

To Evaluate Different Soft Tissue Liners, as Functional Impression Materials, by Determining its Effect on Surface Roughness of Dental Stone Over a Time Period: An *In-Vitro* Study

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Abstract

a) Purpose: To evaluate, compare and contrast the changes in surface roughness of dental stone casts, recovered from commercially available chair-side soft liners, used as functional impression materials.

b) Methods: Ten disk-shaped denture soft liner samples [18 mm wide × 2 mm thick] were fabricated and dental stone poured over it after zero hours [control], one day, seven days, fourteen days and twenty one days, with a total sample size of 100 obtained from GC SOFT LINER [50 samples] and MOLLOSIL [50 samples] respectively. The dental stone samples were then evaluated for mean surface roughness values [Ra] using a profilometer.

c) Results: Student's paired t test [$p < 0.05$] and Co-efficient of variance [C.V] test was used for statistical analysis. The mean surface roughness values of MOLLOSIL samples increased gradually and consistently over the period of zero hours to twenty-one days in comparison to the GC SOFT LINER samples.

d) Conclusion: Within the limitations of this study, silicone-based soft tissue liner showed better results than the acrylic-based soft liner in terms of surface roughness, over the period of zero hours to twenty-one days.

Introduction

Acrylic resin denture base material forms an interface of the oral mucosa which bears the occlusal forces and acts as an artificial foundation and maintains the artificial teeth in place. The modulus of elasticity [stiffness] of the tissues on which they rest [1.25-5.0Mpa] is significantly lower compared to the acrylic denture base material [2400Mpa] [1-3]. To prevent the likelihood of discomfort of denture base material due to tissue trauma and sore spots of the oral mucosa as a result of the friable nature of the supporting mucosa, areas of force concentration, or misfit of the denture base, soft liners covering the soft tissues was developed [4]. A soft denture liner is a polymeric material placed on the intaglio surface of the denture base to assimilate the forces produced by mastication and to act as a type of "shock absorber" between the occluding surfaces of a denture and the underlying oral mucosa [5]. Two main types of soft liners can be identified, namely plasticized acrylics and silicone elastomers, available in both, auto polymerized and heat-

polymerized forms [6,7]. However, the International Organization for Standardization [ISO] classifies soft liner materials into two main types: ISO 10139-1:1991, Part 1: short-term materials and ISO 10139-2:1999, Part 2: materials for long-term use [8,9] Functional impression materials are those materials that are applied to the intaglio [basal] surface of an impression tray or a denture, that record the basal seat and border tissues position and topography in a functional position [10,11]. The placement of soft-liner material can be used as the final impression either following the initial set of material [as with other final impression materials] or by having the patient wear and function with the prosthesis for a defined period of time. However, there is no substantial data for the use of soft liners as functional impression material during denture fabrication [12,13]. During clinical use, denture with soft liner material comes in contact with some form of aqueous liquid solution namely saliva during function in oral cavity or water or denture cleansing agent during storage, thus making determination of water sorption and

solubility of prime importance [14,15]. The usefulness of the soft liners as a soft lining material is limited depending upon the type of soft lining material, due to the leaching out of the plasticizer with consequent hardening of the material, thus resulting in the change of the physical and mechanical properties of the soft relining material with time in the patient's mouth [16-19]. However, surface roughness is considered an important factor in the adhesion and retention of microorganisms onto the surface, with an increased retention of microbial cells seen with an increase in surface roughness [20-25]. So, it is imperative to evaluate the changes in the surface roughness of the stone casts obtained from the soft tissue liners, when used as functional impression materials, over time, immersed in a liquid media. This study is an attempt to evaluate, compare and contrast two different commercially available soft tissue liners, used as functional impression materials, by determining its effect on surface roughness of dental stone over a time period.

Materials and Methodology

The materials and armamentarium used for the study are enumerated in Tables 1 & 2 accordingly. The methodology followed in this study involved, preparation of soft tissue liner samples, preparation of dental stone samples and surface roughness test of the dental stone samples [26,27].

Table 1: List of materials used for the study.

S.No	Material	Manufacturer	Recommended ratio
1	Acrylic temporary relining material	GC-Fuji SOFT LINER, GC India Inc	2.2g/1.8g (Powder/Liquid)
2	Long term, chairside, silicone soft liner	MOLLOSIL, Detax GmBh Co	1:1 (2-paste system)
3	Type III dental stone	KALSTONE, Kalabhai Karson Pvt Ltd	30ml/100g (Water/Powder)
4	Artificial saliva	SALEVA, Goran Pvt Ltd	-

Table 2: List of materials used for the study.

S.No	Material	Manufacturer
1.	Custom made metal mould (18mm diameter; 2mm thickness) with 2 covering metal plates.	-
2.	Rubber bowl, plaster spatula, BP blade	-
3.	Long bladed mixing spatula	-
4.	Tweezer	-
5.	Mechanical vibrator	major vibrator c-71, Confident
6.	Mechanical vacuum mixer	Cuumyx labo-14, Confident
7.	Hydraulic press	Sirio
8.	Incubator	The ile co
9.	Profilometer	SURFTEST SJ.201P/M, Mitutoyo

Methodology Followed

a. Preparation of Soft Tissue Liner Discs

A precise three plate metal mould was fabricated which can be separated and realigned one above the other accurately (Figure 1). The upper and lower metal plate consisted of flat plane metal which was used to maintain and acquire soft tissue liner discs of uniform thickness by application of opposing pressure over the middle metal plate. The middle metal plate consisted of 2 rows of 5 uniform discs with dimension, 18 mm wide and 2mm deep [28]. The two soft tissue liners used for the study were mixed according to the manufacturer's recommendation at room temperature (Table 1). They were then carried and placed into the central plate containing the disc spaces and slightly overfilled. The three-plate metal mould assembly was centered, realigned and subjected to constant pressure on a hydraulic bench press for 15 minutes, in order to obtain soft tissue liner discs of uniform 2mm thickness [29-32]. After 15 minutes, the upper plate was removed and the excess soft liner material was removed using a sharp blade to obtain 10 soft liner discs of uniform thickness and diameter (Figures 2 & 3). Distorted, damaged or broken discs were discarded. Ten disc shaped specimens were recovered from the metal mould and then stored in artificial saliva in an incubator at 37°C for zero hours [control], one day, seven days, fourteen days and twenty one days respectively. Thus, a total of 100 samples were prepared, with 50 soft tissue liner samples obtained from GC SOFT LINER and 50 soft tissue liner samples from MOLLOSIL [33-35].

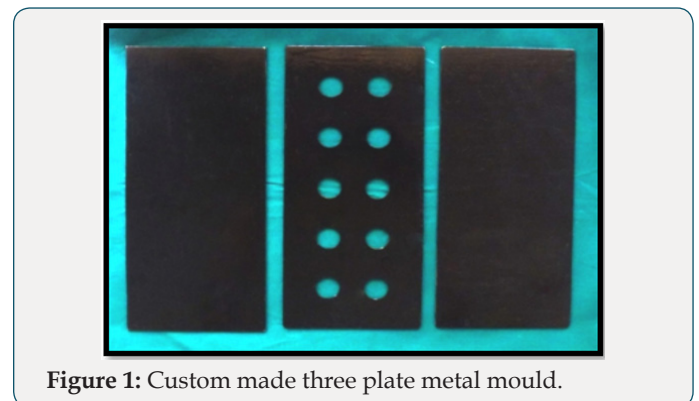


Figure 1: Custom made three plate metal mould.

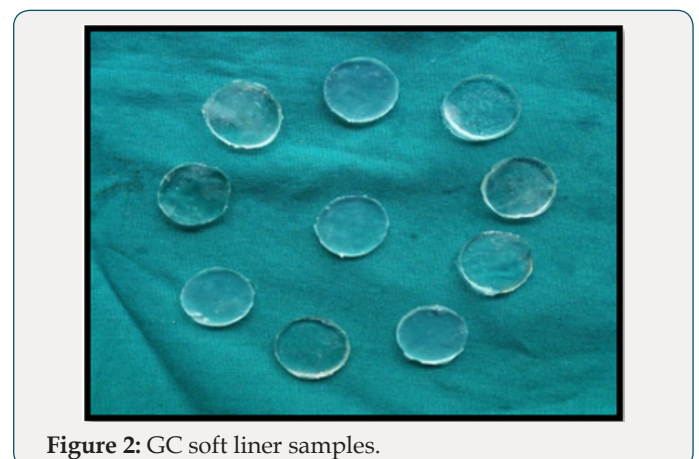
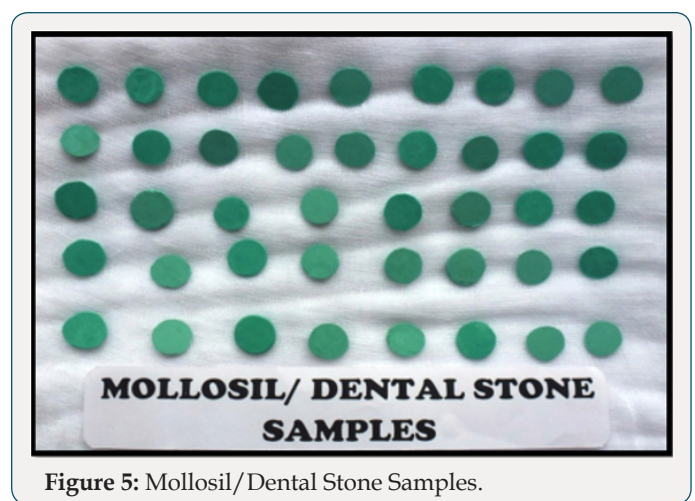
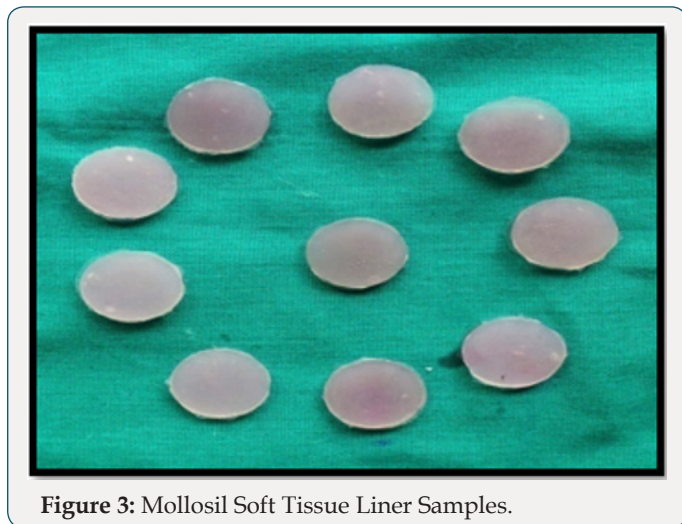
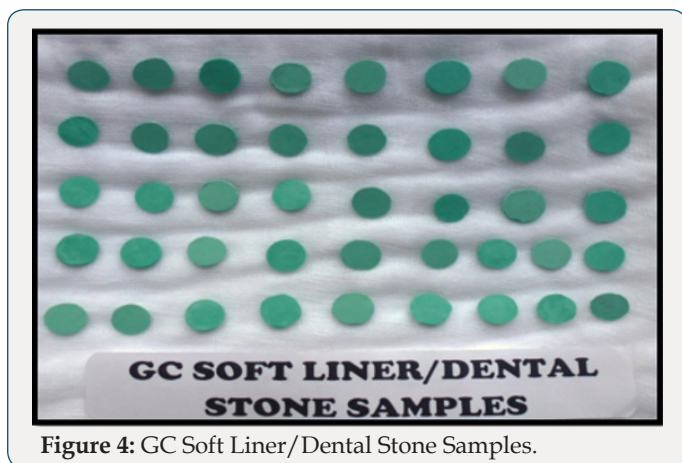


Figure 2: GC soft liner samples.



b. Preparation of Dental Stone Samples

Subsequent to time intervals, the dental stone was hand mixed with water in a rubber bowl and then under vacuum in an auto mixer for 15 seconds, using the manufacturer recommended water/powder ratio (Table 1). The mixed dental stone was poured over the soft-liner samples under gentle vibration and stored at room temperature for 60 minutes (Figures 4 & 5).



c. Surface Roughness Test of the Dental Stone Samples

Subsequent to time intervals, the dental stone samples obtained from the soft tissue liner samples respectively, were tested for determining the surface roughness [Ra] values using a profilometer [36-38]. Ten disk-shaped specimens, for each soft tissue liner/stone sample combination were prepared after zero hours, one day, seven days, fourteen days and twenty-one days, with a total sample size of 100 obtained from GC SOFT LINER [50 samples] and MOLLOSIL [50 samples] respectively.

d. Method of Statistical Analysis

The data collected was tabulated in Microsoft Excel and statistically analysed using the SPSS [version 17] software. Student paired-t test [p<0.05] and Co-efficient of variance [C.V] tests were used to find a significant difference between two means [39].

Results

An in-vitro study was conducted in the Department of Prosthodontics including Crown and Bridge, Sri Siddhartha Dental College, Tumkuru, Karnataka, India to evaluate two different soft tissue liners, as functional impression materials, by determining its effect on surface roughness of dental stone over time [40-42].

Table 3: Surface roughness values (µm) of dental stone samples obtained from GC soft liner samples recorded after five different time durations respectively.

Sample duration	1	2	3	4	5	6	7	8	9	10
Zero Hours (Control)	0.88	0.87	0.89	0.88	0.86	0.87	0.9	0.86	0.88	0.89
One Day	0.9	0.89	0.88	0.87	0.89	0.91	0.9	0.88	0.9	0.91
Seven Days	0.89	0.9	0.9	0.87	0.89	0.92	0.88	0.89	0.91	0.9
Fourteen Days	0.93	0.96	0.97	0.94	0.93	0.96	0.98	0.97	0.99	0.93
Twenty One Days	1.02	1.04	1.05	0.99	1.02	0.99	1.03	1.04	1.02	0.98

i. Data given in (Table 3) shows the surface roughness values [Ra] of dental stone samples recovered from GC SOFT LINER samples, recorded after five different time durations.

ii. Data given in Table 4 shows the surface roughness values [Ra] of dental stone samples recovered from MOLLOSIL soft tissue liner samples, recorded after five different time durations respectively.

Table 4: Surface roughness values (μm) of dental stone samples obtained from Mollosil soft tissue liner samples recorded after five different time durations respectively.

Sample duration	1	2	3	4	5	6	7	8	9	10
Zero Hours(Control)	0.88	0.86	0.87	0.85	0.86	0.88	0.86	0.85	0.87	0.88
One Day	0.89	0.9	0.88	0.87	0.89	0.91	0.88	0.9	0.91	0.9
Seven Days	0.89	0.9	0.9	0.89	0.87	0.92	0.9	0.91	0.89	0.88
Fourteen Days	0.94	0.92	0.96	0.95	0.93	0.96	0.92	0.91	0.98	0.92
Twenty One Days	0.94	0.98	0.95	0.99	1.02	0.96	0.96	1.01	1.02	0.99

iii. Table 5 shows the comparison of the mean surface roughness values [Ra] of 10 dental stone samples obtained from GC SOFT LINER and MOLLOSIL soft tissue liner samples, consecutive to five different time durations namely zero hours [control], one day, seven days, fourteen days & twenty one days.

Table 5: Comparison of mean surface roughness values (Ra) of GC soft liner/dental stone and Mollosil/dental stone samples against different time durations.

Duration	Mean	
	Gc Soft Liner	Mollosil
Zero Hours (Control)	0.88	0.87
One Day	0.89	0.89
Seven Days	0.89	0.9
Fourteen Days	0.96	0.94
Twenty One Days	1.02	0.98

iv. Table 6 shows mean surface roughness values [Ra] of 10 dental stone samples obtained from GC SOFT LINER and MOLLOSIL soft tissue liners respectively at zero hours, which was taken as a control, to which other values were compared and evaluated statistically using co-efficient of variance [C.V]. The values obtained showed a slight & statistically consistent amount of increase in the mean surface roughness values of GC SOFT LINER & MOLLOSIL soft tissue liner samples up to seven days & considerable amount of statistically inconsistent increase in mean surface roughness values of the two soft tissue liner samples was seen from seven days – twenty one days in comparison with the control group [zero hours].

Table 6: Comparison of co-efficient of variance (C.V) of GC soft liner and Mollosil samples for different time durations.

Duration	Co-Efficient Of Variance (C.V)	
	Gc Soft Liner	Mollosil
Zero Hours (Control)	1.43%	1.36%
One Day	1.46%	1.47%
Seven Days	1.61%	1.61%
Fourteen Days	2.22%	2.34%
Twenty One Days	2.23%	2.82%

v. Table 7 shows the comparison of the mean surface roughness values [Ra] of GC SOFT LINER samples for different time durations to the control [zero hours] namely zero hours

- one day, zero hours- seven days, zero hours - fourteen days & zero hours-twenty one days, using Student’s “paired-t” test [$p < 0.05$].

Table 7: Comparison of surface roughness (Ra) of GC soft liner/ dental stone samples for different time durations in relation to the control (ZERO hours) using paired t-test.

T	Df	P-Value	*P<0.05
Zero Hours (Control) - One Day	-2.875	9	0.018*
Zero Hours (Control) - Seven Days	-2.547	9	0.031*
Zero Hours (Control) - Fourteen Days	-10.507	9	0.000*
Zero Hours (Control) – Twenty One Days	-15.652	9	0.000*

vi. Table 8 shows the comparison of the mean surface roughness values [Ra] of MOLLOSIL soft tissue liner samples for different time durations to the control [zero hours] namely zero hours - one day, zero hours- seven days, zero hours - fourteen days & zero hours-twenty one days, using Student’s “paired-t” test [$p < 0.05$].

Table 8: Comparison of surface roughness (Ra) of mollosil/ dental stone samples for different time durations in relation to the control (zero hours) using paired t-test.

T	Df	P-Value	*P<0.05
Zero Hours (Control) - One Day	-6.384	9	0.000*
Zero Hours (Control) - Seven Days	-4.949	9	0.001*
Zero Hours (Control) - Fourteen Days	-10.673	9	0.000*
Zero Hours (Control) – Twenty One Days	-10.2	9	0.000*

vii. The mean surface roughness values [Ra] of both the soft liner samples showed a statistically significant increase respectively.

viii. Table 9 shows the comparison of the percentage increase in surface roughness [Ra] of GC SOFT LINER and MOLLOSIL soft tissue liner samples for different time durations in relation to the control [zero hours] namely zero hours-one day, zero hours-seven days, zero hours - fourteen days and zero hours-twenty one days, using Student’s “paired-t” test [$p < 0.05$].The values

obtained showed a slight percentage of increase in mean surface roughness values [Ra] of GC SOFT LINER & MOLLOSIL soft tissue liner samples between zero hours-one day & zero hours-seven days & a considerable percentage of increase in mean surface roughness values [Ra] between zero hours-fourteen days & zero hours-twenty one days. However, it showed a slight, consistent increase in the mean surface roughness values [Ra] of MOLLOSIL soft tissue liner samples between zero hours-twenty one days in comparison to the mean surface roughness values [Ra] of GC SOFT LINER soft tissue liner samples, which showed a considerable, inconsistent amount of increase.

Table 9: Comparison of percentage increase in surface roughness (Ra) of GC soft liner and Mollosil samples for different time durations in relation to the control (zero hours).

Duration	Percentage Increase (%)	
	Gc Soft Liner	Mollosil
Zero Hours (Control) - One Day	1.7	2.7
Zero Hours (Control) - Seven Days	1.9	3.44
Zero Hours (Control) - Fourteen Days	8.8	8.42
Zero Hours (Control) - Twenty One Days	15.9	13.4
Twenty One Days	2.23%	2.82%

ix. Table 10 shows the comparison of the percentage increase in mean surface roughness values [Ra] of GC SOFT LINER & MOLLOSIL soft tissue liner samples with simultaneous increase in time durations namely zero hours to one day, one day to seven days, seven days to fourteen days & fourteen days to twenty-one days respectively.

Table 10: Comparison of percentage increase in surface roughness (Ra) of GC soft liner and Mollosil samples with simultaneous increase in time duration.

Duration	Percentage Increase (%)	
	Gc Soft Liner	Mollosil
Zero Hours (Control)- One Day	1.7	2.7
One Day-Seven Days	0.22	0.22
Seven Days-Fourteen Days	6.8	4.9
Fourteen Days-Twenty One Days	6.4	4.5
Twenty One Days	2.23%	2.82%

The values obtained showed a considerable amount of increase in mean surface roughness values of GC SOFT LINER samples from zero hours to twenty one days in comparison to MOLLOSIL samples, which showed a slight amount of increase in mean surface roughness values from zero hours to twenty one days. A considerable increase in the mean surface roughness values of MOLLOSIL samples was seen during the time duration of zero

hours to one day, in comparison to the mean surface roughness value changes of GC SOFT LINER samples, however the mean surface roughness values were same after one day of immersion in artificial saliva for both the soft tissue liner samples [43-46].

Discussion

Soft liner materials are mainly divided into two types: auto polymerized [mouth cured] and heat-polymerized [processed] forms of plasticized acrylics and silicone elastomers [47].

Mouth-Cured Soft Liners

Three types of materials are generally used. The first two are acrylic based with the composition as follows:

- a. Powder containing poly [ethyl methacrylate] and peroxide initiator, Liquid containing aromatic esters, ethanol, and tertiary amines.
- b. Powder containing poly [ethyl methacrylate], ethyl glycolate as plasticizers and peroxide as initiator, Liquid containing methyl methacrylate and tertiary amines.
- c. Addition silicone elastomers form the third group [48-49].

Processed Soft Liners

The basic compositions of heat cured acrylic and silicone liners [heat and room temperature cured] are as follows:

Heat Cured Acrylic Liner

- a) Polymer containing poly ethyl methacrylate or poly methyl methacrylate [50].
- b) Monomer containing methyl methacrylate or n-Butyl methacrylate or ethyl methacrylate, at times ethyl acetate may be added.
- c) Plasticizer containing butylphthalyl butyl glycolate [30% to 59%] or Di-n-butyl Phthalate [36.2%] or 2-Ethylhexyl diphenyl phosphate [39%].

Silicone Liner

- a) Polymer containing α - ω - dihydroxy end-blocked poly dimethyl siloxane.
- b) Cross-linking agent containing triethoxy silanol or ethyl polysilicate or methyltriacetoxo silane or acryloxyl silane [51].
- c) Catalyst containing dibutyltin dilaurate or stannous octoate or moisture or heat+benzoyl peroxide
- d) Filler containing micro sized metal oxide or colloidal silica [16.5% to 4.5%].

However, the International Organization for Standardization [ISO] has standardized soft liner materials for removable dentures into two main types as ISO 10139-1:1991; Part 1: short-term use - used intraorally for up to 30 days & ISO 10139-2:1999; Part 2:

long-term use -one that maintains softness and elasticity for more than 30 days [52]. Soft lining materials are indispensable in modern removable prosthodontics and clinically they can be used for the following purposes.

- A. To make functional impressions.
- B. When placed in a denture against edentulous tissues, act as tissue conditioner to help tissue return to a healthy state.
- C. To maintain the fit of the immediate dentures and prevent trauma to the underlying tissues following any oral surgical procedures.
- D. For temporary assessment of border extensions.
- E. SAUER JL enumerated some of the indications for use of soft liners. Residual alveolar ridges with bony undercuts and overlying thin non-resilient mucosa [53-54].
 - a) Knife edge mandibular ridges
 - b) Persistent denture sore mouth
 - c) Thin tissue relief overlying sharp median palatine suture and torus palatinus
 - d) In prosthodontic rehabilitation of congenital or acquired oral defects
 - e) Oral tissues subjected to radiation therapy.

For many years, the ideal protocol for returning the inflamed tissues overlying an edentulous ridge to a normal state, before making any impression has been to advise the patients to keep their dentures out of their mouth for a certain period of time [usually 48 hours]. However, most of the patients do not conform to do this as they do not desire to be without their dentures for even a shorter duration of time. Tissue conditioners act as a viable alternative to return the oral tissues to a normal condition and act as functional impression materials for temporary denture relining accordingly. Placement of soft liner material can be used as the final impression either following the initial set of material [as with other final impression materials] or by having the patient wear and function with the prosthesis for a defined period of time. Functional impression materials are required to make an accurate replica of the surface topography of the underlying supporting tissues under functional and parafunctional loading, thus giving it a composite or modal form. The functional impression material should have adequate flow when loaded onto the denture to adapt the tissue adequately and should become rigid and elastic to prevent permanent distortion on removal from the mouth with adequate compatibility with the gypsum products [55-59]. However, it shows certain physical and microbiological disadvantages with surface colonization and infection by *Candida albicans* and other microorganisms resulting in denture stomatitis [60,61]. BILGE T. BAL, in 2008, conducted a pilot study among four soft liner materials [UFI-GEL, SOFTLINER, COE-SOFT & VERTEX] and acrylic

resin material to evaluate and compare the adhesive properties of oral micro flora onto their surfaces. It was concluded that soft liners showed greater adhesion of oral bacteria and *Candida* than the acrylic resin with soft liner materials showing the maximum number of micro-organisms. On the contrary, it is a proven fact that the continuous aspiration or swallowing of microorganisms from the dental plaque in immunocompromised patients or medicated elderly exposes them to further infection [62]. However, microbial adhesion to the appliance or prosthesis is influenced by the surface characteristics of the appliance namely surface roughness, surface free energy, surface tension, hydrophobicity etc. In 1988, KAZANJI MNM, WATKINSON AC tested for the absorption and solubility behaviour of five soft liners in distilled water and artificial saliva and concluded that all the tested soft liners except for Molloplast B [heat cured silicone rubber] showed lower absorption percentage and solubility in artificial saliva than distilled water. Thus, it was implied that when materials are tested, use of artificial saliva over distilled will show clinically relevant results. Among the surface properties of the materials used in denture construction that affect the adhesion of microorganisms, surface roughness provokes more adhesion of *Candida* and other microbial organism, which is of specific importance in denture-induced stomatitis pathogenesis. In accordance, VERRAN J & MARYAN CJ concluded in their study that difference in surface topography influences the microbial attachment, more to a rougher surface than a smoother surface. Since 1960, various laboratory studies have been conducted to evaluate the physical properties of denture soft liners in accordance to its better flexibility and elasticity over the conventional poly [methyl methacrylate] denture base material. However, most of the studies conducted did not comply with clinically relevant conditions. Thus the present study was conducted to compare and evaluate the most commonly used chair-side soft tissue relining materials, i.e., acrylic based [GC SOFT LINER] and silicone based [MOLLOSIL], when used as functional impression materials, stored in artificial saliva by determining the surface roughness of dental stone over different time periods. Ideally, a material should possess a smooth, polished surface so that plaque accumulation is minimized or avoided. Since a roughened surface attracts plaque, *in vivo* studies have suggested a "threshold of Ra value" located at a score of 0.2 μm , below which no further bacterial accumulation can be expected. According to the findings of the present study, no material tested was found to accomplish this criterion, although one exhibited low Ra values ranging from 0.87 to 0.98 μm , i.e., MOLLOSIL than 0.88 to 1.02 μm , i.e., GC SOFT LINER.

According to GRAHAM BS et al, in order to avoid deformation of the intaglio surface caused by inadequate elastic recovery of the tissue conditioners, a functional impression should be kept intraorally for atleast 24 hours before pouring the dental stone cast. So it was observed in the present study that the stone samples obtained from the GC SOFT LINER showed less surface roughness changes compared to that of the MOLLOSIL samples, however the surface roughness values were the same for both the soft tissue liner samples after one day of immersion in artificial saliva. Although, it

was found out that with the increase in duration of the immersion of soft liner samples in artificial saliva, the surface roughness values of both the soft liners increased gradually upto seven days and considerable increase from seven days to twenty one days. However, the percentage increase in the surface roughness of MOLLOSIL samples was considerably lower in comparison to GC SOFT LINER between zero hours to twenty one days. Numerous factors are involved with the surface conditions of soft liners namely saliva, denture cleansing agents, thermocycling, polishing and finishing procedures etc. It is therefore imperative to understand that the changes in surface roughness of the materials used clinically may be different from those obtained from the present study. In 2013, KAMLESHWAR SINGH et al, conducted a study to conclude that the use of a monopoly, a poly [methyl methacrylate] syrup can significantly reduce the loss of softness of a soft liner. However, the effect of varnish on the roughness of soft liners, its compatibility with dental stones and their durability has not been extensively studied. Hence, additional research needs to be performed to produce the ideal soft denture liners which will have both good cushioning effect and better durability.

Conclusion

The following conclusions were drawn after the comparative study of using two different chair-side soft denture lining materials, as functional impression material, by determining the surface roughness of dental stone over a time period.

- A. The stone samples obtained from GC SOFT LINER showed less mean surface roughness value changes compared to MOLLOSIL from upto one day, however, the mean surface roughness values of both the soft tissue liners were the same after one day of immersion in artificial saliva.
- B. The mean surface roughness values of both the soft tissue liners increased consistently upto seven days and considerably after seven days.
- C. The mean surface roughness values of MOLLOSIL samples increased gradually and consistently over the period of zero hours to twenty days in comparison to the GC SOFT LINER samples, which showed a considerably inconsistent increase.
- D. The silicone-based soft liner showed better results for lower surface roughness compared to acrylic-based soft liner, over the period of zero hours to twenty days.

Clinical Implications

This study suggests that the mean surface roughness of the silicone-based soft liner samples increased consistently, when used as a functional impression material, in relation to the acrylic-based soft liner, over a period of time.

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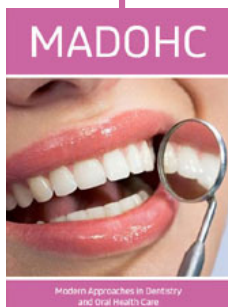
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