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Evaluation and Comparison of Stress Relaxation Property of Different Soft Liners after Thermocycling & Cyclic Loading in Various Time Intervals: An In Vitro Study

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ABSTRACT

Background: Chronic soreness beneath dentures has been the cause of major concern for completely edentulous patients with atrophied submucosa. Soft liners are now being used to overcome this issue. So, a study was conducted to evaluate and compare four soft lining materials where they were subjected to thermal and mechanical stresses over a period of 3 months and their stress relaxation property was checked.

Materials and method: 20 specimens each (total 80 specimens) for four commercially available soft liners were prepared. Acrylic and silicone based lining materials in both Autopolymerizing and heat cured form were used for preparing specimens. Thermocycling and cyclic loading for a period of three months for these specimens was done and their stress relaxation property was evaluated at baseline, 1 month and 3 months. Statistical analysis was done by paired t-test and two way ANOVA test.

Results: The autopolymerizing silicone was found to have maximum stress relaxation property at baseline. The values for heat cure silicones were found to be maximum after 3 months. However, the stress relaxation property was found to be significantly ($p<0.001$) reduced irrespective of the nature of material.

Conclusion: Heat cure silicone liners were found to be superior in terms of stress bearing capacity as compared to autopolymerizing silicones and acrylic based soft liners.

Keywords: Stress Relaxation, Soft Liners, Thermocycling, Cyclic Loading.

INTRODUCTION

'Quality of life' as they say has become the only essence of living and for the edentate subjects whose masticatory efficiency reduce to one fifth or one sixth of the original force[1, 2] this oral health related issue is a prime concern. Severe residual ridge resorption or thin and comparatively non-yielding ridge mucosa may make traditional acrylic denture bases even more agonizing for some edentulous patients[3]. This eventually leads to inefficient chewing performance along with non-uniform distribution of occlusal forces leading to pain and distress to the patient. Denture-lining materials or the Soft- liners are thus used to refit the impression surfaces of complete denture leading to conditioning of traumatized tissues, providing a temporary or permanent cushion like effect[4]. These liners may prevent the further ridge resorption by dissolving the effect of impact forces on the load bearing areas as well as soothen up the atrophied mucosa[5]. These materials are also recommended for irregular bony undercuts, immediate prosthesis, enhance the healing after implant placement, xerostomia and bruxism patients[6,7].

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Soft denture liners comprise of a group of polymer materials who have their glass transition temperature (Tg) below that of mouth temperature. The pliable and rebounding nature of these materials make them useful for diagnostic, adjunctive and treatment purposes in the management of edentulous patients[8]. Soft liners have been divided into permanent and semi-permanent category. The permanent liners have been further subcategorized as (1) autopolymerized silicone, (2) heat-polymerized silicone, (3) autopolymerized acrylic resin and (4) heat-polymerizedacrylic resin[9]. Materials available as permanent soft liners include plasticized acrylics, silicone rubber, plasticized vinyl polymers and copolymers, hydrophilic polymers, polyphosphazine fluoropolymers, fluoroethylene and polyvinyl siloxane addition silicones. Among them, silicone- and acrylic-based materials have been more widely used[10].

From various studies[11,12] it has been suggested that these materials should have proper cushioning effect to assimilate and redistribute functional stress and should remain stable over time. In the oral environment, mastication and occlusal stresses along with thermal changes lead to alterations in properties of these materials depending on the selection of material[13]. Soft denture lining materials may show varied and changeable stress relaxation property under cyclic loading and thermocycling conditions. Assessment of the changes in the stress relaxation of soft denture lining materials under simulated oral conditions over a period of time helps in selecting specific material appropriate for each clinical conditions and also aids in deciding the time interval at which these materials should be replaced. Thus, this study was carried out to evaluate and compare the stress relaxation property of different soft denture lining materials over time under both cyclic loading and thermocycling conditions.

MATERIALS AND METHOD

The present study assessed the effects of cyclic loading and thermocycling on stress relaxation of four commercially available soft lining materials over a period of 3 months.

Materials used in this study were:

Table 1: Soft liners used

BRAND NAME	MATERIAL	POLYMERIZATION PROCESS	MANUFACTURER
Molloplast B (MB)	Silicone based	Heat cure	Detax (Germany)
Mollosil Plus (MP)	Silicone based	Self cure	Detax (Germany)
Permasoft (PS)	Acrylic based	Heat cure	Dentsply (Germany)
GC Soft Liner (GC)	Acrylic based	Self cure	GC Corporation Tokyo(Japan)

METHOD

1. Preparation of specimens

A stainless steel mould with dimensions of 5mm in height and 15mm in internal diameter and two open sides was fabricated along with two stainless steel plates for holding the specimen. The specimens were then polymerized according to manufacturer's instructions. The autopolymerizing liners were dispensed according to ratios mentioned and mixed while for heat cure liners wax patterns were prepared. The entire assembly of mould was then invested in dental flask and dewaxing was done. The specimens were then processed at the desired temperature followed by deflasking.

20 samples of each material (N= 80) were then retrieved from their moulds, excess material was cut with a scalpel and the specimens were then stored at 37°Celsius in distilled water.

2. Thermocycling, Cyclic loading and determination of stress relaxation property

Thermal stressing (LG Model, 051SA, Mahavir, India) of the prepared specimens was done with 500 thermal cycles between 5° C and 55° C with a dwell time of 30 seconds. Cyclic loading of all the specimens was then carried out using a Universal testing machine (Star Testing Systems, India. Accuracy of the machine: ±1%). All the specimens were compressed with a speed of 1mm/s until the specimen was compressed to two-thirds of its original height. Flexural loading was done 1800times per day.The values for stress relaxation propertywere recordedwith the compressive force applied to the specimen at a cross head speed of

1mm/sec until the load reached 68.6 N which was maintained for 12 sec[13]. The above procedures were similarly repeated for all 4 different soft denture lining materials. The values for stress relaxation property were evaluated at baseline, 1 month and 3 months.

The data thus obtained was then subjected to statistical evaluation.

STATISTICAL ANALYSIS:

Paired t-test and two-way ANOVA test were done. The analysis was carried out with SPSS software version 20.

RESULTS

In this in-vitro study, four different soft lining materials showed varied and changeable stress relaxation property under cyclic loading and thermocycling conditions at different time intervals. The mechanical and thermal stresses were given so as to simulate the oral environment. The study showed that stress relaxation property of the liners decreased over time irrespective of the material used. On intragroup comparisons it was found that the stress relaxation property decreased significantly ($p < 0.001$) at all the time intervals (Tables 2-4) for all the materials.

On intergroup comparisons the stress relaxation was maximum with autoplymerizing silicone initially (MP>MB>PS>GC) (Table 2) but with the progression of time heat cure silicone showed the best results (MB>MP>PS>GC) after 3 months (Tables 3 and 4).

Table 2: Distribution of stress relaxation after thermocycling & cyclic loading among different groups at baseline

	N	Mean	Std. Deviation	P value
Molloplast B	20	60.6545	3.72878	
Mollosil Plus	20	64.6145	1.40676	
Permasoft	20	56.5410	1.46272	<0.0001*
G C Soft liner	20	51.9030	1.93686	

Table 3: Distribution of stress relaxation after thermocycling & cyclic loading among different groups at 1 month

	N	Mean	Std. Deviation	P value
Molloplast B	20	59.7385	2.8242	
Mollosil Plus	20	59.5480	1.5476	
Permasoft	20	53.4615	1.4536	<0.0001*
G C Soft liner	20	49.8055	1.9654	

Table 4: Distribution of stress relaxation after thermocycling & cyclic loading among different groups at 3 months

	N	Mean	Std. Deviation	P value
Molloplast B	20	56.8342	3.5674	
Mollosil Plus	20	52.6254	2.4387	
Permasoft	20	50.3675	1.3487	<0.0001*
G C Soft liner	20	45.6729	1.4738	

DISCUSSION

Periodontal ligament is a complex tissue which is present in the natural dentition to provide a cushioning effect by its viscoelastic property but complete dentures are those rigid prosthetic units which because of their non-resilient nature have been a cause of concern for many patients as well as for the prosthodontists. Since years, viscoelastic materials have been searched for, to prevent or reduce the inevitable alveolar resorption associated with the complete dentures and also to provide maximum relief to the distressed patients. Soft liners are the desired materials which have a significant influence on denture wearers with great improvement in masticatory performance[14].

The different quality of materials used for this purpose include a wide variety but most commonly used are silicone and acrylic based. Acrylic soft liners have been found to have higher loss tangent and lower storage modulus as compared to silicone liners which have lower loss tangent and higher storage modulus. The stress relief has been found to be more with the latter variety as their elastic property leads to more improvement than the less elastic acrylic liners[9, 15].

Acrylic resin-based liner materials are made up of polymers and monomers which causes the leaching of plasticizers and other soluble materials on immersion in liquid media. It has also been reviewed that the primary softness of the plasticized acrylic resins is due to the plasticizer, which makes the material soft. Silicone elastomer materials having composition similar to silicone-type impression materials; consist of polyether urethane dimethacrylate, so the leaching effect of plasticizers gets nullified with their use[16]. Also, acrylics have smaller working life because of water sorption and hardening[17,18]. The liner is also desired to have adequate resistance against the absorption of oral fluids as well as the release of ethanol and plasticizer into the saliva. The release of unpolymerized or soluble products as seen in acrylics could result in a stiffer, harder liner material over time[19].

The purpose of the present study was to determine the effect of cyclic loading and thermocycling on stress relaxation property of different soft denture lining materials. Because this was a comparative study, various factors were kept constant during testing like the force used and the size of and shape of the specimens. In the present study, universal testing machine was used to apply cyclic loading to the specimens and thermocycling unit was used to apply thermal stresses to the specimens for the simulation of clinical conditions and test conditions.

The effect of temperature on stress relaxation property have been studied in very few previous studies. Cha H S et al[13] stated that interactions among temperature fluctuations might amplify the effect of cyclic loading and it was found that the amount of compression for the cyclic loading should be 1mm. Thus an investigation of effect of low-magnitude loading was done and effect of temperature on stress relaxation of soft liners was done in present study.

On conducting the study, it was found that there were statistically significant differences in mean and standard deviation values of stress relaxation property after thermocycling and cyclic loading among different materials. The results of stress relaxation property demonstrated that the mean values of the autopolymerized silicone based soft denture lining material after thermocycling and cyclic loading were significantly ($p<0.001$) (Tables 2) greater than those of heat-polymerized acrylic and silicone based and autopolymerized acrylic based groups. The difference in this behaviour is attributed to the fact that although the initial stress relaxation was better with autopolymerizing silicone resins but over the time with continuous flexural and thermal stresses as in oral milieu, the stress relaxation of heat cure silicones was found to be best (Table 3 and 4) as there is structural decomposition of autopolymerizing silicone liners with time[13]. Higher value of stress relaxation attribute to more elastic recovery of the liner which leads to lesser pressure on mucosa and hence it is more tissue friendly.

The superior behaviour of silicone materials over acrylic resins is also inferred from the fact that silicone resins have cross-linked polymer structure along with superior flow and higher elasticity[20]. Also, laboratory studies have documented increase in acrylic based soft denture lining material hardness by as much as 150% during the initial six months of aging in distilled water. In contrast, the hardness of silicone based soft denture lining material that were aged in distilled water was altered by no more than 63%, or it remained unchanged[21].

Thus with the present study it was concluded that acrylic based materials can be used as denture lining materials but since the biological properties of silicones are better, they should be used more preferably. Also, it was observed that the stress relaxation property of all the materials deteriorates with time in oral environment so they should be replaced at appropriate time to aid the maintenance of oral tissues in denture wearers.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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