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Comparison of Tensile strength, Shear strength, Hardness, and Micro-leakage of Silicone and Acrylic based Soft liners. An In-vitro Study

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Abstract

Purpose: To evaluate tensile strength, shear strength, hardness, and micro-leakage of four commonly used soft tissue denture liners applied on surfaces of heat-cured polymethyl -methacrylate resin samples.

Materials and methods: Four soft liners were compared in this study. They are two Silicone soft reliners (GC – Reline™ soft & Mollosil) and two Acrylic soft reliners (GC Soft liner & Acryton). 160 heat cure acrylic specimens were fabricated in Stainless steel molds with ISO standardized specifications. Each soft-liner group (n=40) was applied on fabricated heat-cured acrylic specimens after pre-treating the surfaces with etchant. Samples from each soft-liner group were tested for Tensile strength(n=10), Shear strength(n=10), Hardness(n=10), and Microleakage(n=10) and the values were noted down.

Result: Silicone-based GC- Reline™ soft and Mollosil soft liners had higher tensile and shear strength values when compared to Acrylic-based GC -Soft reliner and Acryton. The hardness values for GC- Reline™ soft reliner and Mollosil are greater than GC- Soft liner, and Acryton. The micro-leakage values are less for Silicone-based GC-Reline™ Soft and Mollosil soft liners when compared to Acrylic GC- Soft reliner and Acryton.

Conclusion: Silicone soft reliners had greater values for tensile strength shear strength and lower hardness values indicating that they are more durable than Acrylic soft liners. Silicone soft liners showed the least micro-leakage than Acrylic soft liners indicating their usage for a longer time. Acrylic soft liners are more suitable for short duration tissue conditioning.

Keywords: Soft denture liners, Denture base resins, Thermo-cycling, Tensile strength, Shear strength, Hardness, and Micro-leakage.

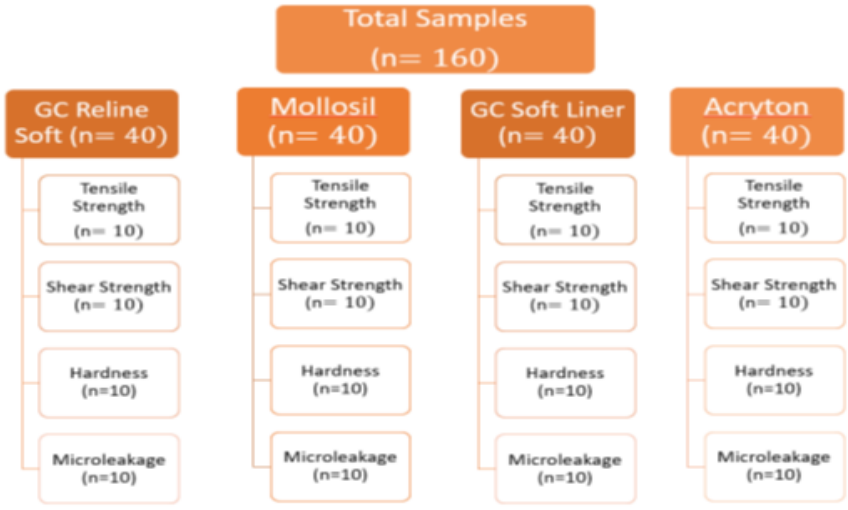
Introduction

Soft liners have been in existence since 1869 discovered by Twitchell [1]. Soft liners have been suggested as an affordable solution for recovery of inflamed tissues and significantly improve patient comfort.[2] Soft liners have glass transition temperature below the mouth temperature and so they are semisolid at mouth temperature attributing to their softness [3]. Soft lining materials provide cushioning effect for dentures in clinical cases of inflamed oral mucosa and bone undercuts [4]. Soft denture liners provide an even distribution of masticatory forces on the denture-bearing area and avoid local stress concentrations.[5] Soft reliners are used for short and long-term applications in the oral cavity and are categorized into acrylic and silicone types.[6]

Materials & Methodology

Short-time usage soft reliners are also referred to as tissue conditioners. Materials available and widely used as long-term soft liners include plasticized acrylics and silicone rubber, which are either chemically or heat polymerized [7]. The choice for the clinical use of a soft liner depends on the material's biocompatibility, mechanical properties, and durability in the oral environment. In this study, the durability of four commercially available soft liners applied on the tissue surface of heat-cured polymethyl methacrylate (PMMA) resin specimens was assessed by testing the tensile strength, shear strength, hardness, and micro-leakage. The reason for the selection of the materials Silicon-based GC-Reline™ Soft (GC Dental, Japan), Mollosil (DE tax, Germany), Acrylic-based GC-Soft liner (Gc Dental, Japan), Acryton (Orthoplast, India) is their availability and preferred mostly in clinical practice.

A total number of 160 Heat -cured acrylic specimens (PMMA) were fabricated. The specimen preparation was carried out by ISO specification No: 10139-2. Steel dies with dimensions of the mold 25mm length x 25mm width x 3.0mm thick were made in the working lab. Wax patterns were prepared from the die and processed in the lab with heat cure resins. Each specimen was measured by Vernier Callipers (Mitutoyo Digmatic). Total samples were divided into four groups of 40 for each soft liner (n=40). The 40 acrylic specimens lined with individual soft liners were further subdivided into subgroups of 10 specimens (n = 10) for each test as indicated in the flow chart.



Pre-treating

The surface of resin samples with a chemical etchant monomer was to create a rough surface, which increases the adhesion between the tissue surface of denture base resin and soft liner. According to many studies pre-treating the resin, surface increased the tensile strength of silicone resilient liner to denture base and decreased the microleakage between the two materials [8].

Thermo cycling

Is intended to simulate the thermal stress to which the material would be exposed due to aging. All the specimens in this study were placed in a water bath for 24 hours at 37^0C. Thermocycling of 3,000 cycles which equals 6 months period in a thermocycler system alternated between 5^0C and 55^0C was used. Dwell time was 1 minute.

Methods of Testing

Tensile strength

Is the maximum stress the material will be able to withstand before rupture. The thermocycled specimens were tested using Universal Testing Machine (Instron model no: 8801) at a cross speed of 10mm /minute. The tensile strength of each specimen from all four groups (n=10) was calculated (in MPa) by the equation: B= F/A where F = Maximum load in Newton(N) before failure and A = Adhesive area in square millimetre (M^2).

Shear strength

Is the maximum stress that a material can withstand before failure in a shear mode of loading. The strength of soft liners was tested using a Universal testing machine (Instron Model No: 8801). The shear strength was calculated (in MPa) according to the equation: B= F/A for all the four soft liners(n=10).

Hardness is the

Resistance of a material to plastic deformation measured under an indentation load. The Shore A Durometer which reads from 0-100 units is a device used for measuring the hardness of a material. The hardness value is determined by the penetration of the Durometer indenter foot into the specimen. Higher values on the scale indicate less resistance to indentation and lower values indicate high resistance to intender. Measurements were recorded for each specimen by placing the specimen below the indenter of the Shore A Durometer. The Shore A Durometer was held in a vertical position, and the presser foot was applied parallel to the surface of the specimens. The readings were obtained one second after firm contact was achieved[9]. Less penetration of the indenter indicates that hardness is high. More penetration of the indenter indicates that hardness is low.

Micro-leakage

specimens for testing micro-leakage were stored in hematoxylin stain for 14 days. Then the disks (n=40) were sectioned with micromotor (Marathon) with the help of acrylic cutting disks. The micro-leakage in this study of all the four groups was tested using a stereomicroscope by measuring the interphase between the soft reliner and the acrylic resin.

Results

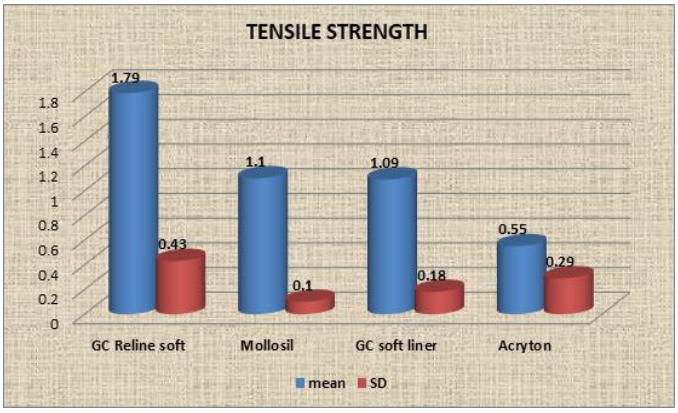
Tensile strength

In this study, the tensile bond strength values are given in units of Mega pascals (MPa). The soft-liner GC-Reline$^{TM\ Soft}$ had the maximum value of tensile strength (1.79), compared to Mollosil (1.10), GC-Soft liner (1.09), and Acryton (0.55). Statistical analysis by one-way ANOVA shows that there is a statistically significant difference ($P < 0.001$) in tensile strength between the four soft reliners.

Table 1: Comparison of Tensile strength of GC-Reline™ Soft, Mollosil, GC-Soft liner &Acryton reliners.

Material	Mean	SD	P-value
GC Reline soft	1.79	0.43	0.001*
Mollosil	1.10	0.10	
GC Soft liner	1.09	0.18	
Acryton	0.55	0.29	

Graph 1



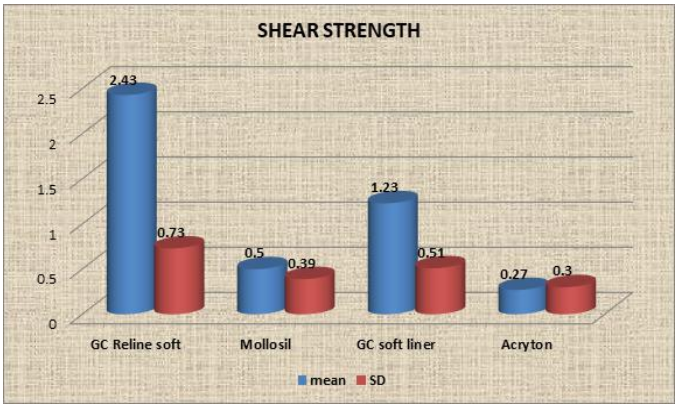
Shear strength

GC Reline™ Soft had the maximum value of shear bond strength (2.43), compared to Mollosil (0.50), GC-Soft liner (1.23), and Acryton (0.27). Statistical analysis was done by one-way ANOVA. There was a statistically significant difference of ($P < 0.001$) in shear bond strength between the soft liners.

Table 2: Comparison of Shear bond strength of GC-Reline™ Soft, Mollosil, GC-Soft liner & Acryton.

Material	Mean	SD	P-value
GC reline soft	2.43	0.73	0.001*
Mollosil	0.50	0.39	
GC soft liner	1.23	0.51	
Acryton	0.27	0.30	

Graph 2



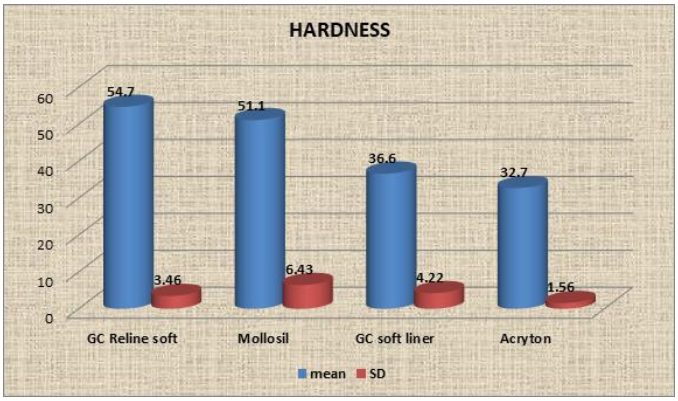
Hardness

An average of five readings was noted for each specimen in all the four groups(n=10) measured in Newtons(N). GC-Reline™ Soft obtained a higher reading of hardness indentation (54.70) compared to other soft liners Mollosil (51.10), GC- soft liner (36.60), and Acryton (32.70). According to statistical analysis of variance (ANOVA), a significant difference ($P < 0.01$) for hardness was seen between the four groups of soft liners.

Table 3: Comparison of Hardness of GC-Reline™ Soft, Mollosil, GC-Soft liner &Acryton

Material	**Mean**	**SD**	**p-value**
GC reline soft	54.70	3.46	0.001*
Mollosil	51.10	6.43	
GC soft liner	36.60	4.22	
Acryton	32.70	1.56	

Graph 3



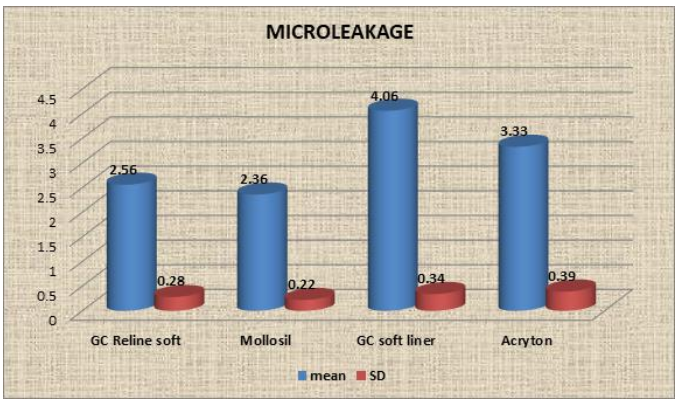
Micro-leakage

Micro-leakage values measured in microns(µm) of soft liners obtained are GC-Reline™Soft (2.56), Mollosil (2.36), GC-Soft liner (4.06) & Acryton (3.3). Among all the soft liners, Mollosil (2.36 µm) showed the least microleakage and GC-Soft liner (4.06 µm) showed the highest microleakage.

Table 4: Comparison of Microleakage of GC-Reline™ Soft, Mollosil, GC-Soft liner &Acryton

Material	Mean	SD	p-value
GC reline soft	2.56	0.28	0.001*
Mollosil	2.36	0.22	
GC soft liner	4.06	0.34	
Acryton	3.33	0.39	

Graph 4



Discussion

Soft reliners are being used in the treatment of denture patients to provide cushioning effect between the denture and the tissues. Their applications for lining the dentures in cases of atrophic ridges, bony undercuts, bruxism, xerostomia, and dentures opposing natural teeth have shown to be clinically beneficial. This study was done to evaluate the adhesion of soft liners to polymethyl methacrylate (PMMA) denture base resin surfaces. In this study, 4 soft liners Silicon-based GC Reline Soft, Mollosil, and Acrylic based GC Soft liner, Acryton were applied on heat cure acrylic specimens (PMMA) and tested to compare their properties of tensile strength, shear strength, hardness, and microleakage.

Tensile Strength

In the present study Silicone, soft liners showed superior strength to Acrylic soft liners." GC-Reline™ Soft" exhibited the highest bond strength of all materials. El-Hadary and Drummond [10] evaluated two soft denture lining materials with different chemical compositions silicone-based soft liner and a plasticized acrylic resin soft liner and concluded that based on tensile bond strength, Silicon soft liner provides a better clinical success**.** Ayse Mese et al[11] stated that silicone-based resilient liners had significantly higher tensile strength values than the acrylic-based resilient liners. Choi et al [12] in their study concluded that Silicone-based resilient denture liners produced the highest tensile bond strength values.

Shear Strength

In the present study, GC-Reline™ soft have higher shear bond strength values than the other three soft reliners. The superior shear strength value of Silicone-based GC Reline™ indicates that it is more durable and can be used in clinical cases for a longer period. Silicone soft liners showed superior strength to Acrylic soft liners. Raja Ganesh et al [13] in their study concluded that the silicone soft liner showed higher shear bond strength than acrylic soft liner before and after thermal cycling.

Hardness

In this study, Silicone-based soft liners had higher values of hardness when compared to Acrylic-based soft liners indicating that silicone soft liners retained their softness better than acrylic soft liners. Acrylic soft liners became harder when compared to Silicon-based soft liners after thermocycling. Ayse Meze et al, [11] stated that the hardness values of acrylic resin showed greater change

than those of the silicone soft liners indicating that acrylic-based soft liners become much harder with time which coincides with the present study.

Mutualy et al [14] conducted hardness tests and concluded that Polysiloxane soft liner materials preserved their softness, surface texture, and surface smoothness better under cyclic loading compared to acrylic resin soft liner materials. Murata et al [15]stated that acrylic soft-liner materials had a significant change in viscoelastic properties and loss of cushioning effect over time than silicone soft liners. They concluded that from the standpoint of durability, silicones are preferred.

Pahuja et al [16] who studied the effect of different chemical disinfection methods on the increase in surface hardness of soft denture liners came up with the conclusion that acrylic-based soft liners showed a significantly higher increase in surface hardness than silicone soft liners.

Mancuso et al [17] tested the hardness and colour stability of acrylic resin and silicone soft liners after thermocycling and concluded that the hardness and colour stability of silicone soft reliners were less affected than acrylic resin soft reliners.

Microleakage

Debonding of liners from the denture base is one of the factors that influence the longevity of soft denture liners as it results in microleakage at the interface [18]. The bond between the acrylic resin denture base and silicone soft liners failed quite too often requiring repeated relines. In the present study silicone, soft liners showed the least microleakage values than acrylic soft liners after thermocycling.

According to the review of literature, most of the studies on the physical properties of soft liners stated that Silicone soft reliners constantly performed better than Acrylic soft reliners. Silicone soft liners showed lower surface roughness values, less water sorption, better tensile bond strength, decreased surface hardness, and better colour stability over a while than acrylic soft liners. It was observed that silicone soft liners performed better than their acrylic counterparts in most of the studies[19]. These positive outcomes contributed to improvement in patient satisfaction and Oral Health-related quality of Life.[20]

Conclusion

From this study it can be concluded that the Silicone soft liners depicted better values for physical properties compared to Acrylic soft liners. Silicone soft liners had higher tensile and shear strength values when compared to acrylic soft liners. Acrylic soft liners were harder when compared to Silicon-based soft liners. Silicone soft liners exhibited the least microleakage values than acrylic soft liners. From the test values obtained for different groups, it can be inferred that Silicone soft liners are better able to withstand tensile and shear forces for a longer time when compared to Acrylic-based liners. Thereby, it can be concluded that for long-duration use and better clinical outcome, Silicone based soft liners are superior to Acrylic based soft liners.

References

1. Twitchell H: Improvement in dental plates. US Patent, No.88,682, 1869.

2. Shim, J.S. and D.C. Watts, 2000. An examination of the stress distribution in a soft-lined acrylic resin mandibular complete denture by finite element analysis. Int J Prosthodont., 13:19-24.

3. Kalamalla Ayappa Saran Babu A Beginners guide for soft liners- Mini review. J. Pharm. Sci. & Res. Vol. 11(12), 2019, 3802-3805.

4. Aylin Bays an. Adhesion and tear energy of a long-term soft lining material activated by rapid microwave energy. J.P.D 1998; 79:182-87.

5. Wright PS. A three-year longitudinal study of denture soft lining materials in clinical use. Clin Mater 1986; 1:281-91.

6. Brożek R, Koczorowski R, Rogalewicz R, Voelkel A, Czarnecka B, Nicholson JW. Effect of denture cleansers on chemical and mechanical behaviour of selected soft lining materials. Dent Mater 2011; 27:281-90.

7. Zarb GA, Bo lender CL. Prosthodontic Treatment for Edentulous Patients. 12th ed. Elsevier India Private Ltd. 2004. p. 198-202.

8. Duygu Sarac, DDS, Ph.D., a Y. Sinasi Sarac, DDS, Ph. D., b Tarik Basoglu, MD, c Oktay Yapici, MD, d and Emir Yuzbasioglu, DDS. The evaluation of microleakage and bond strength of a silicone-based resilient liner following denture base surface pre-treatment J Prosthet Dent 2006; 95:143-51.

9. Gregory. L. Polyzois. Influence of curing method, sealer, and water storage on the hardness of a soft lining material over time, Journal of prosthodontics 2004; 10: 42-45.

10. 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.

11. Ayse Mese [1], Kahraman G Guzel Effect of storage duration on the hardness and tensile bond strength of silicone- and acrylic resin-based resilient denture liners to a processed denture base acrylic resin. J Prosthet Dent 2008 Feb;99(2):153-9.

12. Choi JE, Ng TE, Leong CKY, Kim H, Li P, Waddell JN, et al. Adhesive evaluation of three types of resilient denture liners bonded to heat-polymerized, auto polymerized, or CAD-CAM acrylic resin denture bases. J Prosthet Dent 2018; 120:699-705.

13. Raja Ganesh N, Sabari Nathan S, Azhagar Asan NS, Shankar C, Krishnakumar J, Swathi S. Comparative evaluation of shear bond strength of two different chairside soft liners to heat-processed acrylic denture base resin: An in vitro study. J Pharm Bio allied Sci 2016; 8:154-159.

14. Mutluay MM, Tezvergil Mutluay A. The influence of cyclic stress on surface properties of soft liners. Odontology 2017; 105:214-21.

15. Murata H, Hamada T, Sadamori S. Relationship between viscoelastic properties of soft denture liners and clinical efficacy. Jpn Dent Sci Rev 2008; 44:128-32.

16. Pahuja RK, Garg S, Bansal S, Dang RH. Effect of denture cleansers on surface hardness of resilient denture liners at various time intervals an in vitro study. J Adv Prosthodont 2013; 5:270-7.

17. Mancuso DN, Goiato MC, Zuccolotti BC, Moreno A, dos Santos DM, Pesqueira AA. Effect of thermocycling on hardness, absorption, solubility, and colour change of soft liners. Gerodontology 2012;29: e215-9.

18. Sabarigirinathan C, Muthu Kumar K, Vinaya gavel K et. al. A comparative study of microleakage of heat cure silicone soft liner and self-cure silicone soft liner with heat-cured acrylic denture base after accelerated aging and surface treatment - an in vitro study. Int J Health Sci Res. 2015; 5(7):198-205.

19. Pahuja RK, Kaura S, Roy N. Comparative evaluation of physical properties of commercially available silicone-based soft denture liners and acrylic-based soft denture liners. An In vitro study. Indian J Dent Sci 2020; 12:56-61.

20. Pisani, M.X., L. Malheiros-Segundo Ade, K.L. Balbino, R.F. de Souza, F. Paranhos Hde and C.H. da Silva, 2012. Oral health related quality of life of

edentulous patients after denture relining with a silicone-based soft liner, Gerodontology, 29, 474-480.

Legend Figure

Fig 1: Acrylic Samples used for Tensile strength testing.

Fig 2: Acrylic Sample tested for Tensile strength in UTM.

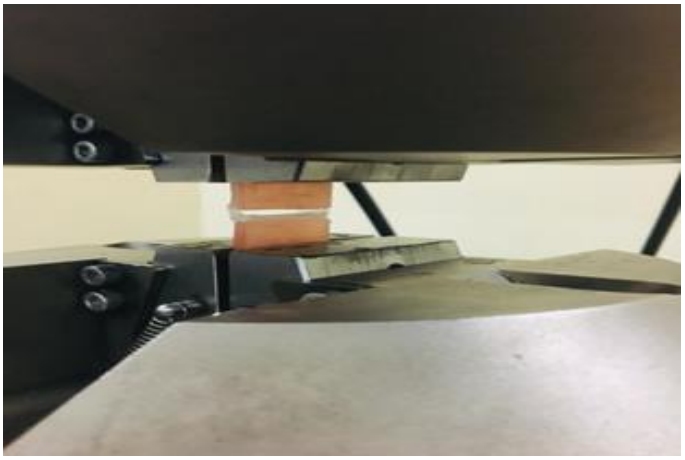


Fig 3: Acrylic Samples used for Shear strength testing.

Fig 4: Acrylic Sample tested for Shear strength in UTM.