Basic Science Research

Effect of Disinfection Treatments on the Hardness of Soft Denture Liner Materials

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Purpose: To evaluate 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.

Materials and Methods: Forty rectangular specimens of four soft lining materials (Molloplast-B, Ufi Gel P, Eversoft, and Mucopren soft) were made for each material. Ten samples of each material were immersed in different disinfectant solutions for 10 minutes or placed in a microwave oven for 3 minutes at 500 W. The hardness values were obtained with a Shore A durometer, before the first disinfection cycle (control), and also after two cycles of disinfection. Data were submitted to analysis of variance and Tukey's test ($p < 0.01$).

Results: The highest value of hardness was obtained for Molloplast-B, independent of the disinfection technique. Mucopren soft demonstrated intermediate values and Ufi Gel P and Eversoft the lowest values of Shore A hardness. For Molloplast-B, the disinfection using glutaraldehyde demonstrated the highest value of hardness. The number of disinfections had no effect on the hardness values for all the materials studied and disinfection techniques.

Conclusions: 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 Ufi Gel P materials, while Eversoft did not present any differences in hardness when submitted to different disinfection treatments.

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THE USE OF SOFT denture liners has increasingly come into favor for various applications in prosthetic dentistry.[1] These liners are most commonly used in patients who are unable to tolerate the pressures transmitted by prostheses because of thin mucosa or severe alveolar resorption.[2] Additional applications have emerged in the past few years for patients with postoperative defects requiring obturation, for transitional prostheses during the healing period for osseointegration, or for retention for implant-supported overdentures.[3] In these cases, the soft denture lining acts as a cushion for the denture-bearing mucosa through absorption of energy and redistribution of forces transmitted to the stress-bearing areas of edentulous patients.[4,5] The ability to achieve the cushioning effect described above depends on the viscoelastic properties and durability of the materials used.[3,6-8]

During clinical use, however, the soft denture liners have shown several problems associated with water absorption, resulting in changes in the structure and properties of the material, such as loss of softness, distortion, surface deterioration,

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accumulation of plaque and debris, and propensity for fungal/microbial accumulation and growth.[9,10] Furthermore, they have been found to be more prone to microbial adhesion than acrylic resin base materials because of their surface roughness and the physical/chemical affinity between microorganisms and the materials.[11-13] Thus, the prosthesis with a soft liner requires adequate disinfection to eliminate microorganisms. The American Dental Association and the Centers for Disease Control and Prevention recommended that dental prostheses and appliances should be disinfected prior to delivery to the patient and before being returned to the laboratory after insertion in the mouth.[14] This procedure is important for preventing cross contamination during the handling of these materials by laboratory personnel or in dental surgery.[14-16]

The most common procedures for the disinfection of dentures include immersion in chemical solutions such as sodium hypochlorite, glutaraldehyde, and chlorhexidine, which efficiently eliminate microorganisms.[17-19] Recently, microwave energy has been used as an alternative to these traditional methods, and many studies have demonstrated its efficiency to disinfect or sterilize dental prostheses.[20–23] In addition, some physical and mechanical properties of dental prostheses and acrylic resin have been shown to be satisfactory after different disinfection procedures.[24-26]

Little information, however, is available in the literature regarding the effects of disinfection treatment with chemical solutions or microwave irradiation on physical properties of soft liners.[27–30] One physical property frequently assessed when comparing the quality of soft liners is hardness.[31-33] Hardness is a simple way of obtaining a measurement of a material's viscoelastic properties.[34,35] In regular use, which includes denture disinfection, soft lining materials are exposed to conditions that may influence the hardness. Loss of elasticity results in delivery of higher occlusal forces to the underlining mucosa and an increase in the incidence of symptoms such as pain, soreness, and tissue irritation, necessitating more clinical management.[1,5] The purpose of this study was to evaluate the effects of two disinfection procedures with chemical solutions and microwave energy on the Shore A hardness of four long-term soft denture liner materials.

Materials and Methods

The laboratory-processed long-term soft denture liners chosen for this study were three silicone materials [Molloplast-B (lot 010204, Detax GmbH & Co., KG, Ettlingen, Germany), Ufi Gel P (lot 015227, Voco, Cuxhaen, Germany), and Mucopren soft (lot 00281, Kettenbach GmbH & Co, Eschenburg, Germany)] and a plasticized acrylic resin [EverSoft (lot 081058, Myerson Austenal, Chicago, IL)].

Forty rectangular specimens (36 mm × 7 mm × 6 mm) were prepared for each material in Teflon molds. The molds were invested in denture flasks between two glass plates, with hard silicone rubber (Zetalabor, Zhermack, Badia Polesine, Rovigo, Italy) and type IV dental stone (Herostone, Vigodent, Rio de Janeiro, RJ, Brazil). Each material was polymerized according to the manufacturers' instructions. The Molloplast-B was polymerized in a microwave oven (AW-30, Continental, Manaus, Amazonas, Brazil) for 10 minutes at 800 W, and the EverSoft was polymerized in a water bath at 70°C for 90 minutes and then at 100°C for 30 minutes. The Mucopren soft and Ufi Gel P were polymerized in a water bath at 45°C for 20 minutes. After heat polymerization, specimens were removed from the flask, the flash was trimmed with a scalpel, and the specimens were stored in distilled water at 37°C for 24 hours.

The samples of each material were divided into four groups of ten specimens each, according to the following disinfection procedures:

1. Soaking in 2% alkaline glutaraldehyde solution (lot 0206220, Glutaron II, Rio Química LTDA, São José do Rio Preto, São Paulo, Brazil) for 10 minutes;
2. Soaking in 5% sodium hypochlorite solution (lot 2048X0901, Miyaco LTDA, Guarulhos, São Paulo, Brazil) for 10 minutes;
3. Soaking in 5% chlorhexidine solution (Farmácia de Manipulação Arte e Ciência Araraquara, São Paulo, Brazil) for 10 minutes;
4. Microwave energy in a conventional microwave oven (AW-30, Continental) with rotating table for 3 minutes at 500 W.

The selection of 10 minutes of soaking in disinfectant solutions and 3 minutes in the microwave was based on studies[17-19,22,24,25] that demonstrated that similar exposure times produce disinfection on prosthetic materials. Each disinfection procedure was performed twice, simulating when contaminated dentures come from the patient and before being returned to the patient.

Indention hardness was performed with a digital Shore A durometer (GS-709, Teclock, Osaka, Japan) fixed on an electro-mechanical stand according to the American Society for Testing and Materials (ASTM) D-2240 specification[36] at room temperature. The durometer was calibrated according to ASTM specifications.[36]

The indentor extension was adjusted to 2.50 ± 0.04 mm, placing a precision ground dimensional block on the support table and beneath the durometer presser foot and indentor. Afterward, a similar arrangement of dimensional gauge blocks was used to verify the linear relationship between indentor and indicated display. The durometer spring was calibrated by supporting the durometer in a vertical position and applying a measurable force (0.55, 1.3, 2.0, 2.8, 3.55, 4.3, 5.05, 5.8, 6.55, 7.3, 8.05 N) to the indentor tip. The force was measured by means of a balance. The displayed readings were 10, 20, 30, 40, 50, 60, 80, and 90 durometer units.

The Shore A measurement is based on the indentation of a blunt-pointed indentor forced into the material under a constant load of 1 kg. 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 1 second after firm contact was achieved. Five readings were taken in the middle of the specimens, at least 6 mm apart. Durometer measurements were made 24 hours after polymerization (control), after the first disinfection cycle, and after the second disinfection cycle. Throughout the study, the specimens were stored in distilled water and dried with absorbent paper before the hardness measurements.

Mean values of hardness for each material under each test condition were submitted to three-way analysis of variance (ANOVA) and Tukey's test ($\alpha = 0.01$). The variables analyzed were material (Molloplast-B, Ufi Gel P, Mucopren soft, and EverSoft), disinfection technique (2% glutaraldehyde solution, 5% sodium hypochlorite, 5% chlorhexidine, and microwave energy), and number of disinfections (control, first, and second disinfection).

Results

Three-way ANOVA results shown in Table 1 indicate that significant differences were found for different materials and disinfection techniques, and also for the interaction of these factors. The number of disinfections was not significant. The highest value of hardness was recorded for the Molloplast-B material, independent of the disinfection technique, as shown in Table 2. Mucopren soft showed intermediate values of hardness for all the disinfection techniques. The Ufi Gel P and Eversoft materials presented lower values of hardness than Molloplast-B and Mucopren soft.

For Molloplast-B material, the disinfection using glutaraldehyde resulted in the highest value of hardness (38.16), followed by chlorhexidine (35.16), microwave energy (33.51), and sodium hypochlorite (29.70) ($p < 0.01$), as shown in Table 3. For Mucopren soft (Table 3) the disinfection technique using glutaraldehyde also resulted in the highest values of hardness (28.14) with significant difference only with chlorhexidine (26.49) ($p < 0.01$).

For Ufi Gel P, the highest values of hardness were obtained for glutaraldehyde (19.07) and chlorhexidine (18.80) with significant difference for microwave energy (17.20) ($p < 0.01$). For Eversoft material, the differences among the disinfection treatments were not significant ($p > 0.01$), as shown in Table 3.

The results in Tables 4 and 5 demonstrate that the number of disinfections did not have any effect on hardness values for all the materials studied and disinfection techniques ($p > 0.01$).

Discussion

The efficiency of soft denture liners is considered to be influenced by their viscoelastic properties.[3,6-8] For clinical use, these properties are important for their cushioning effect, which allows more even pressure distribution and absorption of the energy from masticatory function.[4]

Hardness measurement is a simple way of obtaining a measure of the elastic modulus of a soft

Table 1. Results of Three-Way ANOVA for Shore A Hardness

Source	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F*	*P value*
Materials (*A*)	3	22,089.51	7363.17	1336.75	0.00001
Disinfection technique (*B*)	3	392.40	130.80	23.74	0.0002
Number of disinfections (*C*)	2	17.21	8.60	1.56	0.12
$A \times B$	9	853.83	94.87	17.22	0.0001
$A \times C$	6	46.03	7.67	1.39	0.11
B x C	6	33.34	5.55	1.00	0.12
$A \times B \times C$	18	140.86	7.82	1.42	0.11
Error	432	2379.56	5.50		

Table 2. Comparison of the Mean Values of Shore A Hardness among the Soft Liner Materials for Each Disinfection Technique

	Glutaraldehyde	*Microwave Energy*	*Chlorhexidine*	*Sodium Hypochlorite*
Molloplast-B	38.16 ± 0.65^{A}	33.51 ± 1.04^{A}	35.16 ± 1.10^{A}	29.70 ± 0.85^{A}
Mucopren soft	28.14 ± 1.09^{B}	26.61 ± 1.95^{B}	26.49 ± 0.64^{B}	27.37 ± 0.03^{B}
Ufi Gel P	19.07 ± 0.66^{C}	17.20 ± 0.47^{C}	18.80 ± 0.74^{C}	18.27 ± 0.75^{C}
Eversoft	17.29 ± 0.29^{D}	18.18 ± 0.34^{C}	17.77 ± 0.44^{C}	17.52 ± 0.79^{C}

Means followed by different letters in same columns were significantly different at the 99% confidence level.

material by determining its resistance to a rigid indentor to which a force is applied.[1,2,10,35]

In this study, Shore A hardness of different soft liners was recorded and compared before and after disinfection treatment. Molloplast-B presented higher hardness values when compared with the other test materials (Table 2). Similar findings were reported by Hekimoglu and Anil,[33] who demonstrated that Molloplast-B hardness was higher than Ufi Gel, Simpa, and Flexor before and after aging. According to Waters and Jagger,[35] the reasoning for this result is related to the nature of elastomers and the higher degree of cross-linking present when Molloplast-B chains were compared with acrylic materials.

The other silicone base materials investigated in this study (Ufi Gel P and Mucopren soft) were shown to have lower values of Shore A hardness than Molloplast-B (Table 2). The polymerization method of soft lining materials may influence their physical properties.[5] According to some authors,[1,25,31] materials processed in the laboratory using conventional laboratory techniques may exhibit a higher degree of polymerization than materials not submitted to elevated temperatures and pressures, suggesting that these materials present better physical/mechanical properties.

The samples of Mucopren soft and Ufi Gel P were invested with stone, flasked, and processed in a water bath at 45°C for 20 minutes. Molloplast-B was polymerized in a microwave oven for 10 minutes at 800 W. This time/temperature difference may explain the discrepancy in the Shore A hardness results among the different silicone materials. The filler content of these materials is another factor that may explain the differences in the hardness values. Molloplast-B has a great volume of filler (21%),[35] which may be a contributor to the higher hardness values recorded.

Even though the optimal hardness values of soft denture liners for clinical use have not been determined,[34] their shock-absorbing properties are known to increase with their softness.[1] Thus, lower hardness is a desirable property for soft denture liners.[27] The maintenance of this property is a major problem during use of soft liners, since some of these materials are not stable in an aqueous environment, such as the oral cavity, and/or when immersed in disinfection solutions.[27,31,34]

The results of this study showed that the highest Shore A hardness values were obtained in 2% glutaraldehyde solution for Molloplast-B, Mucopren soft, and Ufi Gel P materials (Table 3). Therefore, the data from this investigation reveal that silicone materials demonstrated similar behavior in glutaraldehyde disinfection, suggesting that this treatment may not be the most optimal for these materials as regards maintaining

Table 3. Comparison of the Mean Values of Shore A Hardness among the Disinfection Techniques for Each Soft Liner Material

	Molloplast-B	*Mucopren Soft*	*Ufi Gel P*	*Eversoft*
Glutaraldehyde	38.16 ± 0.65^{A}	28.14 ± 1.09^{A}	19.07 ± 0.66^{A}	17.29 ± 0.29^{A}
Microwave energy	33.51 ± 1.04^{B}	26.61 ± 1.95^{AB}	17.20 ± 0.47^{B}	18.18 ± 0.34^{A}
Chlorhexidine	35.16 ± 1.10^{C}	26.49 ± 0.64^{B}	18.80 ± 0.74^{A}	17.77 ± 0.44^{A}
Sodium hypochlorite	29.70 ± 0.85^{D}	27.37 ± 0.03^{AB}	18.27 ± 0.75^{AB}	17.52 ± 0.79^{A}

Means followed by different letters in same columns were significantly different at the 99% confidence level.

Table 4. Mean Values of Shore A Hardness in Relation to Denture Soft Liner Materials and Number of Disinfections

	Control	*First Disinfection*	*Second Disinfection*
Molloplast-B	34.91 ± 3.23^A	33.64 ± 3.74^A	33.84 ± 3.83^A
Mucopren soft	26.94 ± 2.02^A	27.41 ± 0.40^A	27.10 ± 0.98^A
Ufi Gel P	18.75 ± 1.01^A	18.37 ± 0.99^A	17.8 ± 0.67^A
Eversoft	17.63 ± 0.93^A	17.75 ± 0.69^A	17.69 ± 0.32^A

Means followed by different letters in same row were significantly different at the 99% confidence level.

their resilient properties. However, for Eversoft, the highest value was obtained for the group submitted to microwave irradiation, but did not present any significant difference from the other disinfection groups ($p > 0.01$) (Table 3). This may be explained by the increase of temperature in the sample during the microwaving process producing a further polymerization and loss of plasticizers present in acrylic materials, which could be responsible for their hardening. This second hypothesis may be more acceptable, since the silicone materials did not demonstrate the same results with microwave energy disinfection.

In spite of this behavior, the acrylic material presented a greater Shore A hardness stability after the different disinfection techniques than the silicone materials, without significant differences among the groups (Table 3). These findings contrast with other reports showing that the acrylic soft liners are less stable in an aqueous environment;[7,9,34] however, results in Tables 4 and 5 demonstrate that the hardness values did not change after the first and second disinfection cycles, independent of material or disinfection technique. Dixon et al[28] reported that disinfection with microwave energy did not change Shore A hardness of the Molloplast-B material. An acrylic resin resilient material (Permasoft), however, presented significant changes in Shore A hardness after the disinfection cycles.[28] Probably, the differences between this study and ours can be explained by the difference in the number of exposures to the disinfection procedures.

This study suggests that the different disinfection techniques affect the hardness of all tested soft liner materials. The soft denture liners demonstrated different behaviors after the disinfection procedures, which depended on the material composition and disinfection technique. The behavior of denture lining materials in this study may only partially predict the clinical performance. Despite the increasing use of soft liners in prosthetic dentistry and the importance of disinfection to prevent cross contamination, factors such as absorption and solubility, roughness, bond strength, color stability, and viscoelastic properties need to be further investigated to define the best disinfection procedure for these materials.

Conclusions

Within the limitations of this in vitro study, the following conclusions were drawn:

1. The application of two disinfection cycles did not significantly change the hardness values.
2. The glutaraldehyde solution promoted the highest values of hardness for Molloplast-B, Mucopren soft, and Ufi Gel P materials.
3. No changes in the hardness of Eversoft were detected independent of disinfection technique.

Table 5. Mean Values of Shore A Hardness in Relation to Disinfection Technique and Number of Disinfections

	Control	*First Disinfection*	*Second Disinfection*
Sodium hypochlorite	23.14 ± 6.89^A	23.35 ± 5.53^A	23.17 ± 6.27^A
Glutaraldehyde	26.18 ± 9.44^A	25.40 ± 9.39^A	25.40 ± 9.99^A
Chlorhexidine	25.22 ± 8.31^A	24.40 ± 8.19^A	23.99 ± 7.77^A
Microwave energy	23.75 ± 7.88^A	24.03 ± 7.75^A	23.86 ± 7.69^A

Means followed by different letters in same row were significantly different at the 99% confidence level.

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References

1. Craig RG, Gibbons P: Properties of resilient denture liners. J Am Dent Assoc 1961;63:382-390
2. Lammie GA, Storer R: A preliminary report on resilient denture plastics. J Prosthet Dent 1958;8:411-424
3. Braden M, Wright PS, Parker S: Soft lining materials—a review. Eur J Prosthodont Restor Dent 1995;3:163-174
4. Kawano F, Koran A, Nuryanti A, et al: Impact absorption of four processed soft denture liners as influenced by accelerated aging. Int J Prosthodont 1997;10:55-60
5. Qudah S, Harrison A, Huggett R: Soft lining materials in prosthetic dentistry: a review. Int J Prosthodont 1990;3:477-483
6. Murata H, Taguchi N, Hamada T, et al: Dynamic viscoelasticity of soft liners and masticatory function. J Dent Res 2002;81:123-128
7. Murata H, Taguchi N, Hamada T, et al: Dynamic viscoelastic properties and the age changes of long-term soft denture liners. Biomaterials 2000;21:1421-1427
8. Jepson NJ, McCabe JF, Storer R: Evaluation of the viscoelastic properties of denture soft lining materials. J Dent 1993;21:163-170
9. El-Hadary A, Drummond JL: Comparative study of water sorption, solubility, and tensile bond strength of two soft lining materials. J Prosthet Dent 2000;83:356-361
10. Kazanji MN, Watkinson AC: Influence of thickness, boxing, and storage on the softness of resilient denture lining materials. J Prosthet Dent 1988;59:677-680
11. Verran J, Maryan CJ: Retention of *Candida albicans* on acrylic resin and silicone of different surface topography. J Prosthet Dent 1997;77:535-539
12. Nikawa H, Iwanaga H, Kameda M, et al: In vitro evaluation of *Candida albicans* adherence to soft denture-lining materials. J Prosthet Dent 1992;68:804-808
13. Okita N, Orstavik D, Orstavik J, et al: In vivo and in vitro studies on soft denture materials: microbial adhesion and tests for antibacterial activity. Dent Mater 1991;7:155-160
14. Molinari JA, Merchant VA, Gleason MJ: Controversies in infection control. Dent Clin North Am 1990;34:55-69
15. Kahn RC, Lancaster MV, Kate W Jr: The microbiologic cross-contamination of dental prostheses. J Prosthet Dent 1982;47:556-559
16. Wakefield CW: Laboratory contamination of dental prostheses. J Prosthet Dent 1980;44:143-146
17. Lin JJ, Cameron SM, Runyan DA, et al: Disinfection of denture base acrylic resin. J Prosthet Dent 1999;81:202-206
18. Chau VB, Saunders TR, Pimsler M, et al: In-depth disinfection of acrylic resins. J Prosthet Dent 1995;74:309-313.
19. Bell JA, Brockmann SL, Feil P, et al: The effectiveness of two disinfectants on denture base acrylic resin with an organic load. J Prosthet Dent 1989;61:580-583
20. Neppelenbroek KH, Pavarina AC, Spolidorio DM, et al: Effectiveness of microwave sterilization on three hard chairside reline resins. Int J Prosthodont 2003;16:616-620
21. Banting DW, Hill SA: Microwave disinfection of dentures for treatment of oral candidiasis. Spec Care Dentist 2001;21:4-8
22. Webb BC, Willcox MD, Thomas CJ, et al: The effect of sodium hypochlorite on potential pathogenic traits of *Candida albicans* and other Candida species. Oral Microbiol Immunol 1995;10:334-341
23. Rohrer MD, Bulard RA: Microwave sterilization. J Am Dent Assoc 1985;110:194-198
24. Thomas CJ, Webb BC: Microwaving of acrylic resin dentures. Eur J Prosthodont Restor Dent 1995;3:179-182
25. Polyzois GL, Zissis AJ, Yannikakis SA: The effect of glutaraldehyde and microwave disinfection on some properties of acrylic denture resin. Int J Prosthodont 1995;8:150-154
26. Asad T, Watkinson AC, Huggett R: The effect of disinfection procedures on flexural properties of denture base acrylic resins. J Prosthet Dent 1992;68:191-195
27. Tan H, Woo A, Kim S, et al: Effect of denture cleansers, surface finish, and temperature on Molloplast B resilient liner color, hardness and texture. J Prosthodont 2000;9:148-155
28. Dixon DL, Breeding LC, Faler TA: Microwave disinfection of denture base materials colonized with *Candida albicans*. J Prosthet Dent 1999;81:207-214
29. Baysan A, Whiley R, Wrigth PS: Use of microwave energy to disinfect a long-term soft lining material contaminated with *Candida albicans* or *Staphylococcus aureus*. J Prosthet Dent 1998;79:454-458
30. Furukawa KK, Niagro FD, Runyan DA, et al: Effectiveness of chlorine dioxide in disinfection on two soft denture liners. J Prosthet Dent 1998;80:723-729
31. Parr GR, Rueggeberg FA: In vitro hardness, water sorption, and resin solubility of laboratory-processed and autopolymerized long-term resilient denture liners over one year of water storage. J Prosthet Dent 2002;88:139-144
32. Polyzois GL, Frangou MJ: Influence of curing method, sealer, and water storage on the hardness of a soft lining material over time. J Prosthodont 2001;10:42-45
33. Hekimoglu C, Anil N: The effect of accelerated aging on mechanical properties of soft denture lining materials. J Oral Rehabil 1999;26:745-748
34. Canay S, Hersek N, Tulunoglu I, et al: Evaluation of color and hardness changes of soft lining materials in food colorant solutions. J Oral Rehabil 1999;26:821-829
35. Waters MG, Jagger RG: Mechanical properties of an experimental denture soft lining material. J Dent 1999;27:197-202
36. American Society for Testing & Materials. D. 2240-00: Standard Test Method for Rubber Property-Durometer Hardness. West Conshohocken, ASTM, 2000, p. 8.