ORIGINAL ARTICLE

COMPARISON OF SOLUBILITY AND WATER SORPTION OF TWO DIFFERENT SOFT LINING MATERIAL

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Background: Soft denture lining materials play a very important role in Removable Prosthodontics because of their ability to provide a cushioning effect for maintaining the health of traumatized, swollen and deformed mucosa through absorption and equal redistribution of stresses over the entire area covered by denture, thus eliminating the distortion of oral mucosa. The objective of this investigation is to quantify and relate the mean solubility and water sorption of acrylic resin based permanent soft liner with a silicone based permanent soft liner. **Method:** Two different permanent soft denture liners, i.e., acrylic and silicone based are selected for this study, 30 samples of each material are prepared in the form of circular disks of the 30 disks, and three subgroups of ten disks each are made for the two materials. Initially the processed disks will be weighed 3 times daily with an analytical balance until a constant weight is achieved. This initial weight of each specimen is denoted by W_1. Each subgroup of 10 specimens is immersed in 250 ml of 37 °C distilled water in a sealed polyethylene container. First subgroup is tested after 1 week, second after 4 weeks and third after 6 weeks of immersion. **Results:** Ever soft has higher solubility (1.67mg/cm^2 ±0.26 mg/cm^{2}laboratory-processed) and sorption (0.84 mg/cm^2 ±0.35 mg/cm^{2}laboratory-processed) than Molloplast B (0.40 mg/cm^2 ±0.08 mg/cm^{2}solubility and 0.27 mg/cm^2 ±0.16 mg/cm^2 sorption) after 6 weeks of immersion. **Conclusion:** It is therefore concluded that Molloplast B may provide better clinical success based on its lower solubility and water sorption.

Keywords: Soft denture liner; Water sorption; Solubility

Citation: Das G, Khokhar M, Naeem S, Reehana. Comparison of solubility and water sorption of two different soft lining material. J Ayub Med Coll Abbottabad 2018;30(2):175–9.

INTRODUCTION

Removable complete denture Prosthodontics includes replacing patient's missing teeth and soft tissue with hard acrylic dentures. Dentures can be tolerable if they fit and are comfortable in patient's mouth.[1,2] Patient's lining mucosa is usually thin and can't tolerate heavy masticatory forces distributed through hard plastic base plate. Mucosa over sharp ridges, bony spicules and undercut areas is especially vulnerable. Initially almost every patient experiences difficulty in adjustment of dentures.[3]

Denture relining is used to resurface the tissue side of denture. Soft denture liners have been used to provide comfortable denture wearing experience especially for the patients having sharp knife edge residual ridges and extremely resorbed alveolar ridges complaining of pain and soreness on denture wearing having a low tolerance to bear the masticatory stresses.[4] Soft denture lining materials play a very important role in removable prosthodontics because of their ability to provide a cushioning effect for maintaining the health of traumatized, swollen and deformed mucosa through absorption and equal redistribution of stresses over the entire area covered by denture, thus eliminating the distortion of oral mucosa.[5,6]

Water sorption and solubility are problems most often encountered on exposure of soft denture lining materials to oral fluids. Either the soft denture liners are immersed in saliva inside the oral cavity or they may be stored or/and exposed to water/aqueous cleansing solutions when not in use. During immersion, therefore, water and saliva are absorbed and plasticizer and other water-soluble components are leached out.[7] High solubility and sorption of soft denture lining materials result in inflammation and deformation of mucosa, supporting growth of *Candida albicans* species and causing absorption of odors.[8] It also causes hardening and colour changes apart from increasing stress at the interface of liner and denture base which in result reduces the bond strength.[9] Water uptake characteristics of soft denture lining materials vary depending upon its type and chemical composition.

Under the exposure to humid environment for extended period, soft lining materials absorb water and their soluble components leach out. Deterioration of functional and mechanical properties for example bond strength and hardness, of these materials occurs under the influence of solubility, dehydration, sorption and oxidization of materials in the humid and moist environment.[12,13] A processed ideal soft liner should have non-soluble components with negligible water sorption. Literature review has been conducted to compare solubility and water sorption of two soft lining materials, a plasticized acrylic resin soft liner viz-a-viz silicone based soft liner to determine less water-soluble material.[3,10,11]

Soft denture liners are classified in four groups based on their chemical composition: Plasticized (chemical or heat cured) acrylic resins, Vinyl resins, Rubbers (polyurethane and poly-phosphazine type) and Silicone rubbers. Physical properties including shear and tensile bond strength depend upon chemical composition of both reline materials and denture base polymers.[11,17] Apart from chemical composition, properties including solubility and water sorption are also dependent upon the curing method, i.e., heat-cured or self-cured. A weak bond between the soft liner and its denture base can promote bacterial growth, foul smell, staining and loss of cushioning effect, finally resulting in debonding of the lining material from its denture base. The mechanical strength of the relined denture base itself is affected by the bond strength between soft denture liner and denture base resins.[2] Shear and tensile bond strength of various commercially available silicone and acrylic based denture relining materials have been investigated and benchmarked against conventional heat cured acrylic denture base resin.[11,12,18]

Dimensional and structural changes occur in soft denture lining material under the influence of water sorption. Resulting changes in the physical properties elevate the stresses at the interface between the soft liner and denture base. These stresses affect the strength of the bond between them. Bond hydrolysis will occur due to diffusion of water to the bond site. It is therefore desirable that minimum amount of water is absorbed at the surface of denture base because overall strength of liner-denture base bond will be reduced due to bond hydrolysis. This gives poor clinical results with repeated debonding of the soft liner from its denture base.[15,16]

Soft denture liners are prone to colonization of pathological microorganisms especially due to porous nature of such materials. Soft lining materials are directly in contact with mucosa of the oral cavity as they are positioned on the tissue surface of the dentures. The growth of microorganism is promoted in this humidity and favourable temperature environment. Due to the porous nature of material, fungi including *Candida albicans* stick to lining surface and eventually penetrate the material. This leads to inflammation of the oral mucosa and complications accompanying denture stomatitis. This is further aggravated in materials showing higher sorption and solubility values. Among other methods used to reduce the pathological colonization, additives such as silver nanoparticles and silver-zeolite have shown promise to enhance antimicrobial efficacy of silicone soft lining materials.[2,13,19]

MATERIAL AND METHODS

Sample size is 60 disks (30 for each material) using 95% confidence level, 80% power of test, taking an expected mean sorption as 0.21±0.13 of the laboratory processed silicone based soft liner and 0.75±0.36 of the laboratory processed acrylic based soft liner. Two different soft denture liners are investigated, laboratory processed silicone based soft liner viz a viz laboratory processed acrylic based soft liner. Thirty specimens for each material are prepared in the form of disks. Each disk has 45 mm diameter with 3mm thickness. After the processing, these discs are dried in a desiccator containing Calcium sulphate (anhydrous). Thirty specimens of both materials are divided in to three subgroups comprising 10 disks each.

Initially the processed disks are weighed 3 times daily with an analytical balance until a constant weight is achieved. This initial weight of the specimen disk is denoted by W_1. All the specimens are immersed in 250 ml distilled water in sealed polyethylene container maintained at 37 °C. First subgroup is tested after 1 week, second after 4 weeks and third after 6 weeks of immersion (for both materials).

Accordingly, the disks are removed from the container and excess water is removed with blotting paper. Each disk is then weighed and W_2 denotes the weight of specimen after absorption of distilled water. After each sorption cycle, the specimen is again desiccated and weighed. Final weight of specimen after desiccation is denoted by W_3. This determines the amount of soluble material lost. The revised ADA Specification No.12 is used to compute the solubility and water sorption for denture base polymers in mg/cm^2

$$Sorption\,(mg/cm\verb|^|2) = \frac{W_2 - W_1}{SurfaceArea}$$

$$Solubility\,(mg/cm\verb|^|2) = \frac{W_1 - W_3}{SurfaceArea}$$

Data is analysed using statistics analysis software SPSS-20. Quantitative data like sorption and solubility are presented by Mean and Standard Deviation. The mean solubility and sorption in both groups is compared through Independent Sample t-test with value greater than 0.05 as significant.

RESULTS

Table-1: Statistical analysis of solubility and water sorption after 1-week immersion

Material		Water Sorption	Water Solubility
Molloplast B	n	10	10
	Mean(mg/cm^2)	0.12267	0.19622
	Std. Deviation	0.109764	0.105496
	Std. Mean Error	0.034710	0.033361
	t-test	0.120	1.364
	p-value	0.733	0.258
Eversoft	n	10	10
	Mean(mg/cm^2)	0.44433	1.22670
	Std. Deviation	0.166641	0.158057
	Std. Mean Error	0.052697	0.049982
	t-test	0.120	1.364
	p-value	0.733	0.258

Table2: Statistical analysis of solubility and water sorption after 4-week immersion

Material		Water Sorption	Water Solubility
Molloplast B	n	10	10
	Mean (mg/cm^2)	.18761	.29557
	Std. Deviation	.037125	.055217
	Std. Mean Error	.011740	.017461
	t-test	7.992	17.111
	p-value	.011	.001
Eversoft	n	10	10
	Mean (mg/cm^2)	.76544	1.44790
	Std. Deviation	.396485	.190767
	Std. Mean Error	.125380	.060326
	t-test	7.992	17.111
	p-value	.011	.001

Table-3: Statistical analysis of solubility and water sorption after 6-week immersion

Material		Water Sorption	Water Solubility
Molloplast B	n	10	10
	Mean (mg/cm^2)	.27504	.40492
	Std. Deviation	.162207	.084307
	Std. Mean Error	.051294	.026660
	t-test	8.963	17.100
	p-value	0.008	0.001
Eversoft	n	10	10
	Mean (mg/cm^2)	.84482	1.67659
	Std. Deviation	.359239	.268948
	Std. Mean Error	.113601	.085049
	t-test	8.963	17.100
	p-value	0.008	0.001

DISCUSSION

Table 1 shows that water sorption of Eversoft is 0.44 $mg/cm^2 \pm 0.16$ mg/cm^2 after 1-week immersion in water. This result is comparable to the study conducted by Collis[24] for plasticized acrylic resin soft liner with water sorption as 0.51 mg/cm^2 ± 0.12 mg/cm^2 after 1 week of immersion. Similarly, water sorption value is found to be 0.84 mg/cm^2 ± 0.36 mg/cm^2 after 6-week immersion, which correlate with the results obtained by Collis[24] as 0.81 mg/cm^2 ± 0.11 mg/cm^2 after 1 and 2 months immersion. Kazanji and Watkinson[21] have reported water sorption and solubility value as 0.46 mg/cm^2 and 1.34 mg/cm^2 respectively for plasticized acrylic soft liner after 4-week immersion.[22] Thus; these results also substantiate this study. After 4-week water immersion, sorption for silicone soft liner is 0.18 $mg/cm^2 \pm 0.03$ mg/cm^2 which closely agrees with the results as 0.21 mg/cm^2 and 0.19 mg/ for two different silicone based liners under equivalent water immersion period.

After 1-week immersion in water, sorption of silicone based soft liner, i.e., Molloplast B is 0.12 $mg/cm^2 \pm 0.10$ mg/cm^2. Kalachandra and Turner[23] have stated water sorption values as 0.11 mg/cm^2 and 0.13 mg/cm^2 for silicone based soft denture liners after several days of immersion. These results further validate this investigation. The material is cross-linked by heat curing which improves the bonding of filler to the silicone; resulting low values for solubility and water sorption are achieved as determined in this study.

Figure-1 and figure 2 present the mean sorption and mean solubility values of Eversoft and Molloplast respectively for all subgroups.

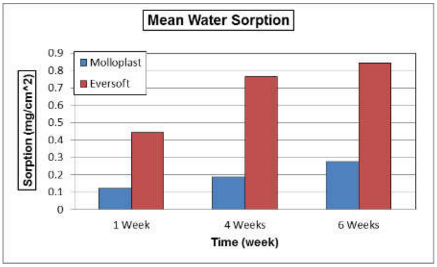

Figure-1: **Mean sorption of Molloplast Band Eversoft**

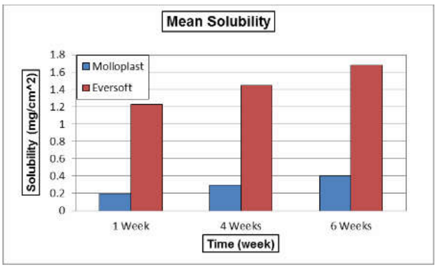

Figure-2: **Mean solubility of Molloplast B and Eversoft**

Kazanji and Watkinson[21] method is based upon the difference between the saturated weight and final dried weight while ADA Standard computes the difference between the saturated and initial weights. Thus, negative value of water sorption is obtained when weight of absorbed water is less than the leached-out components. Over and above the impurities in the acrylic resin soft liners together with loss of ethanol, plasticizers cause water sorption and solubility behaviour. Robinson[15] suggests that ethanol diffuses out of the liner more quickly than water being absorbed. Eversoft material used in this study contains ethanol (manufacturer's listing of 5.0% ethanol, 100% proof not denatured). For calculating solubility and water sorption in mg/cm^2, ADA Specification No. 122 is followed. This study shows water sorption as 0.44±0.16 mg/cm^2 and 0.76±0.39 mg/cm^{2}after1 week and 4 weeks immersion for Eversoft soft liner. These results are comparable to the results of Kawano *et al*[17] which are based on ADA method. He used two different soft-liner materials and reported sorption values as 0.23±0.01 mg/cm^{2}and 0.27±0.02 mg/cm^2 after 1 week and 1 month respectively for one material while 0.31±0.11 mg/cm^2 and 0.43±0.16 mg/cm^2 after 1 week and 1 month respectively for the other material.[22] Both methods for calculating solubility and water sorption are inadequate due to errors in determining small changes in weight. For ADA specification, the actual surface area is larger than the calculated area due to polishing and finishing process. Thus, an additional variable is added to calculations. In estimating water sorption, relative difference (W_2–W_1) is determined in ADA specification while Kazanji and Watkinson[21] method determine the net weight difference (W_2–W_3). Thus, this method is more accurate for estimating the sorption and solubility with an advantage of one less variable, i.e., surface area.[22]

CONCLUSION

Following conclusion can be drawn from this research:

Eversoft liner has higher solubility and sorption values viz a viz Molloplast B liner after 1 week, 4 weeks and 6 weeks under water immersion. Therefore, Molloplast B may provide better clinical success due to lower solubility and water sorption.

AUTHORS' CONTRIBUTION

GD: Article writing. MK: data collection, results. SN: Proof reading. R; Analysis and discussion.

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Received: 29 November, 2017	*Revised: 18 March, 20018*	*Accepted: 14 April, 2018*

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