In Vitro Comparative Evaluation of the Physical and Mechanical Properties of Two Soft-liners Coated with Different Types of Coatings.

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Abstract

Aim: To evaluate the changes on the physical and mechanical properties of acrylic and silicone based soft liners after applying four different types of coatings.

Methods: A total of 60 samples were prepared and divided into two major groups viz. Group A-Exact-On (30 samples) and Molloplast-B (30 samples). Group A and B were further subdivided into 5 subgroups I, II, III, IV and V containing 6 specimens each. The samples were coated with four different types of coatings and were compared to the uncoated control group (subgroup1). Main composition of two types of Monopoly were chemically activated methylmethacrylate monomer, clear methylmethacrylate polymer, heat activated methylmethacrylate monomer. Two new types of coatings were made with n-butyl cyanoacrylate.These two coatings were never tried before in any literature review.The coated samples were tested for Hardness, Permanent deformation, Tensile strength, Water absorption determination and the coated surfaces were observed under SEM and compared with the uncoated control group.

Results: Molloplast-B, a silicone based had longer shelf life but a coated acrylic based liner was seen to be equally good. Cyanoacrylate monomer coating and self cure monopoly coating were superior to other coatings. All results were statistically analyzed by 2-way ANOVA. The mean values for hardness ranged from 24.16 to 29.33 Shore A for Group A and 41.50 to 42 Shore A for Group B. Values of permanent deformation ranged from 1.01 to 0.93% for the Exact-On (Group A) and 0.158 to 0.140 % in coated Molloplast-B samples (Group B). Mean values of Tensile strength ranged from 5kg/cm^2 to 6.00kg/cm^2 in Group A and 16.33 kg/cm^2 to 17.67kg/cm^2 in Group B. It was observed that among the coatings Cyanoacrylate Monopoly coating was more efficient in preventing water absorption and leaching followed by Cyanoacrylate Monomer coating.

Conclusion: None of the coatings affected the physical properties of tissue conditioners. All coatings prevented water absorption from tissue conditioner and prolonged the life of tissue conditioner.

Key words: *Soft liners, monopoly coating, water absorption, leaching, n-butyl cyanoacrylate.*

COI: None declared.

Authors contribution: all authors contributed significantly to this research and writing.

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Introduction

Soft lining materials are commonly used to line obturators, facial prosthesis and as denture reline material especially in case of immediate dentures.[1,2] Tissue conditioners are acrylic or silicone based. The acrylic based liners are supplied in powder – liquid form. The powder is composed of a polymer, polyethylmethacrylate, or its co-polymer, and the liquid contains a mixture of ethyl alcohol and aromatic ester to act as plasticizer. The commonest problems encountered with this material are leaching out of plasticizer and absorption of water that leads to loss of softness of the liner over a period of time. Eventually the liner material decomposes leading to bacterial adhesion, foul odor and color change necessitating a change of the lining material within weeks.[3, 4, 5] The main component of silicone based soft liners is vinyl-terminated poly (dimethylsiloxane), benzoyl peroxide as initiator and silicilic acid. The commonest disadvantages of liners include water absorption, leaching, discoloration leading to changes in physical and mechanical properties. To overcome these problems various sealants were tried by many authors and were found to be successful in increasing the longevity of the liner thereby reducing patient appointments, were more economical and biocompatible to the surrounding oral tissues.

Gardner and Parr reported that coating Soft Oryl, a temporary soft liner with Monopoly, extended the liner life to one year. The advantage of monopoly coating was observed as increased surface smoothness which in turn reduced bacterial and fungal growth. [6] Many other authors also reported extended life span of liners with various types of coatings.[7, 8,9,10] Many studies were also conducted on permanent silicone liners with coating and without coating and have shown increase in longevity of coated samples.[1]

This study was undertaken to evaluate the efficiency of four different types of coatings on an acrylic based and a silicone based liner. Two of the coatings were innovative and tried for the first time. A comparative evaluation of various physical and mechanical properties was also studied after coating which was compared with an uncoated control group.

Materials and Methods:

Materials used were:

- Temporary chair side liner - Exact-On(Confidential Products Louisville, USA).
- Permanent Silicone liner – Molloplast-B (DetaxEttlingen, Germany).
- Chemically activated methyl methacrylate monomer (DPI, India).
- Clear methyl methacrylate polymer (DPI, India).
- Heat activated methyl methacrylate monomer (DPI, India).
- n-butyl cyanoacrylate - Nectacryl. (Dr. Reddy's Laboratories Ltd. Hyderabad, India).

Preparation of four types of coatings

Self Cure Monopoly: Self cure monopoly was prepared by mixing 15gms of chemically activated methyl methacrylate monomer and 1.5 gm of clear methyl methacrylate polymer in the ratio 10:1.

Heat cure Monopoly: Heat cure monopoly was prepared by mixing 15gms of heat activated methyl methacrylate monomer and 1.5gms of clear methyl methacrylate polymer in the ratio 10:1.

Cyanoacrylate combined with self cure Monopoly: Cyanoacrylate monopoly was prepared by adding 1ml of n-butyl cyanoacrylate to freshly prepared self cure monopoly in the ratio 10:1

Cyanoacrylate monomer: Cyanoacrylate monomer mixture was prepared by mixing 15gms of chemically activated methyl methacrylate monomer and 1.5 gm of n-butyl cyanoacrylate in the ratio 10:1.

Mechanical properties studied were Hardness, Permanent deformation, Water absorption, Tensile/tear strength and SEM evaluation.

Sample Groups

Total 60 samples were prepared and divided into two major groups of 30 samples each as Group A.Exact-On (30 samples) and Molloplast-B (30 samples). Groups A and B were further subdivided into 5 subgroups I, II, III, IV and V with each subgroup containing 6 specimens. Samples were coated with four different types of Monopoly. Three different types of specimens were used for different test parameters ***(F**igure: **1)**.*

Subgroup 1 (Control samples, n = 6).
Subgroup II Samples coated with self cure Monopoly (n=6).
Subgroup III Samples coated with heat cure Monopoly (n=6).
Subgroup IV Samples coated with cyanoacrylate Monopoly (n=6).
Subgroup V Samples coated with Cyanoacrylate Monomer (n=6).
The subgroup samples of coated Exact-On was designated as (IE, IIE, IIIE, IVE, VE) Group A.
The other subgroup of coated Molloplast-B was designated as (IM, IIM, IIIM, IVM, VM) Group B.

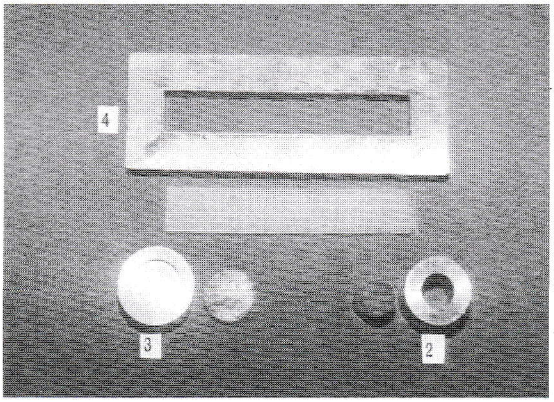


Figure 1: Mould for fabricating specimens.

Parameters Studied were: Hardness, Permanent Deformation, Water absorption of tissue conditioners, Tensile strength / Tear Resistance and Scanning electron microscopy (SEM).

Test for Hardness

All samples from Group A and Group B were prepared from a mold size of 20mm in diameter and 10mm thickness. The coating was applied on all the surfaces by holding it with tweezer and using individual brushes for each type of coating. Each layer was allowed to dry for 3min before recoating. These samples were transferred to sterile glass jars. After 24 hours all the samples were tested for hardness using Shore A Durometer (F***igure: 2)***.The less the indentor penetrated the test material, the higher was the Shore A reading. The values obtained between group IE to VE and IM to VM were compared.

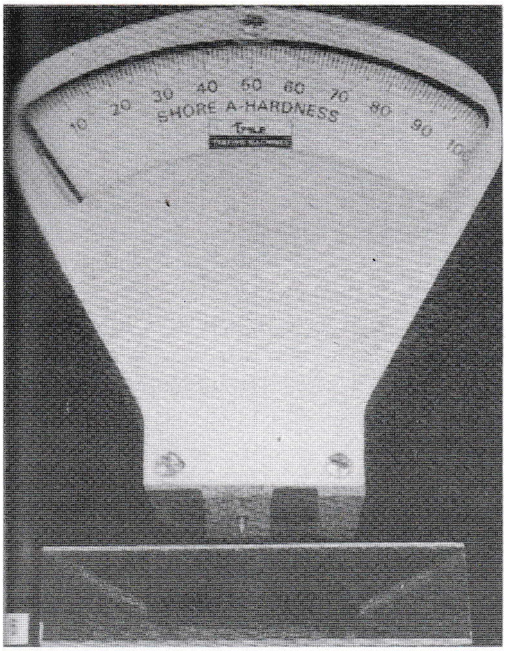


Figure 2: Shore A Durometer.

Test for Permanent Deformation

Sample dimensions of 20mm height and 10mm diameter were prepared and placed in sterile jar and after 24 hours were subjected to testing for permanent deformation. The testing was done with an instrument consisting of a dial gauge graduated in 0.02mm, a glass plate weighing 2.5 + 0.5 gm was placed on top of the specimen and the foot of the dial gauge was brought into contact with the plate ***(Figure 3).*** The weight of the plate plus the force of spring in the gauge was 50± 5gm and reading was taken 30 sec after the foot of the gauge contacted the plate and the value recorded as A. After which the dial gauge of the foot was lowered 2.4mm by means of screw and maintained in this position for 30sec and the dial gauge was released and specimen was permitted to rest under no load for 30sec. The dial gauge was again contacted with the plate on the specimen for 30 seconds and a second reading B was obtained. The permanent deformation was calculated as:

(A - B) × 100 / Original length of specimen (20)

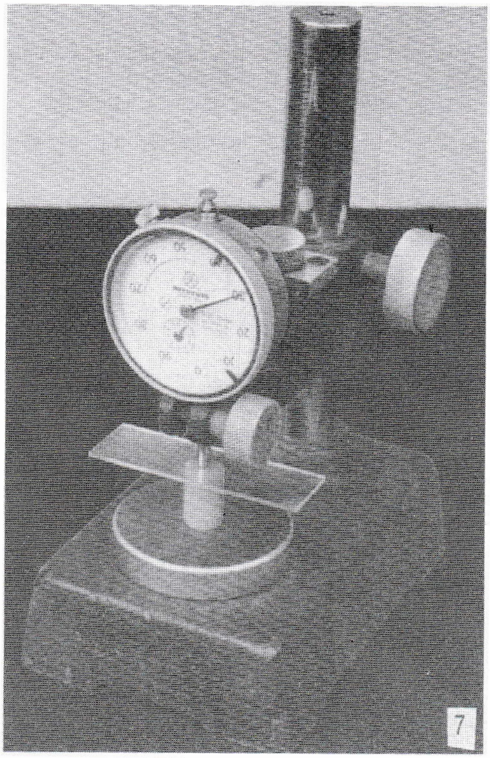


Figure 3: Dial Gauge instrument for measuring permanent deformation in samples.

Test for Tensile Strength

Samples were prepared with a dimension of length 4cm, width 1cm and thickness of 3mm on a flat plate. A second flat plate was pressed on the top of the mold to remove excess material. Samples were tested in an Instron Universal testing machine accurate to 10gm under tensile load ***(Figure: 4).*** Tensile strength was calculated as:

TS (Kg/cm^2) = Load applied (Kg) / Area (cm^2)

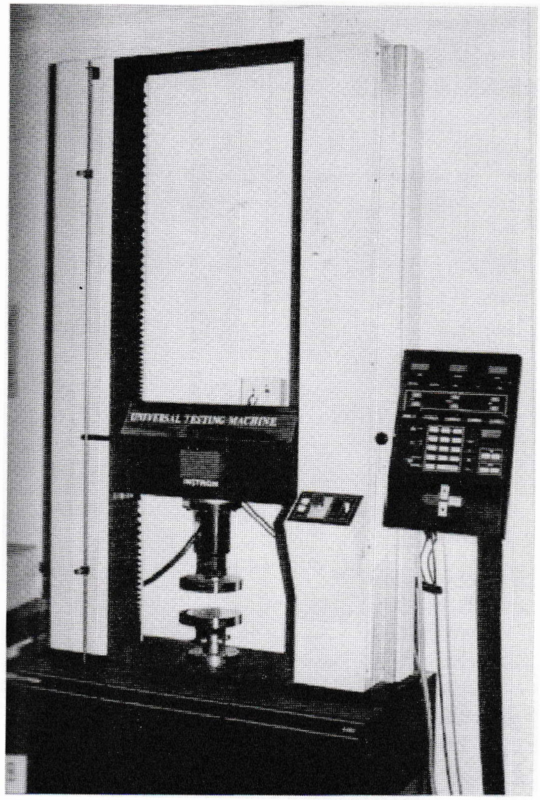


Figure 4: Instron Universal Testing Machine.

Test for water absorption determination

Samples of 10mm thick and 20mm diameter were prepared and the coated and uncoated disks were labeled and placed individually weighed in glass container to arrive at a net disk weight. Six ml of deionized water was added to each container and its disk. All specimens were stored at 37^0C. The samples were tested after first week, second week and third week. For each test the water was decanted from the bottle. Each of the 6 disks was removed and air-dried using a hot air blower for 3min. These samples were replaced in a dry container and weighed to arrive at a net weight.Each sample was weighed three times and the mean of these observations were used.

SEM Study

Samples of 5mm diameter and 3mm thickness were prepared and their surfaces were sputtered with gold. Specimen in group IE to VE and group IM to VM were scanned. The surface texture was studied for smoothness, irregularities and voids.

Results

All results were statistically evaluated by two way ANOVA test.

The mean values for hardness ranged from 24.16 to 29.33 Shore A for Group A and 41.50 to 42 Shore A for Group B (Table:1). Values of permanent deformation ranged from 1.01 to 0.93% for Exact-On and 0.158 to 0.140 % in coated Molloplast-B samples (Table: 2). Mean values of tensile strength ranged from 5kg/cm^2 to 6.00kg/cm^2 in Group A and 16.33 kg/cm^2 to 17.67kg/cm^2 in Group B (Table: 3). It was observed that among the coatings Cyanoacrylate Monopoly coating was more efficient in preventing water absorption and leaching followed by Cyanoacrylate Monomer coating, Self-cure Monopoly and heat-cure Monopoly coating in order from most efficient to least on Exact –On coated samples when compared to control group (Table: 4). When comparing the Coatings on Molloplast-B samples Cyanoacrylate Monomer was more efficient followed by self-cure Monopoly, Cyanoacrylate Monopoly and the least efficient was heat-cure Monopoly (Table: 5). The control specimens showed a weight loss after two weeks possibly due to loss of plasticizer.

Table 1: Mean Hardness Values of Uncoated and Coated Liners.

GROUPS	Mean Hardness (Shore A)	
	Exact –On	Molloplast-B
Control	24.16	41.50
Heat cure Monopoly	23.67	41.50
Self cure Monopoly	24.33	40.33
Cyanoacrylate Monopoly	25.83	42.33
Cyanoacrylate Monomer	24.33	42.00

Table 2: Mean % Permanent Deformation of Uncoated & Coated liners.

GROUPS	Mean % Permanent Deformation	
	Exact –On	Molloplast-B
Control	1.01	0.158
Heat cure Monopoly	1.03	0.143
Self cure Monopoly	0.75	0.142
Cyanoacrylate Monopoly	0.98	0.148
Cyanoacrylate Monomer	0.93	0.140

Table 3: Mean Tensile Strength of Uncoated & Coated liners

GROUPS	Mean Tear Resistance kg/cm^2	
	Exact On	Molloplast-B
Control	5.00	16.33
Heat cure Monopoly	5.02	15.17
Self cure Monopoly	5.47	16.07
Cyanoacrylate Monopoly	5.87	16.93
Cyanoacrylate Monomer	6.00	17.67

Table 4: Mean Water Absorption at Various Intervals in Exact-On Group A.

GROUPS	Mean Water absorption (gm)		
	0 week	2 weeks	3 weeks
Control	2	2.1145	2.2009
Heat cure Monopoly	2	1.0001	2.2002
Self cure Monopoly	2	-	1.0001
Cyanoacrylate +Monopoly	2	0.6668	0.6667
Cyanoacrylate Monomer	2	0.6668	1.0001

Table 5: Mean Water Absorption at Various Intervals in Molloplast-B.

GROUPS	Mean Water absorption (gm)		
	0 week	2 weeks	3 weeks
Control	2	1.6834	2.1002
Heat cure Monopoly	2	1.050	1.7500
Self cure Monopoly	2	0.350	1.4001
Cyanoacrylate Monopoly	2	1.050	1.4001
Cyanoacrylate Monomer	2	0.350	0.7000

On SEM evaluation samples of Exact-On showed good coating compatibility and smoothness when compared to uncoated Exact-On group ***(Figures: 6 & 7)*** Cyanoacrylate monomer coating was thin and regular surfaced compared to other coating ***(Figures: 8,9 & 10).***

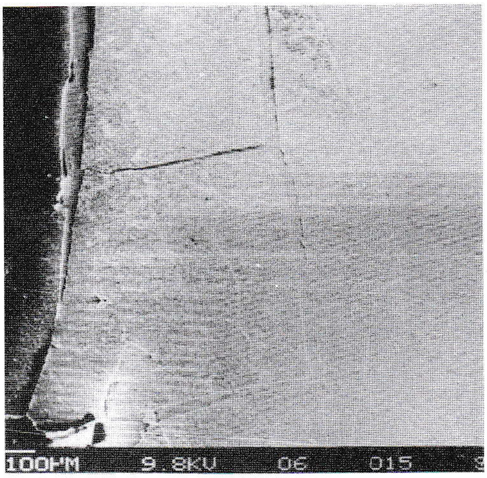
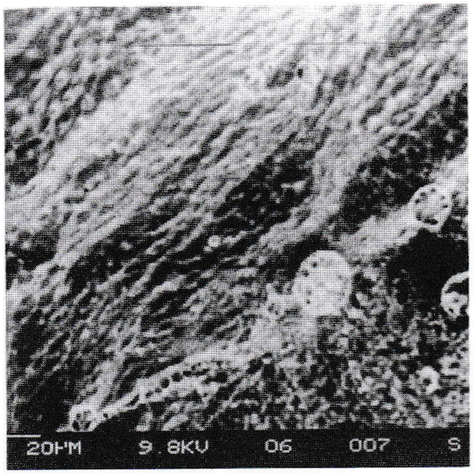
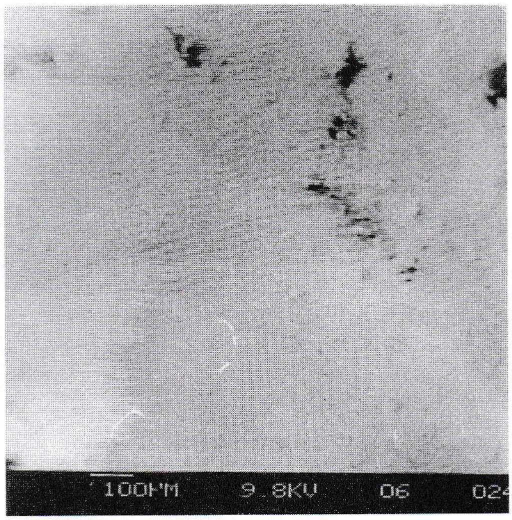


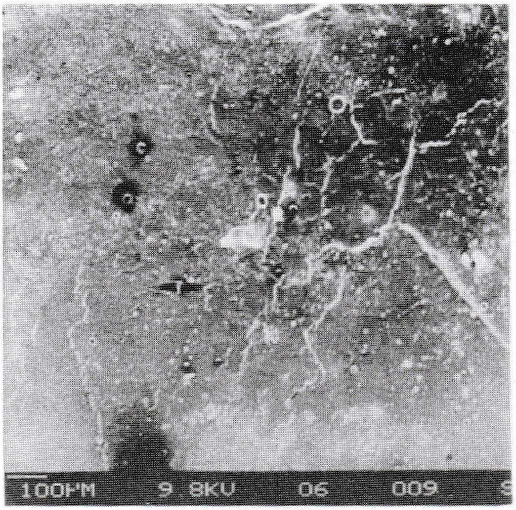
Figure 6: SE Micrograph of control group specimen of Exact-On.



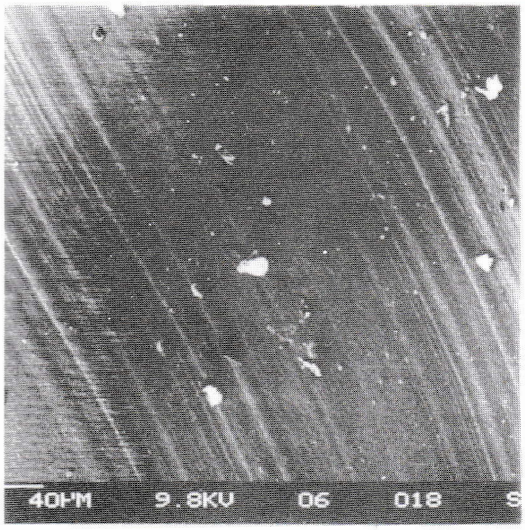
Figures 7: SE Micrograph of heat-cure monopoly coated on Exact-On.



Figures 8: SE Micrograph of self-cure monopoly coated on Exact-On.



Figures 9: SE Micrograph of cynoacylate monopoly coated on Exact-On.



Figures 10: SE Micrograph of cynoacylate mixture coated on Exact-On.

On SEM evaluation all coatings on Molloplast-B showed crumbling except Cyanoacrylate monomer coating. Coating left by self-cure, heat-cure and cyanoacrylate monopoly was thicker and had undergone shrinkage over Molloplast- B samples this was due to chemical incompatibility when compared to the control group ***(Figures: 12, 13, 14, & 15).***

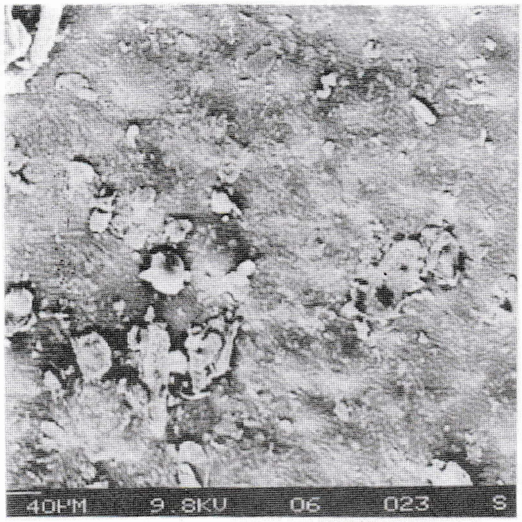


Figure 11: SE Micrograph of control group specimen in Molloplast-B.

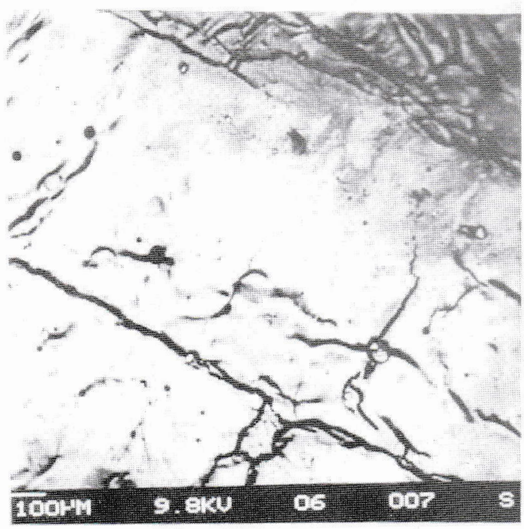


Figure 12: SE Micrograph of heat-cure monopoly coated on Molloplast-B.

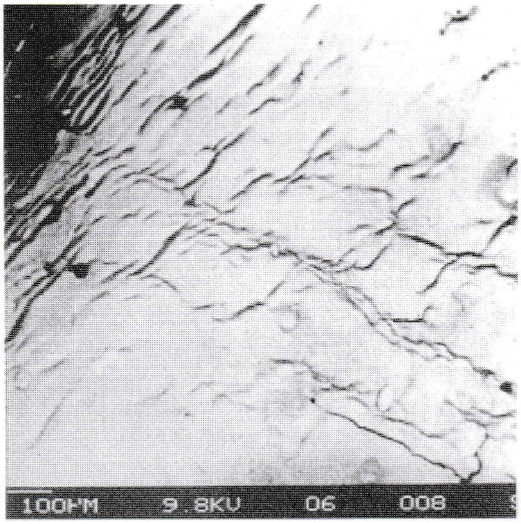


Figure 13: SE Micrograph of self-cure monopoly coated on Molloplast-B.

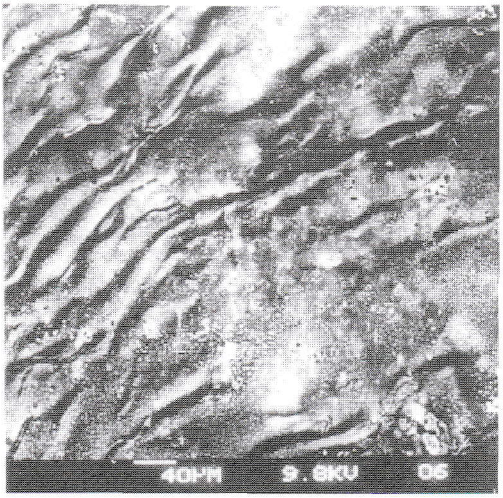


Figure 14: SE Micrograph of cynoacrylate Monopoly coated on Molloplast-B.

Figure 15: SE Micrograph of cynoacrylate Monomer coated on Molloplast-B.

Discussion

The use of tissue conditioning was first reported by Chase et al in 1961 for abused denture supporting tissue and to restore a normal healthy state.[12] The physical properties of various acrylic based soft liners were studied in detail by Travaglini et al [13] in 1960 and physical properties of silicone based liners were reported by Robinson.[14] The disadvantages of lining materials include water absorption, leaching of components eventually making them hard along with bacterial colonization and discoloration. Hence the concept of sealed tissue conditioner was first described by Beumer et al [15] for maxillofacial prosthesis. The term Monopoly was used as this was a semi set mixture of ethylmethacrylate polymer and chemically activated monomer. The use of monopoly prolonged the life of the temporary soft denture liner and was shown to decrease microbial growth and the benefits of coating lasted for one year. From then on many authors including White et al[16] and Aslanetal[17] used monopoly coatings on obturators and found it to be beneficial.

Modified coating techniques and various other sealants were also studied by others[18,19] claiming to further increase the life of the liner material with decreased water absorption and no plasticizer loss.

Various types of sealing agents used were monopoly, palaseal and fluorinated copolymer coatings. Kandil et al[20] observed three different type of coating agents and found that all coating agents decreased candidial growth and maintained colour stability of denture bases when sealed. Many authors have tried different sealants and have observed that fungal growth on soft liners and acrylic materials decreased or was not present. The latest trend was to use silver nano-particles coating. Studies by Oei et al [21] observed that silver nano-particles prevented fungal growth when coated on acrylic based materials.

In this present study apart from the two different types of monopoly coatings such as self-cure and heat-cure type two other types of coatings were developed based on cyanoacrylate. Cyanoacrylate has in recent past proved to be an efficient adhesive material with high biocompatibility profiles. It is also used for suturing procedures. It has not been tried in the past either independently or in combination with acrylic monomer neither as a binding medium nor as a barrier. In this present study a mixture of n- butyl cyanoacrylate (Nectacryl) was used in combination with chemically activated monomer. All the most important physical properties were evaluated to observe if the coating had caused any change in the physical properties of the soft liners. It was observed that there were no changes in the physical properties and yet the coatings prevented water absorption and leaching of plasticizer.

Conclusions

1. Physical properties of tissue conditioners were not hampered by any type of coatings used in this study.
2. Hardness of Molloplast-B was more than Exact-On. Cyanoacrylate monomer and cyanoacrylate monopoly coated samples of Exact-On and Molloplast-B showed a slight hardening of surface layers by 2 Shore A.
3. Molloplast-B recovered after compression where as Exact-on samples showed incomplete recovery and permanent deformation of 1% to 1.2%. This permanent deformation was not due to coatings.
4. Water absorption was seen in both Molloplast-B and Exact-on control groups. Molloplast-B showed much less water absorption than Exact-On. All types of coatings prevented water absorption. Cyanoacrylate monomer mixture and self cure monopoly coatings improved the prevention of water absorption compared to other coatings.
5. All types of coatings gave a smooth finish to the liners which in turn would better prevent bacterial colonization.
6. Molloplast-B liner was superior in all aspects but the coated Exact-On liner improved in its properties. Silicone liners with primer are expensive, but coated acrylic liners are equally effective and less expensive.
7. Tensile strength of Molloplast-B was higher than Exact-On. Cyanoacrylate plus monopoly and Cyanoacrylate monomer mixture coatings on Exact-On and Molloplast-B showed greater tensile strength.
8. SEM results proved cyanoacrylate monomer coating to be superior on Exact-On and Molloplast-B. All coatings adhered well with acrylic based liners. Coatings on Molloplast-B showed crumbling due to chemical incompatibility hence silicone liners may need frequent application of coatings whereas acrylic liners would not require subsequent application of coating.

References:

1. Farrell DJ. Tissue conditioning and tissue conditioners. Dent Clin North Am 1975; 19:255-268.
2. Harrison A. Temporary soft lining materials. A review of their uses. Br Dent J 1981; 151:419-422.
3. Ellis B, Lamb DJ, Al-Nakash S. Water sorption by a soft liner. J Dent Res 1977; 56:15-26.
4. Wilson J. In vitro loss of alcohol from tissue conditioner. Int J Prosthodont 1992; 5:17-21.
5. McCarthy JA, Moser JB. Mechanical properties of tissue conditioners. Part II: creep characteristics. J Prosthet Dent 1978;40: 334-342.

6. Gardner LK, Parr GR. Extending the longevity of temporary soft liners with a mono-poly coating. J Prosthet Dent 1988;59:71-72.
7. Casey DM, Scheer EC. Surface treatment of a temporary soft liner for increased longevity. J Prosthet Dent 1993: 69:318-324.
8. Dominguez NE, Thomas CJ, Gerzina TM.Tissue conditioners protected by a poly (methyl methacrylate) coating. Int J Prosthodont 1996;9:137-141.
9. Gronet PM, Driscoll CF, Hondrum SO. Resiliency of surface-sealed temporary soft denture liners. J Prosthet Dent 1997; 77: 370-374.
10. Malmström HS, Mehta N, Sanchez R, Moss ME. The effect of two different coatings on the surface integrity and softness of a tissue conditioner. J Prosthet Dent 2002; 87:153-157.
11. Kazanji MN, Al-Ali AA, Ahmed ZM. Water absorption and solubility of coated and non–coated silicone–based permanent soft liner. Al–Rafidain Dent J. 2010; 10:162-168.
12. Chase WW. Tissue conditioning using dynamic adaptive stress. J Prosthet Dent 1961;11:804.
13. Travaglini, Gibbons, Craig. Resilient liners for dentures. JADA 1960;10:664.
14. Robinson JE. Clinical experiments and experiences with silicone rubber in dental prosthetics. J Prosthet Dent 1963;13,669-675.
15. Beumer J, Curtis.TA, Firtell DN. Maxillofacial rehabilitation- Prosthodontic and surgical consideration. St. Louis MO, Ishiyaku Euro America Publication, 1979, 360-361.
16. White KC, Beckley, Connelly ME. Trial base adapted with sealed temporary soft liner. J Prosthet Dent 1990; 64:618-619.
17. Aslan Yy et al. Monopoly coating on acrylic resin surfaces a bacteriologic study. J Prosthet Dent 1990; 63:478-481.
18. Owen J et al. Temporary soft liners: Modified curing technique to extend liner longevity. J Prosthet Dent 1992; 68:714-15.
19. Casey DM, Ellen. Scheer C. Surface treatment of a temporary soft liner for increased longevity. J Prosth Dent 1993;. 69:318-324.
20. Kandil MMN, Jaffer NT, Shehap EY. The effect of three coating materials on the candida growth, on the surface and color of a heat–cured acrylic resin denture base. Al–Rafidain Dent J. 2009; 9(1):279-288.
21. Oei JD, Zhao WW, Chu L, DeSilva MN, Ghimire A, Rawls HR. Whang K. Antimicrobial acrylic materials with in situ generated silver nanoparticles. J Biomed Mater Res 2012. Part B: Applied Biomaterials, 100B (2):409-415.