

# A comparative evaluation of effect on water sorption and solubility of a temporary soft denture liner material when stored either in distilled water, 5.25% sodium hypochlorite or artificial saliva: An *in vitro* study

Aditi Garg, K. Kamalakanth Shenoy<sup>1</sup>

Department of Prosthodontics, Inderprastha Dental College, Sahibabad, Uttar Pradesh, <sup>1</sup>Department of Prosthodontics, Yenepoya Dental College, Mangalore, Karnataka, India

## Abstract

**Introduction:** Soft denture liners have a key role in modern removable prosthodontics since they restore health to inflamed and abused mucosa by redistribution of forces transmitted to the edentulous ridges. The most common problems encountered using soft denture liners are water sorption and solubility when in contact with saliva or storage media. These problems are associated with swelling, distortion, support of *Candida albicans* growth, and stresses at the liner/denture base interface that reduces the bond strength.

**Objective:** To evaluate the water sorption and solubility of commercially available acrylic based self cure soft denture lining material (GC RELINE™ Tissue Conditioner) after immersion in three different storage media (distilled water, Shellis artificial saliva, 5.25% sodium hypochlorite disinfectant solution) at time interval of 4, 7, 11, and 15 days.

**Material and Methods:** The study involved preparation of artificial saliva using Shellis formula. A total 45 standardized samples of the material (GC RELINE™) were prepared in disk form (15 mm in diameter and 2 mm in thickness). The study was divided into three groups with storage in Control (distilled water), Shellis artificial saliva, and 5.25% sodium hypochlorite. Samples were dried in a desiccator and weighed in the analytical balance to measure the initial weight (mg/cm<sup>2</sup>) of the disks (W1). The first groups (15 samples) were placed in 30 ml distilled water (Group A) at 37°C, second group 30 ml of artificial saliva (Group B) and third group in 5.25% sodium hypochlorite (Group C). Disks were removed from disinfectant after 5 min and placed in 30 ml distilled water. On days 4, 7, 11, and 15, all samples were removed from their containers and reweighed to measure the weight (mg/cm<sup>2</sup>) of the disks after sorption (W2). The solubility was measured by placing the disks back in the desiccator after each sorption cycle and drying them to constant weight in the desiccator. These values were weight after desiccation

Contd...

### Address for correspondence:

Dr. Aditi Garg, Department of Prosthodontics, Inderprastha Dental College, Sahibabad, Uttar Pradesh, India. Email: [gaditi82@gmail.com](mailto:gaditi82@gmail.com)

Received: 9<sup>th</sup> January, 2015, Accepted: 30<sup>th</sup> August, 2015,

Access this article online	
Quick Response Code:	Website: <a href="http://www.j-ips.org">www.j-ips.org</a>
	DOI: 10.4103/0972-4052.167931

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: [reprints@medknow.com](mailto:reprints@medknow.com)

**How to cite this article:** Garg A, Shenoy KK. A comparative evaluation of effect on water sorption and solubility of a temporary soft denture liner material when stored either in distilled water, 5.25% sodium hypochlorite or artificial saliva: An *in vitro* study. J Indian Prosthodont Soc 2016;16:53-62.

(W3). Water sorption and solubility was calculated: 1. Sorption (mg/cm<sup>2</sup>) = (W2–W1)/Surface area 2. Solubility (mg/cm<sup>2</sup>) = (W1–W3)/Surface area.

**Statistical Analysis:** Statistical Analysis was done using one way analysis of variance and the intercomparison between each group was done using Tukey's honestly significance difference (HSD) test.

**Results:** Within the limitations of this study it was concluded that water sorption of the GC RELINE™ soft denture liner material was highest in distilled water followed by 5.25% sodium hypochlorite and least in Shellis artificial saliva at 4, 7, and 11 day interval. However, on the 15th day, the results showed maximum water sorption in 5.25% sodium hypochlorite followed by distilled water and least in artificial saliva. The results on solubility showed highest solubility of GC RELINE soft denture liner in artificial saliva followed by distilled water and least in 5.25% sodium hypochlorite at 4, 7, 11, and 15 day interval.

**Discussion:** The least water uptake of the soft liner in artificial saliva was due to its ionic properties and supports the theory that water uptake of these materials is osmotically driven. However, the solubility was highest in artificial saliva since it is a mix of various salts and other additives, so there is a possibility of interaction with soft denture lining material.

**Key Words:** Artificial saliva, soft denture liners, solubility, water sorption

## INTRODUCTION

The success of removable complete or partial denture depends on esthetics, comfort, and function. In an edentulous individual with a complete or a partial denture prosthesis the masticatory load and functional stresses are transmitted to the bone through mucoperiosteum. These functional stresses lead to chronic soreness, pathologic changes to oral tissues, and subsequent bone loss resulting in loss of accurate adaptation of the denture to the underlying tissues.<sup>[1]</sup>

Soft denture liners are often used for management of these problems by acting as a cushion, thereby reducing the impact force in the load bearing areas of the supporting structures during the function.<sup>[2,3]</sup>

However, these soft liners exhibit multiple clinical failures characterized by loss of adhesion to denture base, surface, and/or bulk deterioration, accumulation of debris and plaque, loss of resilience and fungal or microbial accumulation.<sup>[4-6]</sup> Many of these problems result from the increased water sorption and solubility when dentures are soaked in saliva during use or kept in water or aqueous disinfecting solution during storage.<sup>[7]</sup>

The purpose of this study is to evaluate the effect of three different storage media on water sorption and solubility of acrylic based self cure soft denture lining material.

### Aim

The aim of this study is to evaluate the water sorption and solubility of acrylic based self cure soft denture liner material when stored in three different media, namely: Distilled water,

Shellis artificial saliva, and 5.25% sodium hypochlorite at an interval of 4, 7, 11, and 15 days. This is in accordance with specification by Council on Dental Materials and Devices as mentioned in revised American Dental Association (ADA) Specification No. 12 denture base polymers.

## METHODOLOGY

**The materials used in this study include**

1. GC Reline Tissue Conditioner (GC Corp, Tokyo, Japan), Lot No. 0612053
2. Distilled water
3. 5.25% Sodium hypochlorite
4. Artificial saliva (Shellis artificial saliva)
5. Standardized three piece brass mold for fabrication of 15 mm × 2 mm disks of acrylic based soft denture liner
6. Desiccator containing silica gel maintained at room temperature for conditioning of specimens
7. Kemi™ Magnetic Stirrer for preparation of Shellis artificial saliva
8. Contech™ Electronic Precision Balance for preparation of artificial saliva
9. Oriental™ Electronic Precision Balance for weighing the soft liner specimens
10. Elico™ pH Meter for maintaining the pH of Shellis artificial saliva
11. Rotek™ Incubator for maintaining the specimens at room temperature
12. Filter paper.

**The methodology followed in this study was**

1. Preparation of Shellis artificial saliva using Shellis formula.

2. Preparation of 45 acrylic based soft denture liner disks using acrylic based soft denture lining material (GC RELINE™ TISSUE CONDITIONER (GC CORP)).
3. Numbering of the specimens
4. Initial weighing of the specimens after placing them in a desiccator containing silica gel.
5. Storage of acrylic based soft denture liner disks (15 in each group) in three different media. Following were the three sample groups with different storage media:
  - Group A (15 disks): Storage in distilled water
  - Group B (15 disks): Storage in Shellis artificial saliva
  - Group C (15 disks): Storage in 5.25% Sodium hypochlorite
6. Periodic weighing of samples after 4, 7, 11, 15 days using Oriental™ Electronic Precision Balance
7. Conditioning of specimens in desiccator containing silica gel
8. Weighing of samples after conditioning
9. Calculation of water sorption and solubility after time interval of 4, 7, 11, and 15 days.

#### Preparation of Shellis artificial saliva using Shellis formula

The artificial saliva used in this study was prepared with the chemical formula given by Shellis<sup>[8]</sup> [Table I]. The components were weighed using an Electronic Precision Balance (Contech™ Precision Balance, Figure 1a) and mixed with a magnetic stirrer (Kemi™ magnetic stirrer, Figure 1b) by adding distilled water. The pH was maintained at 6.8 by using pH Meter (Elico™ pH Meter, Figure 1c) as described by Shellis.

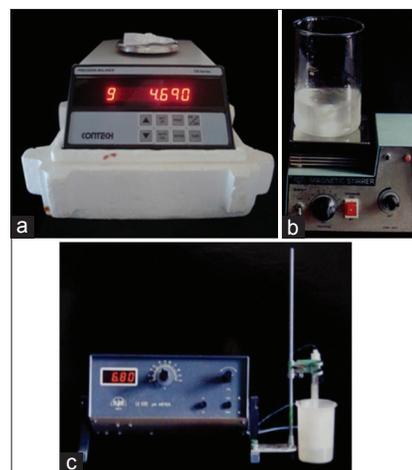
#### Preparation of acrylic based soft denture liner disks using acrylic based soft denture lining material

The study required 45 acrylic based soft denture liner disks, of dimensions 15 mm × 2 mm. A customized three piece brass mold, of dimensions 65 mm × 40 mm × 6 mm was fabricated, which contained six mold spaces of 15 mm × 2 mm separated from each other by distance of 2 mm in length and 5 mm in breadth, corresponding to the dimensions of acrylic based soft denture liner disks. Four screws were placed at the corners of the mold, which helped in assembling the three pieces [Figure 2a and b]. This customized mold helps in the fabrication of six acrylic based soft denture liner disks of dimension 15 mm × 2 mm [Figure 2c and d].

The inner surface of the customized mold was coated with a thin layer of petroleum jelly, to aid in easy removal of acrylic based soft denture liner disks. Acrylic based soft denture liner (GC RELINE™ Tissue Conditioner) was mixed in the ratio of 2.2/1.8 g by weight (first graduation on powder measure to four graduations of the liquid syringe by volume). Measures of both powder and liquid were poured into glass jar

**Table 1: Composition of artificial saliva<sup>[8]</sup>**

Constituent (inorganic)	Concentration (mg/l)
Ammonium chloride	233
Calcium chloride, dehydrate	210
Magnesium chloride, hexahydrate	43
Potassium chloride	1162
Potassium dihydrogen orthophosphate	354
Potassium thiocyanate	222
Sodium citrate	13
Sodium hydrogen carbonate	535
Disodium hydrogen orthophosphate	375
pH	6.8



**Figure 1:** (a) Contech™ Precision Balance. (b) Magnetic stirrer showing the preparation of Shellis artificial saliva. (c) pH Meter showing the pH of Shellis artificial saliva

and mixed for 30 s. After mixing it was packed into the spaces in the customized mold.

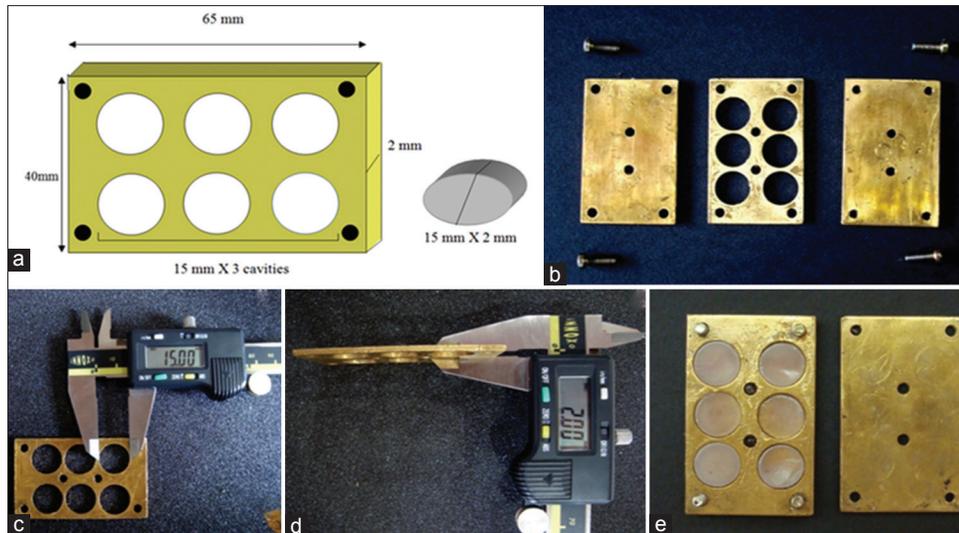
The intermittent pressure was used to close this mold in a bench press, and the screws were tightened. The customized mold was then transferred to a clamp and was allowed to cure for 5 min, according to manufacturer's instructions. Then it was immersed in a bowl of cold water for the polymerization of self cure acrylic based soft denture liner.

After polymerization, the customized mold opened, polymerized acrylic based soft denture liner disks were retrieved [Figure 2e]. Any excess material was removed, and the disks were polished with a GC RELINE™ Finishing Wheel using a speed of <6000 RPM.

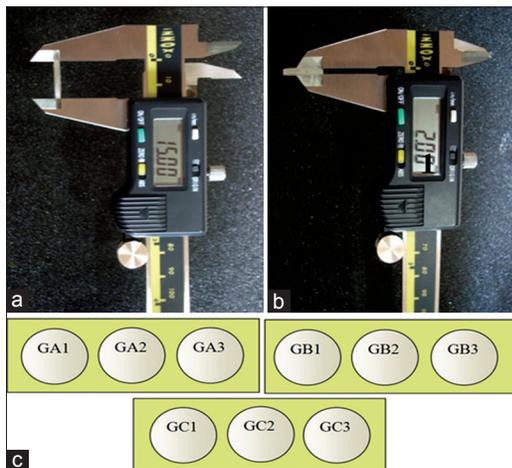
A total set of 45 acrylic based soft denture liner disks of dimensions 15 mm × 2 mm were prepared in above manner [Figure 3a and b].

#### Numbering of the specimens

The retrieved specimens were numbered using a permanent marker in three digits code [Figure 3c]:



**Figure 2:** (a) Schematic diagram of customized brass mold and recommended size of the sample. (b) Customized three piece brass mold. (c) Diameter of the customized brass socket. (d) Thickness of the customized brass socket. (e) Self cured denture liner samples within the mold after polymerization



**Figure 3:** (a) Diameter of the specimen. (b) Thickness of the specimen. (c) Schematic diagram showing numbering of the specimen

- First digit denoted acrylic based denture soft lining material product- GC RELINE™ Tissue Conditioner
- Second digit denoted the group to which the specimens belonged
- Third digit denoted the specimen number.

#### Initial weighing of the specimens after placing them in desiccator containing silica gel

All of the 45 soft denture liner disks were then dried in the desiccator containing silica gel at room temperature [Figure 4a and b] and weighed daily to an accuracy of 0.001 g using an Oriental™ Electronic Precision Balance [Figure 4c]. Disks were reweighed at regular intervals of 12 h, until constant weight was achieved. All disks were found to be stable after 48 h. This was considered as the initial weight of the disks (WI).

#### Storage of acrylic based soft denture liner disks in three different media

##### Group A: Storage in distilled water

Group A contained 15 acrylic based soft denture liner disks. After initial weighing, they were immersed in 30 mL distilled water at 37°C in sealed polyethylene containers. The container was then stored in Rotek™ incubator at 37°C ± 1°C [Figure 4d].

##### Group B: Storage in Shellis artificial saliva

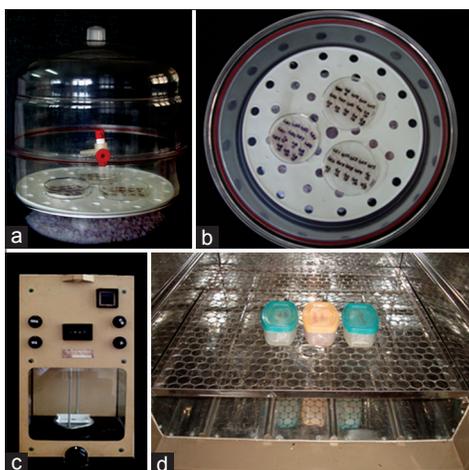
Group B contained 15 acrylic based soft denture liner disks. After initial weighing, they were immersed in 30 mL Shellis artificial saliva at 37°C in sealed polyethylene containers. The container was then stored in Rotek™ incubator at 37°C ± 1°C [Figure 4d].

##### Group C: Storage in 5.25% sodium hypochlorite

Group C contained 15 acrylic based soft denture liner disks. After initial weighing, they were immersed in 30 mL 5.25% sodium hypochlorite for recommended time of 5 min. After 5 min, the disks are removed using tweezers and disinfectant was blotted dry using filter paper. The disks were then placed in 30 mL distilled water at 37°C in sealed polyethylene containers. The container was then stored in Rotek™ incubator at 37°C ± 1°C [Figure 4d].

#### Periodic weighing of samples after 4, 7, 11, and 15 days using Oriental™ electronic precision balance

After storage, on the days 4, 7, 11, and 15 (Recommended experimental protocol to study denture reline materials) following procedures were undertaken:



**Figure 4:** (a and b) Desiccator showing specimens being conditioned for the test. (c) Oriental™ Electronic Weighing Balance with the specimens being weighed. (d) Self cure soft liner samples in three storage media: Distilled water, Shellis artificial saliva, 5.25% sodium hypochlorite kept in incubator

All disks were removed from their containers with the help of tweezers. The disks were blotted dry by using filter paper till no free moisture was visible on the surface.

1. The disks were reweighed using Oriental™ Electronic Precision Balance
2. These values were considered as the weight of the acrylic based soft denture liner disks after absorption (W2).

This procedure was repeated after time interval of 4, 7, 11, and 15 days.

### Conditioning of specimens in desiccator containing silica gel

After each sorption cycle that is, after 4, 7, 11, and 15 days, following procedures were undertaken:

- All the denture liner disks were removed from distilled water, 5.25% sodium hypochlorite, Shellis artificial saliva
- Disks were blotted dry with filter paper and after weighing for sorption, were placed in the desiccator containing the silica gel for measuring the amount of soluble material loss.

### Weighing of samples after conditioning

All the three groups of denture liner disks were placed separately in a desiccator containing silica gel at room temperature and weighed daily to an accuracy of 0.001 g using an Oriental™ Electronic Precision Balance. Disks were reweighed at regular intervals of 12 h, until constant weight was achieved. This was the initial weight after desiccation (W3).

### Calculation of water sorption and solubility after time interval of 4, 7, 11, and 15 days

Water sorption and solubility of commercially available acrylic based soft denture relining material (GC RELINE™ Tissue Conditioner) was measured after storing in three different

storage media (distilled water, 5.25% sodium hypochlorite, Shellis artificial saliva) for 4, 7, 11, and 15 days.

Relative solubility and water sorption were determined according to the ADA specification No. 12 for denture base polymers in mg/cm<sup>2</sup>.

### Water sorption

Water sorption (mg/cm<sup>2</sup>) = (W2–W1)/Surface area

W2: Weight after absorption

W1: Initial weight.

### Solubility

Solubility (mg/cm<sup>2</sup>) = (W1–W3)/Surface area

W3: Weight after desiccation

W1: Initial weight

Surface area:  $2\pi r(h + r)$

r: Radius of the acrylic based soft denture liner disk

h: Thickness of the acrylic based soft denture liner disk.

## RESULTS

The water sorption and water solubility values obtained from various groups were tabulated and analyzed for statistical significance. The mean between three groups were compared using one way analysis of variance and the intercomparison between each group was done using Tukey's honestly significance difference (HSD) test.

"P" values:

- $P < 0.05$  – Significant
- $P < 0.005$  – Highly significant
- $P < 0.0005$  – Very highly significant
- $P > 0.05$  – Nonsignificant.

The results were analyzed using software package SPSS "version 7.0." (IBM Corporation, Newyork, United States).

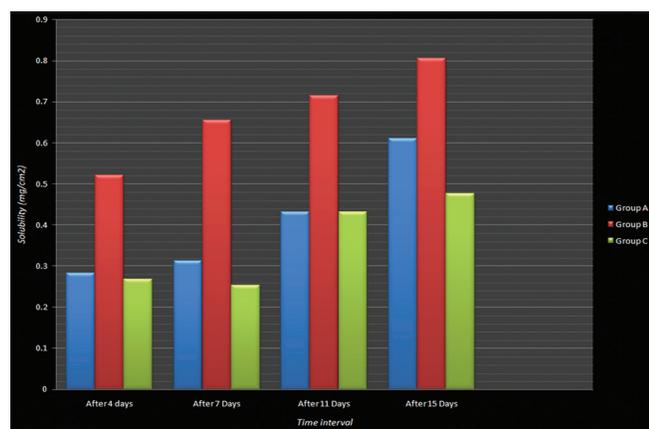
The result of this comparative study indicate that the solubility of the GC RELINE soft denture liner was highest in artificial saliva (Group B) followed by distilled water (Group A) and least in 5.25% sodium hypochlorite (Group C) at 4, 7, 11, and 15 day interval [Table 2, Figure 5].

The comparative evaluation on water sorption showed highest sorption of the GC RELINE™ soft denture liner material in distilled water (Group A) followed by 5.25% sodium hypochlorite (Group C) and least in Shellis artificial saliva (Group B) at 4, 7, 11 day interval. However, on the 15<sup>th</sup> day, the results showed maximum water sorption in 5.25% sodium hypochlorite followed by distilled water and least in artificial saliva [Table 3, Figure 6].

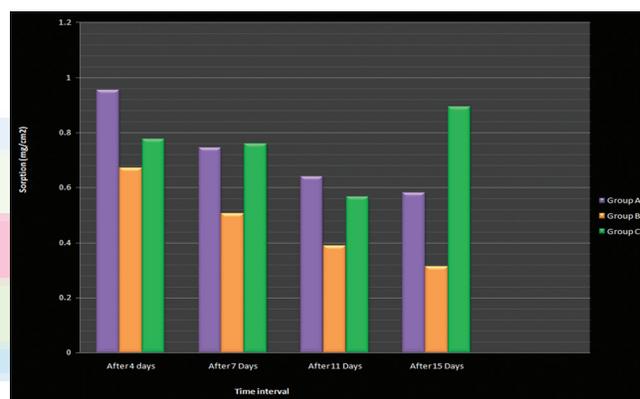
**Table 2: Comparison of water solubility of specimens of acrylic based denture soft lining material - GC RELINE at time interval of 4, 7, 11, and 15 days between group A, B and C**

	<i>n</i>	Mean	SD	Minimum	Maximum	<i>F</i>	<i>P</i>
Solubility after 4 days							
Group A	15	0.28347	0.102076	0.224	0.447	20.096	<0.0005
Group B	15	0.52173	0.161988	0.224	0.895		
Group C	15	0.26860	0.092331	0.224	0.447		
Total	45	0.35793	0.167734	0.224	0.895		
Solubility after 7 days							
Group A	15	0.31320	0.113082	0.224	0.447	48.460	<0.0005
Group B	15	0.65607	0.157636	0.447	0.895		
Group C	15	0.25373	0.078466	0.224	0.447		
Total	45	0.40767	0.214685	0.224	0.895		
Solubility after 11 days							
Group A	15	0.43227	0.132633	0.224	0.671	23.666	<0.0005
Group B	15	0.71580	0.125577	0.447	0.895		
Group C	15	0.43227	0.132633	0.224	0.671		
Total	45	0.52678	0.185696	0.224	0.895		
Solubility after 15 days							
Group A	15	0.61127	0.157636	0.447	0.895	21.057	<0.0005
Group B	15	0.80540	0.141670	0.447	0.895		
Group C	15	0.47687	0.115673	0.447	0.895		

SD: Standard deviation



**Figure 5:** Comparison of mean water solubility between distilled water (Group A), Shellis artificial saliva (Group B) and 5.25% sodium hypochlorite (Group C) at 4, 7, 11, and 15 day interval



**Figure 6:** Comparison of mean water sorption between distilled water (Group A), Shellis artificial saliva (Group B) and 5.25% sodium hypochlorite (Group C) at 4, 7, 11, and 15 day interval

## DISCUSSION

Long-term use of the complete or partial denture prosthesis leads to soreness, pathological changes in the oral tissues, with associated bone loss, due to the functional stresses resulting in the loss of accurate adaptation of the prosthesis to the underlying tissues.<sup>[1]</sup>

Relining the complete or partial dentures is a method by which the lifespan of the prosthesis may be prolonged since both biological supporting tissues and materials in denture fabrication are vulnerable to time dependent changes. Lining materials are used to regain the optimal adaptation of the denture base to residual ridges and to achieve a more uniform and equal distribution of functional stresses by rehabilitation of the reversible tissues changes such as the atrophied mucosa or traumatic painful ulcerations. Kawano *et al.*<sup>[4]</sup> evaluated the

cushioning effect of soft denture liners indicating that a soft liner reduced the impact force during the function.

Short-term soft denture liners are soft, resilient materials that absorb some of the energy produced by the masticatory impact and serves as the “shock absorber” between the occlusal surface of the denture and underlying oral tissues. They are the plasticized acrylic resins and may be heat activated or chemically activated. Chemically activated soft liners employ poly (methyl methacrylate) or poly (ethylmethacrylate) as principle structural components. These polymers are supplied in powder form and subsequently are mixed with liquids containing 60–80% of the plasticizer. The plasticizer usually is a larger molecular species such as dibutyl phthalate. The distribution of larger plasticizer molecules minimizes entanglement of polymer chains and thereby permits individual chains to “slip” past one another. This slipping motion permits rapid changes in the shape of the soft liner and provides a cushioning effect for the

**Table 3: Comparison of water sorption of specimens of acrylic based denture soft lining material - GC RELINE at time interval of 4, 7, 11, and 15 days between Group A, B and C**

	<i>n</i>	Mean	SD	Minimum	Maximum	<i>F</i>	<i>P</i>
Sorption after 4 days							
Group A	15	0.95467	0.157460	0.671	1.342	9.019	0.001
Group B	15	0.67100	0.189315	0.447	1.119		
Group C	15	0.77553	0.205066	0.447	1.119		
Total	45	0.80040	0.216113	0.447	1.342		
Sorption after 7 days							
Group A	15	0.74567	0.182895	0.447	1.119	16.059	<0.0005
Group B	15	0.50673	0.102533	0.447	0.671		
Group C	15	0.76060	0.113589	0.671	0.895		
Total	45	0.67100	0.178690	0.447	1.119		
Sorption after 11 days							
Group A	15	0.64113	0.078818	0.447	0.671	20.558	<0.0005
Group B	15	0.38760	0.132529	0.224	0.671		
Group C	15	0.56647	0.115673	0.447	0.671		
Total	45	0.53173	0.152958	0.224	0.671		
Sorption after 15 days							
Group A	15	0.58147	0.185352	0.224	0.895	50.327	<0.0005
Group B	15	0.31327	0.141218	0.224	0.671		
Group C	15	0.89500	0.146642	0.671	1.119		
Total	45	0.59658	0.286216	0.224	1.119		

SD: Standard deviation

underlying tissues. Consequently, these liners are considered as tissue conditioners.<sup>[9]</sup>

Soft liners have been used since long, but none of the lining materials have been wholly satisfactory, since virtually all exhibited some form of clinical failure. Wright<sup>[10]</sup> found that the most common problems encountered when using short-term soft liners were regarding water sorption, solubility, and linear hardness. Kawano *et al.*<sup>[4]</sup> stated that high sorption and solubility of soft denture liners are associated with swelling, distortion, hardening, the growth of bacteria, color change, and debonding of liners from the denture bases. Plasticizers, together with impurities in acrylic resin soft liners and loss of ethanol, are thought to be the causes of water sorption and solubility behavior.

Poly (methyl methacrylate) absorbs relatively small amounts of water when placed in the aqueous environment. Nevertheless, this water exerts significant effects on the mechanical and dimensional properties of the polymer. Although absorption is facilitated by the polarity of poly (methyl methacrylate) molecules, the mechanism primarily responsible for the ingress of water is diffusion. Following diffusion, water molecules penetrate the poly (methyl methacrylate) mass and occupy a position between polymer chains.

This produces two important effects: First, it causes slight expansion of the polymerized mass and second, water molecules interfere with the entanglement of polymer chains and thereby acts as plasticizers and changing the physical properties of the resultant polymer. When this occurs, polymer chains become

more mobile, there is a relaxation of stresses incurred during polymerization and the material undergo significant change in physical and dimensional properties. Large water sorption may lead to swelling and stress at the liner/denture base interface, increased distortion, reduced bonding, and increased the growth of bacteria between liner and denture base. As this occurs, soft liners become progressively more rigid.

Solubility is another important property that acts as a general guide to the suitability of the soft denture liner material. Although plasticizers (dibutyl phthalate) do impart flexibility to the soft liner, they also present certain difficulties. Plasticizers are not bound within the resin mass and, therefore, may be "leached out" of soft liners when surrounded by the aqueous medium. During clinical use, denture with soft liner is in contact with saliva and during storage they are soaked in water or aqueous disinfecting solution. During such immersion, soft liner materials undergo two responses: Plasticizers and other soluble components are leached out, and water or saliva is absorbed. Plasticizers, together with impurities in the acrylic resin soft liners and the loss of ethanol, are thought to be the cause for solubility behaviors. This adversely affects the physical and mechanical properties of the material. Consequently, it is advantageous to use liners that are less prone to leaching phenomenon.

An ideal processed liner should have no soluble components and low water sorption. American National Standards Institute/ADA Specification No. 75 (ISO I0139) identifies guidelines of resilient lining materials for removable dentures. This specification has two parts: Part-I covers materials for

short-term use and specifies requirements for the development of the elastic recovery and change in compliance with age. Part-II covers materials for long-term use and specifies requirements for depth of penetration and depth of penetration ratio. However, ADA specification No. 12 (ISO 1567)<sup>[7]</sup> identifies guidelines regarding the testing and acceptance of water sorption and solubility of denture base polymers. This is used as the reference in the present study. According to the ADA specification No. 12, the sorption value for denture base polymers should not be more than 0.8 mg/cm<sup>2</sup> after 1 week and solubility should not be more than 0.4 mg/cm<sup>2</sup>. Such a loss may seem negligible from the clinical standpoint, but adverse tissue reaction may occur.<sup>[7]</sup> The quantity of water sorption and solubility depends on the material type and thickness.

Arima *et al.*<sup>[11]</sup> found that highly crosslinked reline materials generally exhibit lower water sorption compared to noncrosslinked reline materials. El-Hadary and Drummond<sup>[3]</sup> found that Permasoft liner (plasticized acrylic resin soft liner) has higher solubility and sorption than Luci-sof liner (silicone based soft liner) after 6 weeks of aging in distilled water. Sadamori *et al.*<sup>[12]</sup> found that thicker denture base specimens compared to thinner denture base specimens take a longer time for water sorption to achieve equilibrium. Hence, water sorption and solubility are important for evaluating the longevity of particular liner. During clinical use, denture with soft liner is in contact with saliva and during storage they are soaked in water or aqueous disinfecting solution.<sup>[7]</sup>

In this study, a comparative evaluation of the effect of three storage media (distilled water, Shellis artificial saliva, and 5.25% sodium hypochlorite) on water sorption and solubility of acrylic based self cure soft denture liner material at interval of 4, 7, 11, and 15 days was done.

A total 45 standardized samples of the material (GC RELINE™) were prepared in disk form (15 mm in diameter and 2 mm in thickness) with the help of customized three piece brass mold. The study was divided into three groups with the following storage media: Control group (with distilled water), storage in Shellis artificial saliva, and storage in 5.25% sodium hypochlorite. Chau *et al.*<sup>[13]</sup> concluded that an in-depth satisfactory disinfection of acrylic resin can be obtained using 5.25% sodium hypochlorite. Rudd *et al.*<sup>[14]</sup> also found effective sterilization of complete dentures with sodium hypochlorite.

Samples were dried in a desiccator and weighed in the analytical balance until a constant weight is achieved. These values were considered to be the initial weight (mg/cm<sup>2</sup>) of the disks (W1). The first groups (15 samples) were placed in 30 mL distilled water (Group A) at 37°C in sealed polyethylene

containers. Second group was placed in 30 mL of artificial saliva (Group B). Third group was placed in 5.25% sodium hypochlorite (Group C) for recommended time of 5 min. Disks were removed from disinfectant and placed in 30 mL distilled water at 37°C in sealed polyethylene containers. The samples were stored as to simulate the mouth conditions before testing.

On days 4, 7, 11, and 15, all samples were removed from their containers and reweighed. These values were considered to be the weight (mg/cm<sup>2</sup>) of the disks after sorption (W2). The amount of soluble material lost was measured by placing the disks back in the desiccator after each sorption cycle and drying them to constant weight in the desiccator. These values were initial weight (mg/cm<sup>2</sup>) after desiccation (W3). Water sorption and solubility was calculated according to the ADA specification No. 12:

1. Sorption (mg/cm<sup>2</sup>) = (W2–W1)/Surface area
2. Solubility (mg/cm<sup>2</sup>) = (W1–W3)/Surface area.

The results of this comparative study indicate that water sorption of the GC RELINE™ soft denture liner material was highest in distilled water (Group A) followed by 5.25% sodium hypochlorite (Group C) and least in Shellis artificial saliva (Group B) at 4, 7, and 11 day interval. However, on the 15<sup>th</sup> day, the results showed maximum water sorption in 5.25% sodium hypochlorite followed by distilled water and least in artificial saliva. The sorption values were statistically significant on the 4<sup>th</sup> day between the Group A, Group B, and Group C, however, the difference was highly significant on 7<sup>th</sup>, 11<sup>th</sup>, and 15<sup>th</sup> day interval [Table 3].

The higher water uptake of the soft liner in distilled water when compared to artificial saliva and disinfectant solution supports the theory that water uptake of these materials is osmotically driven. As the osmotic pressure of the external solution is higher than distilled water, the difference between the internal droplet and external solution will be lower. This will result in a reduced force for the growth of the droplets leading to lower uptake.

Kazanji and Watkinson<sup>[15]</sup> noted that the least uptake in artificial saliva is explicable in terms of ionic properties in the polymer. This leads to an enhanced uptake in distilled water, since water droplets will form at the impurity sites until elastic and osmotic forces balance. The osmotic pressure will be proportional to the difference in ionic concentrations between the polymer and external liquid, this difference being greater for water than for artificial saliva. Yilmaz *et al.*<sup>[2]</sup> found that disinfectants display different absorption behaviors according to the type of soft liner material and the days on which measurements was made. The results of this study are in agreement with those of Kalachandra and Turner<sup>[16]</sup>

who reported water sorption values of 0.83% and 0.63% for plasticized acrylic resin denture liners after immersion period of several days.

However, the water sorption and thus the mass change got altered on the 15<sup>th</sup> day, probably due to the leaching of the plasticizer, which is soluble in distilled water. The processes of water sorption and solubility occurred concurrently, with solubility dominating in the later stages of the experiment, resulting in reversed results on the 15<sup>th</sup> day.

The intercomparison between each group for water sorption was done using Tukey's HSD test. When compared to the control Group A, specimens in Group B showed the high statistically significant difference on 4, 7, 11, and 15 day interval. Group C, when compared to control Group A, showed no statistically significant difference in 7, 11-day interval; however, the difference was significant on the 4<sup>th</sup> and 15<sup>th</sup> day. Between the Group B and Group C the sorption values were not statistically significant on the 4<sup>th</sup> day, but there was a significant difference on 7<sup>th</sup>, 11<sup>th</sup>, and 15<sup>th</sup> day [Table 4].

The results of this comparative evaluation on solubility showed highest solubility of GC RELINE soft denture liner in artificial saliva (Group B) followed by distilled water (Group A) and least in 5.25% sodium hypochlorite (Group C) at 4, 7, 11, and 15 day interval. The solubility values showed a very high statistically significant difference on 4, 7, 11, and 15 day interval [Table 2]. Kazanji *et al.*<sup>[8]</sup> resulted in a study where four of the commercial soft lining materials had higher solubility in artificial saliva than distilled water. The reason being artificial saliva is a mix of various salts and other additives, so there is the possibility of interaction with the soft lining material. However, contrary results were found by Parker and Braden<sup>[17]</sup> showing that for silicone based commercial soft liner, solubility is higher for those specimens in distilled water than those in immersion solution. This was due to the fact that lower water uptake will lead to less swelling of the matrix thus restricting leaching of the material from the matrix.

The intercomparison between each group for solubility was done using Tukey's HSD test. When compared to control Group A, values for Group B were highly statistically significant on 4<sup>th</sup>, 7<sup>th</sup>, 11<sup>th</sup> and 15<sup>th</sup> day. However, Group C showed no statistically significant difference on 4, 7, and 11, day interval when compared to control Group A but the difference was statistically significant on the 15<sup>th</sup> day. Between the Group B and Group C, the solubility values showed the high statistically significant difference on 4, 7, 11, and 15 day interval [Table 5].

According to ADA specification No. 12 for denture base polymers, the reason solubility values obtained in this study

**Table 4: Comparison of water sorption of specimens of acrylic based denture soft lining material between control group A and group B/group C at interval of 4, 7, 11, 15 days**

	Group	Mean difference	P
Sorption after 4 days	Group A		
	Group B	0.283667	<0.0005
	Group C	0.179133	0.034
Sorption after 7 days	Group B		
	Group C	0.104533	0.388
	Group A		
Sorption after 11 days	Group A		
	Group B	0.238933	<0.0005
	Group C	0.014933	1.000
Sorption after 15 days	Group B		
	Group C	0.253867	<0.0005
	Group A		
Sorption after 4 days	Group A		
	Group B	0.253533	<0.0005
	Group C	0.074667	0.220
Sorption after 7 days	Group B		
	Group C	0.178867	<0.0005
	Group A		
Sorption after 11 days	Group A		
	Group B	0.268200	<0.0005
	Group C	0.313533	<0.0005
Sorption after 15 days	Group B		
	Group C	0.581733	<0.0005
	Group A		

**Table 5: Comparison of water solubility of specimens of acrylic based denture soft lining material between control Group A and Group B/Group C at interval of 4, 7, 11, 15 days**

	Groups	Mean difference	P
Solubility after 4 days	Group A		
	Group B	0.238267	<0.0005
	Group C	0.014867	1.000
Solubility after 7 days	Group B		
	Group C	0.253133	<0.0005
	Group A		
Solubility after 11 days	Group A		
	Group B	0.342867	<0.0005
	Group C	0.059467	0.555
Solubility after 15 days	Group B		
	Group C	0.402333	<0.0005
	Group A		
Solubility after 4 days	Group A		
	Group B	0.283533	<0.0005
	Group C	0.000000	1.000
Solubility after 7 days	Group B		
	Group C	0.283533	<0.0005
	Group A		
Solubility after 11 days	Group A		
	Group B	0.194133	0.001
	Group C	0.134400	0.035
Solubility after 15 days	Group B		
	Group C	0.328533	<0.0005
	Group A		

are higher than the ADA specifications is that the structures of the acrylic resins and soft liner materials are different from each other, the plasticizers and other components of soft-liner material are leached out, and also, water or saliva is absorbed by the soft liners during the immersions.

**Limitations of the study**

In this study, samples were prepared in accordance with ADA specification No. 12 and the study was designed and carried out with utmost accuracy. This study has certain limitations which are enlisted below.

1. In the oral cavity, the relined denture base is exposed to fluids of varying compositions and temperature. The same situation could not be simulated in this *in vitro* study
2. The surface area of the specimens tested in this study is small, in comparison to an entire intaglio surface of the complete denture, which is generally greater. Therefore, further investigations are required to evaluate water sorption and solubility under more closely simulated clinical conditions.

#### Scope of further study

The study results are based on single brand of temporary soft denture liner material, and further study may be required to compare different available brands

#### CONCLUSION

Within the limits of this study and on the basis of results obtained, it can be concluded that:

1. Water sorption of the acrylic based self cure soft denture liner is highest in distilled water followed by 5.25% sodium hypochlorite and least in Shellis artificial saliva
2. Water solubility of the acrylic based self cure soft denture liner highest in Shellis artificial saliva followed by distilled water and least in 5.25% sodium hypochlorite.

#### Financial support and sponsorship

Nil.

#### Conflicts of interest

There are no conflicts of interest.

#### REFERENCES

1. Boucher CO, Hickey JC, Zarb GA. Prosthetic Treatment for Edentulous Patients. St. Louis: Mosby; 1975.
2. Yilmaz H, Aydin C, Bal BT, Ocak F. Effects of different disinfectants on physical properties of four temporary soft denture-liner materials. Quintessence Int 2004;35:826-34.
3. El-Hadary A, Drummond JL. Comparative study of water sorption, solubility, and tensile bond strength of two soft lining materials. J Prosthet Dent 2000;83:356-61.
4. Kawano F, Dootz ER, Koran A 3<sup>rd</sup>, Craig RG. Sorption and solubility of 12 soft denture liners. J Prosthet Dent 1994;72:393-8.
5. Emmer TJ Jr, Emmer TJ Sr, Vaidynathan J, Vaidynathan TK. Bond strength of permanent soft denture liners bonded to the denture base. J Prosthet Dent 1995;74:595-601.
6. Craig RG. Restorative Dental Materials. Vol. 9. St. Louis: Mosby; 1995.
7. Council on Dental Materials. Revised ADA specification no 12 for denture base polymer. J Am Dent Assoc 1975;90:145-54.
8. Kazanji MN, Watkinson AC. Soft lining materials: Their absorption of, and solubility in, artificial saliva. Br Dent J 1988;165:91-4.
9. Anusavice KJ. Phillip's Science of Dental Materials. 10<sup>th</sup> ed. W.B. Saunders Co; 1996.
10. Wright PS. Composition and properties of soft lining materials for acrylic dentures. J Dent 1981;9:210-23.
11. Arima T, Murata H, Hamada T. Properties of highly cross-linked autopolymerizing reline acrylic resins. J Prosthet Dent 1995;73:55-9.
12. Sadamori S, Ishii T, Hamada T. Influence of thickness on the linear dimensional change, warpage, and water uptake of a denture base resin. Int J Prosthodont 1997;10:35-43.
13. Chau VB, Saunders TR, Pimsler M, Elfring DR. In-depth disinfection of acrylic resins. J Prosthet Dent 1995;74:309-13.
14. Rudd RW, Senia ES, McCleskey FK, Adams ED Jr. Sterilization of complete dentures with sodium hypochlorite. J Prosthet Dent 1984;51:318-21.
15. Kazanji MN, Watkinson AC. Influence of thickness, boxing, and storage on the softness of resilient denture lining materials. J Prosthet Dent 1988;59:677-80.
16. Kalachandra S, Urner DT. Water sorption of polymethyl methacrylate: 3. Effects of plasticizers. Polymer 1987;28:1749-52.
17. Parker S, Braden M. Formulation of tissue conditioners. Biomaterials 1990;11:579-84.