A COMPARATIVE EVALUATION OF BOND STRENGTH AND HARDNESS OF SOFT DENTURE LINERS AFTER THERMOCYCLING – AN INVITRO STUDY

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BRANCH VI – PROSTHETIC DENTISTRY INCLUDING CROWN AND BRIDGE AND IMPLANTOLOGY

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DEPARTMENT OF PROSTHETIC DENTISTRY INCLUDING CROWN AND BRIDGE AND IMPLANTOLOGY

CERTIFICATE

This is to certify that this dissertation **"A comparative evaluation of bond strength and hardness of soft denture liners after thermocycling – an invitro study"** is a genuine work done by **Dr.V.Manoj** under my guidance during his postgraduate study period between 2007-2010.

This Dissertation is submitted to THE TAMILNADU Dr.M.G.R.MEDICAL UNIVERSITY, in partial fulfillment for the Degree of **MASTER OF DENTAL SURGERY IN PROSTHETIC DENTISTRY INCLUDING CROWN AND BRIDGE AND IMPLANTOLOGY BRANCH VI.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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This Dissertation is Dedicated
to

my father

Late Mr.S.Vincent

CONTENTS

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Above all I thank **almighty for His Grace and Blessings.**

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Abstract

Title: *A comparative evaluation of Bond strength and hardness of soft Denture liners after thermocycling.*

Mesh words: *Thermocycling, shore A hardness, soft denture liners, shear bond strength, tensile strength, Denture base resin.*

Aim: *The aim of the study was to evaluate and compare tensile bond strength, shear bond strength and Hardness of four soft denture liners after thermocycling.*

Materials and methods: *Two silicone based soft liners (GC Reline™ soft, Ufigel-P) and two acrylic based soft liners (GC soft liner, visco-gel) were used in this study and a heat polymerized acrylic resin Fourty Eight specimens (25mm x 25mm x 3mm) were fabricated in stainless steel molds for testing Tensile and shear strength. Twenty disk shaped specimens (31mm x 6mm) were fabricated in stainless steel molds for hardness testing. These specimens were subjected to thermocycling (3000 cycles) between baths of 5^0 and 55^0C. The specimen preparation and test for hardness were carried out in accordance with the ISO Specification No. 10139 for soft denture liners.*

Result: *After thermocycling, GC reline soft had higher tensile bond strength than (2.0185 MPa) Ufigel –P (1.5740 MPa), GC soft liner (1.1974 MPa) and visco-gel (0.5306 MPa) The shore A hardness values for GC reline soft, Ufigel – P, GC soft liner, visco-gel after thermocycling were (48.16, 28.4, 24.36, 5.68). The shear bond strength values were also higher for GC reline soft (2.5039MPa) compared to Ufigel – P (1.5675 MPa) GC soft liner (1.2161MPa) and visco-gel (0.4162 MPa)*

Conclusion: *The silicone based soft liners (GC reliner, Ufigel –P) had higher values for tensile bond strength and shear bond strength, showing that they were more durable than acrylic based softliners. The acrylic based soft liners (viscogel, GC soft liner) showed lower values for hardness indicating they are more suitable for short term tissue conditioning.*

INTRODUCTION

INTRODUCTION

The characterization of soft lining materials was done as early as in 1958 by Lammie and Storer. The use of tissue conditioning was first reported by Chase W.W. et al in 1961 for abused denture supporting tissues and to restore a normal healthy state. Travaglini et al later in 1960 studied the physical properties of various brands of acrylic based soft liners.

Soft liners are provided to absorb some of the energy produced by masticator impact. Hence it serves as a shock absorber between the occlusal surfaces of a denture and the underlying oral tissue.

The resilient lining materials are classified as temporary and soft permanent. The temporary materials are used for a limited period, approximately 7 days, to aid the healing of the tissues in contact with the denture. Soft permanent or long-term materials are used on complete dentures where it is necessary to absorb masticatory loads, and are indicated for patients who are unable to tolerate the pressures transmitted by the denture to the underlying mucosa of the edentulous ridge.

The choice for a soft liner for clinical use should be based on the material's biocompatibility, mechanical properties and durability in the oral environment. However, these lining materials may present physical and mechanical problems during clinical use such as color alteration, loss of plasticizer and resilience, poor rupture strength and porosity. In this context it is essential to study the physical properties of commonly used soft liners after subjecting to thermocycling (aging)

Therefore, the purpose of this study was to compare the effect of the tensile bond strength and shear bond strengths and hardness of soft liner materials after thermocycling.

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES

This study is under taken with the following Aims and Objectives.

1. To study and compare the Tensile Bond strength of four soft denture liners. (GC Reline^{TM} soft, Ufigel-P, GC soft liner, visco-gel) to heat polymerized acrylic resin after thermocycling.

2. To study and compare the shear bond strength of four soft denture liners (GC Reline^{TM} soft, Ufigel-P, GC soft liner, visco-gel) to heat polymerized acrylic resin after thermocycling.

3. To study and compare the hardness of four soft denture liners (GC Reline^{TM} soft, Ufigel-P, GC soft liner, visco-gel) after thermocycling.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soft denture liner: Polymeric material placed on the tissue-contacting surface of a denture base to absorb some of the energy produced by masticatory impact and to act as a type of 'shock absorber' between the occlusal surfaces of a denture and the underlying oral tissues[1].

Lammie et al (1960)[2] stated the desirable properties of tissue liners as follows:

1. Cushioning effect upon the mucosa
2. Permanent resilience and dimensional stability
3. Should inhibit fungal growth
4. Minimal water absorption and solubility
5. Adhesion to denture base.
6. Resistance to abrasion
7. Should be hygienic and color stable.
8. Processing should be relatively easy adjustable and repairable
9. Should not deteriorate or weaken the denture base.

INDICATIONS FOR THE USE OF TISSUE CONDITIONERS

a) Thin non-resilient mucosal coverage.

b) Poor ridge morphology

c) Persistent denture sore mouth

d) Acquired or congenital oral defects

e) Patients who have undergone radiation therapy.

Chase W et al in (**1961)**[3] was the first person to report tissue conditioners as a material designed to reconsider abused denture supporting tissue and to restore a normal healthy state.

Craig and Gibbons in (**1961)**[4] early workers as **Lammie and storer** studied the physical properties of resilient liners and concluded that no resilient denture base material had all the desirable properties originally proposed by other authors.

H.J. Wilson et al (1969)[5] tested seven soft lining materials for their softness and elastic recovery by means of compression and indentation tests. The surface appearance of each material also was noted after storage in a 37^0C water bath for six months. The stress in compression is determined by percentage change in length with time of each specimen under stress. A test was performed in which a stress of 5.6 N / cm^2 was applied to 24 hours cylindrical specimen for one minute and then was released. The percentage change in length of a specimen during stress application is a measure of strain in compression of material indication its rigidity or compression hardness. Another method of compression at a constant strain was also used. The force was applied to a 24 hour specimens at 37^0C at a rate of 1 cm / min reaching a 1 Newton force. Each percentage change in length is plotted as a functioning of force, and result appears as a straight line. Instron machine was used for this test. Indentation tests were done on all specimens, 24 hour old and 2mm thick, stored in a 37^0C water bath. Softer the material, the greater the depth of indentation, the softer materials showed more incomplete recovery with increased initial compression, while harder materials showed more complete recovery with less initial compression. Preferably, the material most suitable for clinical use should be soft and should completely recover after compression. while harder materials showed more complete recovery with less initial compression. Preferably, the material most suitable for clinical use should be soft and should completely recover after compression, this study proved that the hardest materials among the soft liners as Flexibase and Molloplast B recover completely.

EDGAR STARCKE et al (1972)[6] studied five tissue conditioners for their hardness and other physical properties. They used Shore A Durometer with hardness number on the scale reading from 0-100 units. The less the indentor penetrates the test materials, the higher will be the hardness reading. Readings were made every 15 minutes for the first hour, with subsequent readings at two, four, six, eight and twenty four hours. All products showed an abrupt resistance to penetration by the indentor at 15-30 minutes, indicating the initial setting time. This was followed by a gradual increase in resistance upto 24 hours.

J.A. McCarthy et al (1978)[7] tested three brands of soft tissue conditioners after setting at 37^0C for 15 minutes. The specimen sheet was removed from the mold and aged in water at 37^0C for additional periods of one hour, one day, three days and one week, after which these specimens were trimmed to 0.034 inch thick specimens and were subjected to tension on a mechanical testing machine. Load-deformation curve was obtained for each specimen. Gauge width and length were obtained with vernier caliper accurate to ± 0.00024 inch. Cross-head speed of testing machine was varied from 2 inches / minute to 50 inches / minute to obtain information concerning strain rate sensitivity. All other comparative data was obtained at a cross head speed of 20 inches / minute Maximum stress values increased generally as a function of both time and material. Coe-comfort did not significantly increase its maximum stress values from 14 – 24 hours or from three days to one week. Lynal showed no significant increase in maximum stress values from one hour to three days. There was a significant rise in stress between twenty four hours and one week and between one hour and one week specimens. The results indicate that the loads required for tensile failure were several orders of magnitude above those reported to be acting during intraoral function.

R.L. Duran, et al (1979)[8] conducted a study where the creep compliance and dynamic modulus of two tissue conditioners and five soft liners were determined after storage in water at 37C. Under static conditions the tissue conditioners functioned like viscous liquids, whereas the soft liners were more elastic. In general, linear viscoelasticity was not observed. It was concluded that under dynamic conditions, the materials were stiffer.

Moodhy Saleh et al (1986)[9] evaluated bond strength of resilient lining materials to various denture base resins. Coe super soft failed cohesively, Molloplast B failed cohesively and Novus failed adhesively. Therefor it was apparent that the bond strengths of Molloplast B and Coe super soft exceeded the cohesive strength. The bond strength of Novus ws seen to depend on the denture base material and was greatest with Lucitone 199 and TS 1195.

E.R. Dootz et al (1993)[10] studied three oft liners which were stored in a humidor for twenty four hours and tested for tensile strength, percent elongation, Hardness, Tear strength, tear energy. The tests were repeated after a second test of samples were subjected to an accelerated aging chamber. The weathering cycle was 900 hours of exposure to visible light source at 110^0 f and 90% relative humidity. The soft liners showed higher values to the physical properties tested after weathering. This may be due to continued polymer and loss of plasticizer.

Omer Kutay (1994)[11] evaluated the bond strength of resilient liners by means of 180^0 peeling and but tensile strength testing. Seventy two specimens were divided into peel bond and tensile bond specimen groups and were then subdivided into four test groups to evaluate each resilient liner. Tests were conducted with Instron at a cross-head speed of 2mm/ minute for tensile specimens and 5mm / minute for peel specimens. This study found supersoft resilient liner to have the highest bond strength with both peel and tensile tests. Molloplast. B showed both adhesive and cohesive modes and the lowest tensile and peel bond strength values. Moodhy S.L et al studied the peel, tensile and shear bond strength values of Molloplast. B bonded to denture base resin. This study also evaluated the effect of liner thickness and deformation rate on bond strength. The peel bond strength was 2.67 N mm and tensile bond strength was 180 Ibs / $inch^{2.}$ All types of failure were observed in tensile and shear specimens, the tendency was more towards cohesive failure.

Fumiaki Kawano et al (1994)[12] studied six soft denture liners by a two-phase tensile test. The samples were fabricated by processing them against polymerized polymethylmethacrylate, against unpolymerized polymethylmethacrylate. Samples were tested using an Instron Universal testing machine and the mode of failure was recorded. The bond strength against polymerized polymethyl methacrylate ranged from 0.94 to 2.56 MPa and for unpolymerized polymethylmethacrylate the bond strength ranged from 0.48 to 2.60 MPa. A two-way analysis of variance revealed a significant increase in bond strength against polymerized denture base except for Novus which had no change. B=Vina-soft decreased in bond strength. The study concluded that bonding can be influenced by the processing method.

Thomas.J.Emmer, Jr. et al (1995)[13] studied the adhesive and cohesive strength of different soft tissue liners bonded to the denture base by use of new technique. The specimen were tested after 24 hours and after 6 minutes immersed in water. The soft liners that were tested after 24 hours showed a cohesive failure, where specimens immersed in water for 6 minutes showed adhesive failure.

W.C. Wagner, et al (1995)[14] evaluated the dynamic viscoelastic properties of 12 laboratory-processed soft denture liners. The statistical significances of the results was tested by ANOVA and Scheffe's intervals test. Large differences in the storage modulus were found. Significant differences were found in the damping factor between many of the materials. Most of the acrylic and vinyl resins had higher damping factors than the silicone and polyphosphazine rubbers. Their conclusions well that the values of the storage moduli, loss moduli, and the damping factor were affected by temperature and by applied strain frequency with some materials.

Fumaiki Kawano et al (1997)[15] evaluated bond strengths of six commercial soft denture liners modified tensile test. The liners 10x10x3 mm were processed between two PMMA blocks. The samples were placed in tension and mode of failure, cohesive, adhesive or mixed were recorded. The results showed that Prolastic, Vina soft, Flexor had the lowest bond strength to cured PMMA. Super soft, Novus and Molloplast B demonstrated better bond strengths ranging from 16.7 to 17.6 Kg / cm^2. Bonding agents improved bond strength in Novus at 26.1 Kg / cm^2.

Pete M. Gronet et al (1997)[16] study was to determine whether coating three temporary soft denture liners with two different denture surface sealants, followed by thermocycling, affected the resiliency of the liners. They concluded that coating the porous surface of a temporary soft liner with a denture surface sealant increases the period of resiliency and overall longevity of the liners.

Aylin Baysan, et al (1998)[17] study was to determine whether using microwave energy to activate the polymerization of a silicone rubber denture soft lining material affected its properties. This method of polymerization does not compromise the strength of a soft lining material and its adhesion to polymethyl methacrylate. This study suggests the use of 3 minutes 650W microwave energy for processing a silicone soft lining material.

Michael G. Reeson, LCGI, and Nicholas J.A. Jepson, et al (1998)[18] studied on the thickness of long-term soft denture linings influences both their compliance and durability.He described a method for obtaining a uniform thickness of soft denture lining through the use of a vacuum-formed, thermoplastic blank as a spacer.The method can be applied to long-term soft linings placed in both old and newly fabricated dentures. The spacer can be modified to allow variations in the prescribed extension of the soft lining within the denture base.

Han-Kuang Tan, et al (2000)[19] performed a study to compare color, texture, and Shore A hardness of a resilient silicone denture liner with as-polymerized, roughened, or pumiced surface after treatment with perborate, persulfate, or hypochlorite-containing denture cleansers at 25^0C or 55^0C. He concluded that after silicone resilient denture liner treatment with certain perborate-containing denture cleansers, a greater amount of components could leach from the liner leading to loss of color if the liner surface is rough.

Nesrin Anil, et al (2000)[20] investigated microleakage at the interface of various soft liners and base materials. Microleakage of Mucopren and Molloplast B lining materials was the lowest. However, the microleakage of Flexor and Simpa was the highest. The aging process did not significantly affect the microleakage characteristics of the Simpa, Flexor, Mucopren (silanized), or Tokuyama materials.

Fumiyo Tamura, et al (2002)[21] conducted a study to evaluate the viscoelastic characteristics of a group of soft denture liners by means of a creep test. Concluded that the silicone rubber was as soft as the tissue conditioner and softer than the polyolefin liner. The stiffer the material, the lower the permanent deformation observed.

H. Murata, et al (2002)[22] evaluated the influence of variety of commercial tissue conditioners on alteration of viscoelastic properties of a heat-polymerized denture base acrylic resin. The dynamic viscoelastic properties of the acrylic resin specimens were measured and concluded that there was no much difference. Some tissue conditioners significantly plasticized the acrylic base resin of 0.5 mm thick. When the acrylic resin was 1mm thick, no plasticzation by the tissue conditioners was seen.

Gregory R. Parr, **et al (2002)**[23] investigated material property changes of 2 new resilient denture lining materials that represent 2 different curing modes: autopolymerization and conventional laboratory processing. He concluded that the laboratory-processed material was harder than the autopolymerized product and demonstrated greater resin solubility over time.

Yasemin Kulak-Ozkan, et al (2003)[24] study was to investigate the effect of thermocycling on the tensile bond strength of 6 soft lining materials. Six commonly used silicone-based resilient denture liners were chosen for the investigation. The bond strength was determined, in tension, after processing to PMMA. He concluded the adequate adhesive value for soft lining materials is given 4.5 kg/cm^2, all of the materials were acceptable for clinical use.

Gregory L. Polyzois, et al (2004)[25] studied the hardness of plasticized acrylic resin soft lining materials over time when curing procedures were modified and when surface sealers were either used or omitted. Their study showed differences relative to material and to time after processing. The heat processed plasticized resin material showed significantly higher shore A hardness values than the chair side. Increased hardness was seen depending on the processing method and surface treatment.

Naik Amit, etal (2005)[26] determined the tensile bond strength of three commercially available soft liners to polymethyl methacrylate denture base resin, to help the clinicians to select the liner for their patients, and to comparative database when new materials are introduced. Materials used for Tensile bond strength of super soft (acrylic based liner) was better compared to molloplast (silicone based liner) and mucopren (silicone based liner). He concluded the three materials factors such as processing methods, water sorption, bonding agents, changes in the bond strength in the harsh oral environment and chemistry of the material need further investigations to increase the serviceable life of the materials.

M.M. Mutluay, et al (2005)[27] determined the bond strength between four poly (organosiloxone) denture soft liners and a heat-cured acrylic resin denture base polymer. Furthermore, to evaluate the effect of bonding agents or primers on the PMMA denture base surface using SEM. He concluded the significant differences were found among materials with similar chemistry, probably because the bonding agents or primers were different.

Sudarat Kial – Amnuay, etal (2005)[28] investigated the influence of water storage on the durometer hardness of 2 RTV soft denture liners over a 1-year period. After 347 days in water. All HTV soft denture liners had higher indentation hardness than RTV liners initially.

Blanca Liliana Torres Leon, etal (2005)[29] evaluated and compared water sorption, solubility, and tensile bond strength of 2 resilient liner materials polymerized by different methods after being thermal cycled. Materials polymerized by microwave energy and visible light showed predominantly adhesive / cohesive failures and he concluded that the Light Liner material polymerized with visible light showed the lowest solubility values. Ever-Soft may be polymerized by microwave energy to obtain the greatest tensile bond strength values.

Ana Lucia Machado, et al (2006)[30] evaluated the potential effects of denture base resin water storage time and an effective denture disinfection method (microwave irradiation at 650 W for 6 minutes) on the torsional bond strength between two hard chairside reline resins (GC Reline and New Truliner) and one heatpolymerizing denture base acrylic resin. Up to seven microwave disinfection cycles did not decrease the torsional bond strengths between the hard reline resins. GC Reline and New Truliner to the denture base resin Lucitone 199 and that the effect of additional disinfection cycles on reline material may be clinically significant and requires further study.

Vanessa Migliorini Urban, et al (2006)[31] evaluated the ultimate tensile strength of a tissue conditioner without nystatin incorporation and the same tissue conditioner modified by the addition of nystatin in two concentrations and they concluded that the results of this study suggest that the addition of nystatin into the tissue conditioner investigated in concentrations below 1,000,000 U did not affect its ultimate tensile strength.

Duygu Sarac, et al (2006)[32] did a study which examined the effects of denture base resin surface pretreatments with different chemical etchants preceding the silicone-based resilient liner application on microleakage and bond strength. Treating the denture base resin surface with chemical etchants increased the bond strength of silicone-based resilient denture liner to denture base and decreased the microleakage between the 2 materials.

Carlos Nelson ELIAS in **(2007)**[33] evaluated the effect of thermocycling on tensile and shear bond strengths of three soft liner materials to a denture base acrylic resin. He concluded the bond strength of the three soft denture liners tested in this study changed with their chemical composition and all of them exhibited higher than those usually reported as clinically acceptable. The soft liners tested showed a significant decrease in the bond strength to as acrylic denture base resin after thermocycling.

Luciana Valadares Oliveria, etal (2007)[34] study was to test the effect of brushing on surface roughness of two resilient liners (Lusi Sof and Sofreliner) compared with an acrylic resin that the founded mechanical brushing increased it surface roughness of two resilient liners and the acrylic resin.

Sabrina Paran, et al (2007)[35] evaluated the effects of disinfection treatments with chemical solutions (2% glutaraldehyde, 5% sodium hypochlorite, and 5% chlorhexidine) and microwave energy on the hardness of four long-term soft denture liners. The application of two disinfection cycles did not change the Shore A hardness values for all the materials. The glutaraldehyde solution demonstrated the highest values of Shore A hardness for the Molloplast – B, Mucopren soft, and Ufigel-P materials, while Eversoft did not present any differences in hardness when submitted to different disinfection treatments.

Guang HONG, et al (2007)[36] conducted a study was to compare the influence of three kinds of storage methods on surface roughness of tissue conditioners. Four commercial tissue conditioners were used in this study. Mean surface roughness values of dental stone casts made from the tissue conditioners were measured using a profilometer. It was found that the materials stored in air showed the most stable and lowest values. Results obtained suggested that a tissue conditioner exhibited smooth and minimal change in surface roughness with time when stored in air than in distilled water and denture cleanser.

Calo herman et al (2008)[37] conducted a study to investigate the effects of aging on resilient denture lines. A plasticized acrylic resin (Dentuflex) and 2 silicone based (Molloplast – B, Softliner MS) resilient denture liners were examined and concluded that shore A hardness values for Dentuflex, Molloplast – B, Softliner MS soft liners were different from each other. (P<0.5) before (79±2.9; 40±1.4; 33±0.7) and after (80±3.1; 40±1; 34±0.9) thermocycling. He concluded thermocycling promoted increased hardness for Softliner and Dentuflex. Molloplast-B experienced no deleterious effects from either of the tests.

MATERIALS AND METHODS

MATERIALS AND METHODS

I. Armamentarium

i. Stainless steel, spacer. (Colour plate – II)

ii. Silicone rubber to allow easy removel. (Colour plate – II)

iii. Conventional denture flasks and clamps.

(Colour plate – II)

iv. 240 – grit silicone carbide paper.

v. Thermocycler. (Colour plate – IV)

vi. Universal testing machine (instron model No. 3365)

(Colour plate – V)

vii. Shore A Durometer. (Colour plate – VI)

viii. Vernier caliper – (Mitutoyo Digmatic caliper)

(Colour plate – VI)

The materials, type of reaction, formulations, manufacturer and batch no. are listed in table – I

Table – I, Material used in this study

Sl. No	Product	Type	Manufacture	Batch
1.	GC Reline^{TM} soft	Auto_Polymerized Silicone rubber.	GC Dental Products corp. 2-285 Toriimatsu-CHO, Japan.	0803111
2.	Ufi Gel-P	Auto_Polymerized Silicone rubber.	VOCO-Cuxhaven, Germany.	0845445
3.	GC-Soft Liner,	Auto_Polymerized Acrylic based.	GC Dental Products corp. 2-285 Toriimatsu-CHO, Japan	0804033
4.	Visco-Gel	Auto_Polymerized Acrylic based.	Dentsply Detrey Gmgh 78467 Konstanz, Germany.	0812000454

The mechanical properties studied were:

a. Tensile bond strength.
b. Shear bond strength
c. Hardness

Sample preparation

Total 68 specimens were prepared for testing the properties of tensile bond strength, shear bond strength and hardness. 24 specimens were prepared for tensile bond strength (6 for each soft denture liners. 24 specimens were prepared for shear bond strength (6 for each soft denture liners). 20 specimens were prepared for hardness (5 for each soft denture liners).

METHODOLOGY

FOR TENSILE BOND STRENGTH

The specimen preparation were carried out in accordance with the conditions laid down in ISO specification No: 10139-2 for soft liners. The polymethyl methacrylate blocks were made by investing stainless steel model in dental stone. The dimensions of model was 26mm long x 26mm wide x 3.5 thick with a slight convergence to one end to facilitate the easy removal of model and processed specimens from dental stone (Fig No: 2). After the dental stone was set the model plate was removed to create a space for packing acrylic resin (DPI Heat Cure).

A layer of undiluted alginate mould seal was painted uniformly on the mould. The heat cure PMMA resin packed into the mould space and cured according to manufacturer's instructions. After polymerization, the PMMA blocks were removed and wet grinded using P500 paper. The final dimension of specimens were 25 long x 25 wide x 3mm thick. Each specimens were individually measured by Vernier Caliper (Mitutoyo Digmatic Caliper) (Fig No: 13). The surface of PMMA blocks were cleaned dried and treated according to instructions by each soft liner manufacturers. The PMMA blocks were put top to top in silicon rubber separated by 25mmlong x 3mm wide x 3mm thick stainless steel spacer (Fig No: 2). The PMMA blocks and spacer were invested in silicon rubber to allow easy removal of specimens from the die. The silicon rubber along with PMMA blocks spacer was invested in dental stone in a dental flask. After dental stone was set, the stainless steel spacer were removed. The soft liner was packed into the space and the liner was processed according to manufacturer instruction. There after the specimens were removed from the mould, smoothened with 240 grit silica paper and the dimensions recorded (Fig No:5). The specimens were stored in water bath for 24 hours at 37^0C. The specimens were then subjected to thermocycling regimen of 3,000 cycles in a thermocycler system. (Haake-W15) (Fig No: 8) Alternated between 5^0C and 55^0C water bath. Dwell time was 1 minute. Theymocycled specimen were tested in a Universal Testing machine (instron model no: 3365) (Fig No: 9) at a cross speed of 10mm / minute. The maximum load “F” before failure was recorded.

The tensile bond strength was calculated (in MPa) according to the equation:

$$B = \frac{F}{A}$$

Where, F = Maximum load in Newton(N) before failure.

A = Adhesive area in square millimeter (M^2)

SHEAR BOND STRENGTH

The polymethyl methacrylate blocks were made by investing stainless steel model in dental stone. The dimensions of model is 26mm long x 26mm wide x 3.5 thick with a slight convergence to one end to facilitate the easy removal of model and processed specimens from dental stone (Fig No: 3). After the dental stone was set the model plate was removed to create a space for packing acrylic resin (DPI Heat Cure). A layer of undiluted alginate mould seal was painted uniformly on the mould. The heat cure PMMA resin packed into the mould space and cured according to manufacturer's instructions. After polymerization, the PMMA blocks were removed and wet grinded using P500 paper. The final dimension of specimens were 25 long x 25 wide x 3mm thick. Each specimens were individually measured by Vernier Caliper (Mitutoyo Digmatic Caliper) (Fig No: 13). The surface of PMMA blocks were cleaned, dried and treated according to instructions by each soft liner manufacturers.

The PMMA blocks were put side to side in silicon rubber separated by 6mm long x 3mm wide x 3mm thick stainless steel spacer (Fig No: 3). The PMMA blocks and spacer were invested in silicon rubber to allow easy removal of specimens from the die. The silicon rubber along with PMMA blocks spacer was invested in dental stone in a dental flask. After dental stone was set, the stainless steel spacer were removed. The soft liner was packed into the space and the liner was processed according to manufacturer instruction.

There after the specimens were removed from the mould, smoothened with 240 grit silica paper and the dimensions recorded (Fig No :6). The specimens were stored in water bath for 24 hours at 37^0C. The specimens were then subjected to thermocycling regimen of 3,000 cycles in a thermocycler system. (Haake-W15) (Fig No: 8) Alternated between 5^0C and 55^0C water bath. Dwell time was 1 minute. Theymocycled specimen were tested in a Universal Testing machine (instron model no: 3365) (Fig No: 9) at a cross speed of 5mm / minute. The maximum load "F" before failure was recorded.

The shear bond strength was calculated (in MPa) according to the equation: $B = \frac{F}{A}$

Where, F = Maximum load in Newton(N) before failure.

A = Adhesive area in square millimeter (M^2)

HARDNESS

The specimen preparation and testing were carried out in accordance with conditions laid down in ISO specification No: 10139-2 for soft liners. Disc shaped stainless-steel disk of dimension 31mm diameter x 6 mm thick were invested in silicon rubber (Fig -4). The silicon rubber along with stainless steel disk was invested in dental stone in a dental flask. After the dental stone was set, the stainless steel disk was removed. The soft liner were packed into the mould. Dental flask was clamped and the specimens were processed according to manufacturer's instructions. The specimens were removed from dental flask, the flash was trimmed with a scalpel and the specimens were stored in distilled water at 37^0C for 24 hours.

The specimens were subjected to thermocycling regimen of 3,000 cycles. A thermocycling system alternates between 5^0C & 55^0C water bath. Dwell time was 1 minute. After thermocycling, specimen were tested for hardness with shore –A Durometer test (Fig No: 12). Five measurement were recorded for each of the specimens. The average of the five readings was recorded for each specimens.

Colour Plate – I

Fig -1:- Materials used in this study

GC RELINE-Soft

Ufi-Gel-P

GC SOFT-LINER

Visco-Gel

Colour Plate – II

MOULDS USED IN THIS STUDY

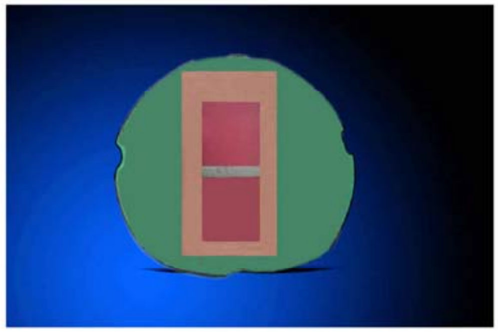


Fig-2 Stainless steel spacer and PMMA Blocks in the Dental flask for tensile bond strength

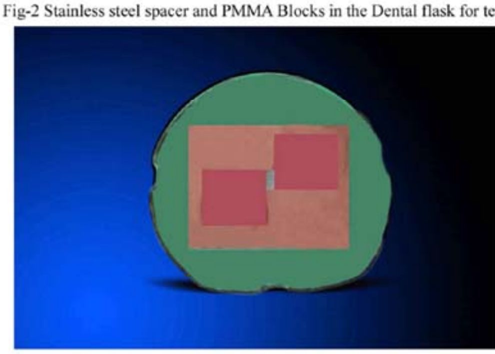


Fig-3 Stainless steel spacer and PMMA Blocks in the Dental flask for shear bond strength

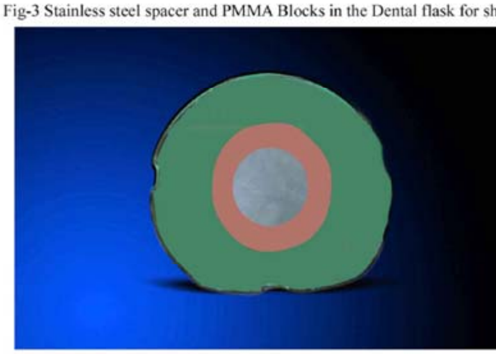


Fig-4 Stainless steel disk is spaced in the Dental flask for Hardness testing

Colour Plate - III

SPECIMENS USED IN THIS STUDY

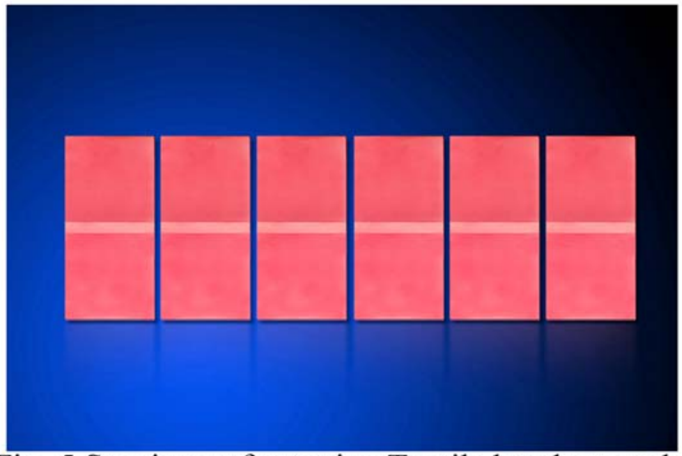


Fig -5 Specimens for testing Tensile bond strength

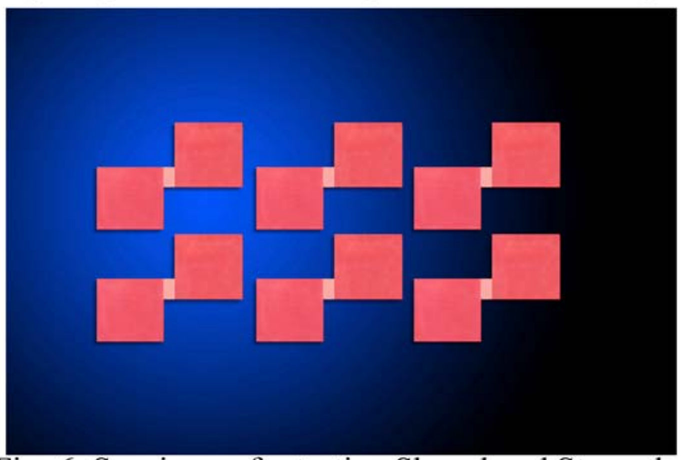


Fig -6 Specimens for testing Shear bond Strength

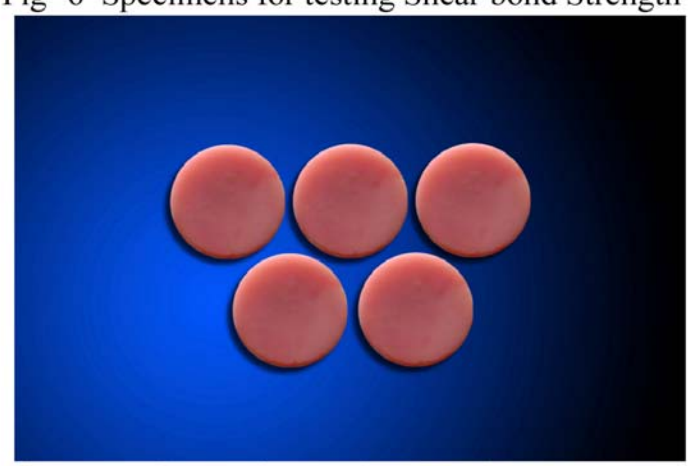


Fig -7 Specimens for Hardness testing

Colour Plate - IV

EQUIPMENTS USED IN THIS STUDY

Fig -8 Thermocycler (HAAKE-W15)

Colour Plate – V

TENSILE AND SHEAR BOND STRENGTH TESTING

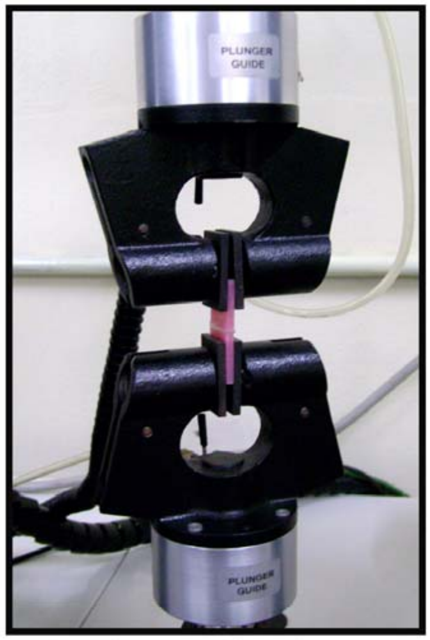


Fig -9 Universal testing machine (instron model no: 3365)

Fig - 10 Tensile bond strength testing

Fig -11 Shear bond strength testing

Colour Plate – VI

EQUIPMENTS USED IN THIS STUDY

Fig -12 Shore A Durometer

Fig -13 Vernier Caliper (Mitutoyo Digmatic Caliper)

RESULTS AND OBSERVATIONS

RESULTS AND OBSERVATIONS

The tensile bond strength, shear bond strength and hardness of four soft denture liner materials were evaluated. 24 specimens were tested for tensile bond strength, 24 specimens were tested for shear bond strength and 20 specimens were tested for hardness after thermocycling.

Statistical constants such as mean and standard deviations were calculated. Data were analyzed using computer software, statistical package for social science (SPSS) version 10. Data are expressed in its mean and standard deviation. Analysis of variance (One way ANOVA) was performed as parametric test to compare different soft denture liners. Duncan's Multiple Range (DMR) Test was also carried out as post hoc comparison to elucidate the individual group difference. Non parametric kruskal wallis ANOVA was employed to compare hardness of four soft denture liners. For all statistical evaluations, a two-tailed probability of value < 0.05 was considered significant. The superscript a, b, c and d indicates the difference between the values statistically and the values with the same superscript indicates no significant difference.

The basic data for Tensile Bond Strength, Shear Bond Strength and Hardness were shown in Table II to Table IV. The mean value of parameters studied for the four soft liners were presented in (Figure no: 14-16). The mean values and statistical analysis of the parameters studied were presented in Table V to Table X.

Table V shows the mean Tensile Bond Strength in MPa for four soft liners, values ranged from 0.5306 to 2.0185. The highest value of Tensile Bond Strength was obtained for G.C. reline soft. The lowest value of Tensile Bond Strength was obtained for viscogel.

Statistical analysis by one way ANOVA (Table VIII) showed that there was statically significant difference between the Tensile Bond Strength of four soft liners. GC reline had greater Tensile Bond Strength than other soft liners. Viscogel had least Tensile Bond Strength than other materials.

Table VI shows the mean Shear Bond Strength in MPa for four soft liners, values ranged from 0.4162 to 2.5039. The highest value of Shear Bond Strength was obtained for G.C. reline soft. The lowest value of Shear Bond Strength was obtained for viscogel.

Statistical analysis by one way ANOVA (Table IX) showed that there was statically significant difference between the Shear Bond Strength of four soft liners. GC reline had greater Shear Bond Strength than other soft liners. Viscogel had least Shear Bond Strength than other materials.

Table X shows that (Kruskal Wallis ANOVA) test for hardness compared between four soft liners. Statistical analysis showed that the difference between hardness of materials was significant. G.C reline had greater hardness than other soft liners. Viscogel had least hardness value compared to other soft liners.

TABLE – II

Table showing basic data for tensile bond strength (MPa) among the four soft denture liner materials tested.

Materials	Test No.						Mean
	1	2	3	4	5	6	
GC-Reline Soft	2.0261	2.7004	1.5639	2.6643	1.1380	2.0185	2.01853
Ufigel-P	1.6091	1.2027	1.8541	1.8393	1.0319	1.9074	1.574083
GC.Soft liner	1.3375	0.8424	1.0801	1.3925	1.3349	1.1975	1.197483
Viscogel	0.2013	0.8792	0.6088	0.3473	0.3913	0.4855	0.53063

TABLE – III

Table showing basic data for shear bond strength (MPa) among the four soft denture liner material tested

Materials	Test No.						Mean
	1	2	3	4	5	6	
GC-Reline Soft	2.1025	2.6018	2.5039	3.0937	1.2821	3.4395	2.5039
Ufigel-P	0.9701	1.5032	1.5675	0.9978	1.6749	2.6916	1.5675
GC.Soft liner	2.1455	1.2638	1.2161	1.2481	0.6956	0.7276	1.2161
Viscogel	0.6893	0.1690	0.4162	0.1806	0.8335	0.2084	0.4162

TABLE – IV

Table showing basic data for Hardness (Shore A) among the four soft denture liner material tested

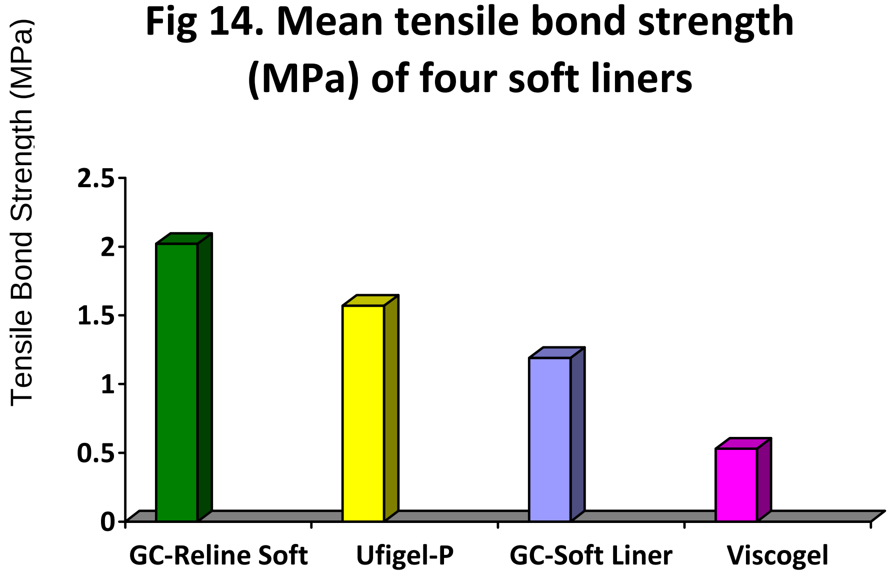
Materials	Test No.					Mean
	1	2	3	4	5	
GC-Reline Soft	53.4	45.8	46.8	45.8	49	48.16
Ufigel-P	28.6	27.8	28.2	29	28.4	28.4
GC.Soft liner	24.8	22.8	25	25	24.2	24.36
Viscogel	6	6	5.8	5.2	5.4	5.68

TABLE – V

Table showing Mean Tensile bond strength (MPa) among the four soft denture liner materials tested

Materials	Mean
GC-Reline Soft	2.01853
Ufigel-P	1.574083
GC.Soft liner	1.197483
Viscogel	0.53063

Fig 14. Mean tensile bond strength (MPa) of four soft liners



<u>TABLE – VI</u>

Table showing Mean Shear bond strength (MPa)

among the four soft denture liner materials tested

Materials	Mean
GC-Reline Soft	2.5039
Ufigel-P	1.5675
GC.Soft liner	1.2161
Viscogel	0.4162

Fig 15. **Mean shear bond strength (MPa) of four soft liners**

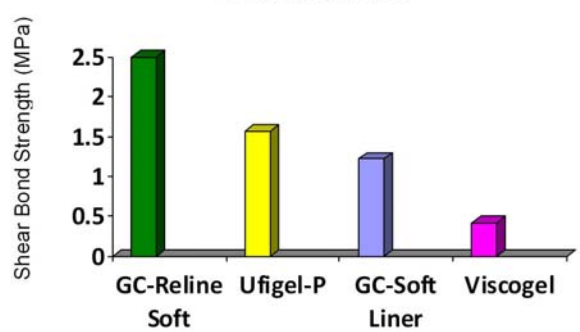


TABLE – VII

Table showing Mean Hardness (Shore – A) among the four soft denture liner materials tested

Materials	Mean
GC-Reline Soft	48.16
Ufigel-P	28.4
GC.Soft liner	24.36
Viscogel	5.68

Fig 16. **Mean shore A hardness of four soft liners**

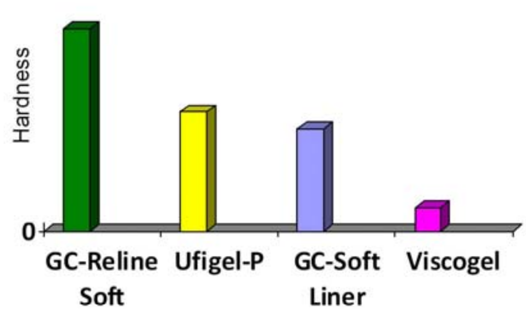


Table VIII

Analysis of variance (One Way ANOVA) comparing mean tensile bond strength (MPa) between four different groups.

Group	Mean	± SD	F value	P value
GC-Reline Soft	2.02[d]	0.59	37.047	< 0.001
Ufigel – P	1.71[b]	0.24		
GC-Soft Liner	0.90[c]	0.87		
Viscogel	0.49[a]	0.26		

A, b, c, d – Means with same superscript do not differ each other (Duncan's Multiple Range Test)

Table IX

Analysis of variance (One Way ANOVA) comparing mean shear bond strength (MPa) between four different groups.

Group	Mean	± SD	F value	P value
GC-Reline Soft	2.50[d]	0.72		
Ufigel – P	1.57[c]	0.60	58.049	< 0.001
GC-Soft Liner	0.22[b]	0.51		
Viscogel	0.42[a]	0.30		

A, b, c, d – Means with same superscript do not differ each other (Duncan's Multiple Range Test)

Table X

Analysis of variance (One Way ANOVA) comparing mean shore A hardness between four different groups.

Group	Mean	Medium	± SD	F value	P value
GC-Reline Soft	48.16[d]	47.00	3.29		
Ufigel – P	28.40[c]	28.00	0.82		
				93.701	< 0.001
GC-Soft Liner	24.36[b]	25.00	1.19		
Viscogel	5.68[a]	5.00	1.14		

A, b, c, d – Means with same superscript do not differ each other (Duncan's Multiple Range Test)

DISCUSSIONS

DISCUSSION

Soft liners are mainly used on complete dentures, where it is necessary to absorb masticatory loads and are indicated for patients who are unable to tolerate the pressures transmitted by the denture to the underlying mucosa of the edentulous ridge.

In this study, 4 liners were studied for their properties tensile bond strength, shear bond strength and hardness.

4 denture liners studied were:

1. GC Reline Soft
2. Ugifel – P
3. GC Soft liner
4. Visco-gel

The properties desirable for denture liners are as follows:

1. Cushioning effect upon the mucosa.
2. Permanent resilience and dimensional stability.
3. Should inhibit fungal growth.
4. Minimal water absorption & solubility.
5. Adhesion to denture base.

6. Resistance to abrasion.
7. Processing should be relatively stable adjustable & replaceable.
8. Should not deteriorate or weaken the denture base.

Indications for use of Tissue Conditioners

1. Thin non-resilient mucosal coverage.
2. Poor ridge morphology.
3. Persistent denture sore mouth.
4. Acquired or congenital oral defects.
5. Patients who have undergone radiation therapy.

- Specimens preparation & tests were carried at under ISO specifications No:10139 for soft denture liners.

TENSILE BOND STRENGTH

It is the maximum stress the material will with stand before rupture. The tensile bond strength of soft liners were tested using in a universal testing machine (instron moel No: 3365) (Fig No: 9). **Carlos Nelson Elias (2007)**[33] used it same instrument to find the tensile bond strength of soft liners. In the present study the GC-reline soft had the maximum value of tensile bond strength is 2.0185 MPa, compared to Ufigel-P is 1.5740 MPa, GC-Soft liner is 1.1974 MPa and Viscogel is 0.5306 MPa. Statistical analysis by one way ANOVA and Duncan's multiple range test showed that there is statistically significant difference ($P < 0.001$) for tensile bond strength between the soft liners. GC reline soft was found to have higher tensile bond strength than other 3 soft denture liners. The superior tensile bond strength of GC reline indicates that it more durable and can be used in clinical cases, where soft liners has to be used for a long period of time.

SHEAR BOND STRENGTH

It is the maximum stress that a material can withstand before failure in a shear mode of loading. Shear strength is used to study the interface between 2 materials. The shear bond strength of soft liners were tested using in a universal testing machine (instron moel No: 3365) (Fig No: 9). In the present study GC Reline soft had the maximum value of shear bond strength 2.5039 MPa, compared to Ufigel-P 1.5675 MPa, GC-soft liner 1.2161, Visco-gel 0.4162. Statistical analysis by one way ANOVA and Duncan's multiple range test showed that there is statistically significant difference ($P < 0.001$) for shear bond strength between the soft liners. GC-reline soft was found to have higher shear bond strength than other 3 soft denture liners. The superior shear bond strength of GC reline indicates that it more durable and can be used in clinical cases, where soft liners has to be used for a long period of time.

HARDNESS

Resistance of a material to plastic deformation typically measured under an indentation load. The hardness of soft liners were tested using shore A Durometer (Fig:12). **Calo Hermonn (2008)**[37] used it same instrument to find the hardness of soft liners. It is a compact portable unit with a spring loaded metal indenter. The blunt pointed indenter is of 0.8mm (1/33 inch) in diameter that tapers to a cylinder 1.6 mm (1/16 inch). The indenter is attached by a lever to a scale that is graduated from 0-100 units. If the indenter completely penetrates the sample a rating of 0 is obtained. If no penetration occurs 100 units results.

According to ISO specification the hardness value of soft liners tested with shore A Durometer should be $\leq$ 55 is ‘soft’ and $\leq$ 35 is ‘extra soft’. In the present study the GC-reline obtained a higher reading (48.16) compared to other soft liners. The least value for hardness was obtained for viscogel (5.68). Hardness was compared using statistical analysis of variance (Kruskal Wall is ANOVA). There was statistically significant difference ($P < 0.01$) for hardness between GC-reline soft, Ufigel-P, GC-soft liner and Viscogel). The clinician can select GC-reline soft for the long term use of soft liners, such as in obturator or complete denture on sharp ridges. For conditioning of abuses tissue the clinician can select viscogel which has got high degree of softness.

THERMOCYCLING

Yasemin Kulak - Ozkon (2003)[24] study was to investigate the effect of thermocycling on the tensile bond strength of 6 soft lining materials. This study indicate that the bond strengths of soft lining materials had significantly decreased after thermocycling. Thermocycling is the process by which the materials ages. After thermocycling, "VISCOGEL" showed significant reduction in bond strength. This is due to the result of swelling and stress building at the bond interface or of the changed viscoelastic properties of the resilient lining material. "GC-RS" showed highest bond strength of all materials after thermocycling. For silicone based resilient lining materials, an adhesive applied to aid in bonding to the denture base resin because silicone denture base liners have little or no chemical adhesion to PMMA resin. From this study it was seen that the thermocycling generally decreased the tensile bond strength & changed the mode of adhesive failure in resilient liner materials / thermocycling resulted in significant decrease in tensile & shear bond strengths and hardness (Shore A Hardness) of silicone based liners to an acrylic denture base resin.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The study was conducted to compare the tensile bond strength, shear bond strength and hardness of four commonly used soft liners after thermocycling.

The materials used in this study were:

1. GC-reline soft
2. Ufigel-P
3. GC-Soft liners
4. Viscogel

Statistical analysis of the results by one way ANOVA was done.

Conclusion

With in the limitation of the study the following conclusions can be made.

1. GC-reline soft showed higher values for Tensile bond strength and Shear bond strength than the other three soft liners.
2. Viscogel showed least value for hardness showing that it is the softest of the soft liners tested.
3. The hardness of GC-reline conformed to the values specified in the ISO specification for 'soft' where as the hardness of

other 3 soft liners conformed to the values specified in the ISO specification for “extra soft”.

4. The silicone based soft liners (GC-reline, Ufigel-P) showed higher values for the properties tested compared to Acrylic based soft liners.
5. This study shows that for long term use of soft liners, GC-reline is the material of choice, where as for short term use such as for conditioning of tissues the “extra soft” viscogel is the materials of choice.

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