417</td>
<td>0.00</td>
<td>Highly sig. (P≤0.01)</td>
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<tr>
<td>Within Groups</td>
<td>0.0254</td>
<td>20</td>
<td>0.0012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.0882</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 3: Mean distribution of sorption test among studied groups.

<table>
<thead>
<tr>
<th>Studied groups</th>
<th>No.</th>
<th>Mean (N/mm²)</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ufi Gel SC</td>
<td>6</td>
<td>0.3554</td>
<td>0.0506</td>
<td>0.0206</td>
<td>0.2906</td>
<td>0.4210</td>
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<tr>
<td>Permafix</td>
<td>6</td>
<td>0.3157</td>
<td>0.0103</td>
<td>0.0042</td>
<td>0.3045</td>
<td>0.3309</td>
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<tr>
<td>Molloplast B</td>
<td>6</td>
<td>0.2628</td>
<td>0.0395</td>
<td>0.0161</td>
<td>0.2201</td>
<td>0.3260</td>
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<tr>
<td>Permaflex</td>
<td>6</td>
<td>0.2208</td>
<td>0.0294</td>
<td>0.0120</td>
<td>0.1896</td>
<td>0.2630</td>
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<tr>
<td>Total</td>
<td>24</td>
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</table>

Table 4: The ANOVA test for shear bond strength between and within studied groups.

<table>
<thead>
<tr>
<th>ANOVA Test</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>P-value</th>
<th>Sig.</th>
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<tbody>
<tr>
<td>Between Groups</td>
<td>0.0377</td>
<td>3</td>
<td>0.0125</td>
<td>46.774</td>
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<td>Highly sig. (P≤0.01)</td>
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<td>Within Groups</td>
<td>0.0053</td>
<td>20</td>
<td>0.0002</td>
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<tr>
<td>Total</td>
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Table 5: The least significant difference (LSD) of multiple comparison test for surface roughness between studied groups.

<table>
<thead>
<tr>
<th>Multiple groups</th>
<th>P-value</th>
<th>LSD (F-test)</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permafix</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ufi Gel SC</td>
<td>0.00</td>
<td>Highly Sig.</td>
<td>(P&lt;0.01)</td>
</tr>
<tr>
<td>Molloplast B</td>
<td>0.883</td>
<td>Non Sig.</td>
<td>(P&gt;0.05)</td>
</tr>
<tr>
<td>Permaflex</td>
<td>0.174</td>
<td>Non Sig.</td>
<td>(P&gt;0.05)</td>
</tr>
<tr>
<td>Ufi Gel SC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molloplast B</td>
<td>0.00</td>
<td>Highly Sig.</td>
<td>(P&lt;0.01)</td>
</tr>
<tr>
<td>Permaflex</td>
<td>0.00</td>
<td>Highly Sig.</td>
<td>(P&lt;0.01)</td>
</tr>
<tr>
<td>Molloplast B</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Permaflex</td>
<td>0.221</td>
<td>Non Sig.</td>
<td>(P&gt;0.05)</td>
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Table 6: The ANOVA test for solubility test between and within the groups.

<table>
<thead>
<tr>
<th>ANOVA test</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Within the group studied groups.</th>
<th>P-value</th>
<th>Sig.</th>
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<tbody>
<tr>
<td>Between Groups</td>
<td>0.0873</td>
<td>3</td>
<td>0.0291</td>
<td>23.417</td>
<td>Highly Sig.</td>
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<tr>
<td>Within Groups</td>
<td>0.0248</td>
<td>20</td>
<td>0.0012</td>
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</tr>
<tr>
<td>Total</td>
<td>0.112</td>
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