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The effect of accelerated aging on color stability of denture liners

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Abstract: The objective of the present study was to determine the color changes resulting from the aging process in two cold and three hot curing soft liners and two hard liners. Seven samples were fabricated for each material. The initial color measurements were made with a UV-Visible Recording Spectrophotometer. The samples were then placed in an accelerated aging chamber to simulate the aging process. The color of the samples was then measured again with a colorimeter, and the color changes (ΔE) were calculated. The critical mark of color change (ΔE) has been quantified by the NBS. It was concluded that cold curing soft liners were not color-stable, and that hot curing soft liners and hard liners had similar color durability. These results suggest that colorants used in cold curing soft liners must be reinforced. (J. Oral Sci. 40, 105-108, 1998)

Key words: color stability; soft denture liner; hard denture liner.

Introduction

The success of complete and partial dentures depends on esthetics, comfort and function. The use of resilient denture liners become increasingly popular for providing comfort for denture wearers. However, the primary disadvantage of these materials is that their physical and mechanical properties change rapidly with time in the oral environment. Few of the currently available soft denture liners can be used for more than 3 years (1). Soft denture lining materials often show changes in mechanical properties with aging (2). In contrast, the denture bases last many years longer. Therefore, it is important to be able to assess the resistance to aging of denture liners. Color stability is one of the criteria that may provide important information on the serviceability of these materials (3, 4).

The purpose of this study was to determine the color stability of soft and hard denture liners by subjecting them to an in vitro accelerated aging process.

Materials and Methods

Table 1 lists the materials and manufacturers of the five tested commercially available soft (two cold, three hot curing) and two hard lining materials.

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Seven sample disks were made for each material. The samples were 15 mm in diameter and 4 mm thick. A 2 -mm- thick lining material was polymerized on a 2 -mm-thick heat-cured acrylic resin disk (Fig. 1). All materials were processed according to the manufacturer's instructions. Before testing, the samples were stored in distilled water for 24 h. The initial color measurements were made with a UV-Visible Recording Spectrophotometer (UV 2100, Shimadzu, Japan). Four measurements were made for each sample.

After the measurements, the samples were placed in an accelerated aging chamber (QUV Accelerated Weathering Tester, The Q-Panel Company 26200 First St., Cleveland, Ohio, 1044145 USA) and kept there for 900 h. In the Weather-Ometer instrument, the samples were exposed to continuous UV and visible light, a temperature of 43.3°C and a programmed cycle of 18 min of distilled water spray within each 2 h period (5).

After 900 h , the color of the samples was evaluated again with the colorimeter. Color changes (ΔE) were calculated by measuring tristimulus values at several wavelengths in the visual spectrum with the use of the Commission International de l'Eclairge Lab (CIE-LAB) uniform color scale (6) .

This system represents a three-dimensional color space having components of lightness (L), red-green (a), and yellow-blue (b).

An important aspect of the CIE-LAB system is that color differences between specimens can be given by use of a single parameter, ΔEab (6, 7).

The color difference between two samples, each given in terms of L, a and b, is calculated as follows:

$$\Delta Eab = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]1/2$$

The critical mark of color change (ΔE) has been quantified by the National Bureau of Standards (NBS) with NBS units of color difference (8) (Table 2). NBS units are expressed by the following formula:

$$\text{NBS unit} = \Delta Eab \times 0.92$$

Mean ΔE values were calculated for each material and compared statistically using Kruskal-Wallis Variance Analysis and Mann-Whitney U-Wilcoxon Rank Sum W Tests.

Results

The effects of accelerated aging on the samples are shown in Fig. 2. Ufigel P ($\overline{X}$ = 60.92) and Simpa ($\overline{X}$ = 104.03), which are cold curing soft liners, showed the greatest color changes. Simpa showed significantly greater color change than Ufigel P (u = 0.0, p = 0.000).

Molloplast B ($\overline{X}$ = 2.11) and Flexor ($\overline{X}$ = 2.70), which are hot curing soft liners, demonstrated slightly greater changes than Ufigel L ($\overline{X}$ = 1.94). There were statistically insignificant differences among Ufigel L-Molloplast B, Ufigel L-Flexor, and Molloplast B-Flexor (u = 19.0, p = 0.535; u = 14.0, p = 0.2086; u = 16.0, p = 0.3176).

The difference between ΔE values for Tokuso Rebase ($\overline{X}$ = 4.18) and CT liners ($\overline{X}$ = 4.28) was insignificant (u = 19.0, p = 0.535). Tokuso Rebase and CT liner, which are hard liners, showed significantly greater color changes than hot curing soft liners (u = 0.0, P = 0.006). However, they showed significantly lower color changes than cold curing soft liners (u = 0.00, p = 0.006). The critical marks of color difference according to NBS units were as follows:

Ufigel L/NBS unit = 1.94×0.92 = 1.78 noticeable
Ufigel P/ NBS unit = 60.92×0.92 = 56.05 very much
Simpa/NBS unit = 104.03×0.92 = 95.7 very much
Molloplast B/NBS unit = 2.11×0.92 = 1.94 noticeable
Flexor/NBS unit = 2.70×0.92 = 2.48 noticeable
Tokuso Rebase/NBS unit = 4.18×0.92 = 3.8 appreciable
CT Liner/NBS unit = 4.28×0.92 = 3.9 appreciable

Discussion

The longevity of denture liners is a major problem in prosthodontics. Use of in vitro accelerated aging treatment has increased extensively for dental investigations recently. The accelerated aging process has been widely used to examine temporal changes in color, and the mechanical and physical characteristics of various materials (2, 9-14).

In this study, an aging device was used to subject samples to both visible and ultraviolet (UV) light, and a distilled water spray to simulate aging. Although the oral environment is more complex,this simulated aging treatment is useful for comparing different lining materials.

Water spray and visible ultraviolet light have a direct effect on the properties of soft liners and cause them to swell (15). In this method, the effects of extrinsic coloring, surface roughness, and leakage between the soft liner and base materials on color change should not be taken into consideration; it is possible to examine only those color changes that are related to material properties.

Many molecular changes occur in polymers as a result of treatment in the Weather-Ometer instrument. The chemical processes that may have caused the observed changes in storage and loss of moduli are (15,16) :

1. Scisson of the polymer chains by UV light
2. Oxygen cross-linking
3. Leaching of plasticizers
4. Absorption of water

The causative factors that may contribute to the change in color of esthetic restorative materials include stain accumulation, dehydration, water sorption, leakage, or poor bonding and surface roughness (8).

The color changes in soft denture liners are attributed to changes in the colorants used, a change in the color of the elastomer, or both. It has been suggested that some colorants or elastomers may be affected by humidity or higher temperature in the aging chamber (14). The mechanism of the color changes is not known exactly, but

Table 1 The materials used in the present study

Material	Type	Manufacturer
Ufigel L	Silicone (hot curing)	Voco, Postfach 767, D-27457 Cuxhafen, Germany
Ufigel P	Silicone (cold curing)	Voco, Postfach 767, D-27457 Cuxhafen, Germany
Simpa	Polymethylsiloxan (cold curing)	Kettenbach, D-35713 Eschenburg, Germany
Molloplast B	Silicone (hot curing)	Buffalo Dental Manufacturing Co. Inc. Syosset, NY 11791
Flexor	Copolymer (hot curing)	Schutz Dental GmbH Hamburger Straβe 64, D-6365 Rosbach 1, Germany
Tokuso Rebase	–	Tokuyama Soda Co., Ltd 1-4-5 Nishi-shimbashi, Minato-ku Tokyo, Japan
CT Inc. Liner	–	Nissan Dental Products

Table 2 Clinical marks of color difference according to the NBS

Cinical marks of color difference	Textile terms (NBS unit)
Trace	0.0-0.5
Slight	0.5-1.5
Noticeable	1.5-3.0
Appreciable	3.0-6.0
Much	6.0-12.0
Very much	(12.0)

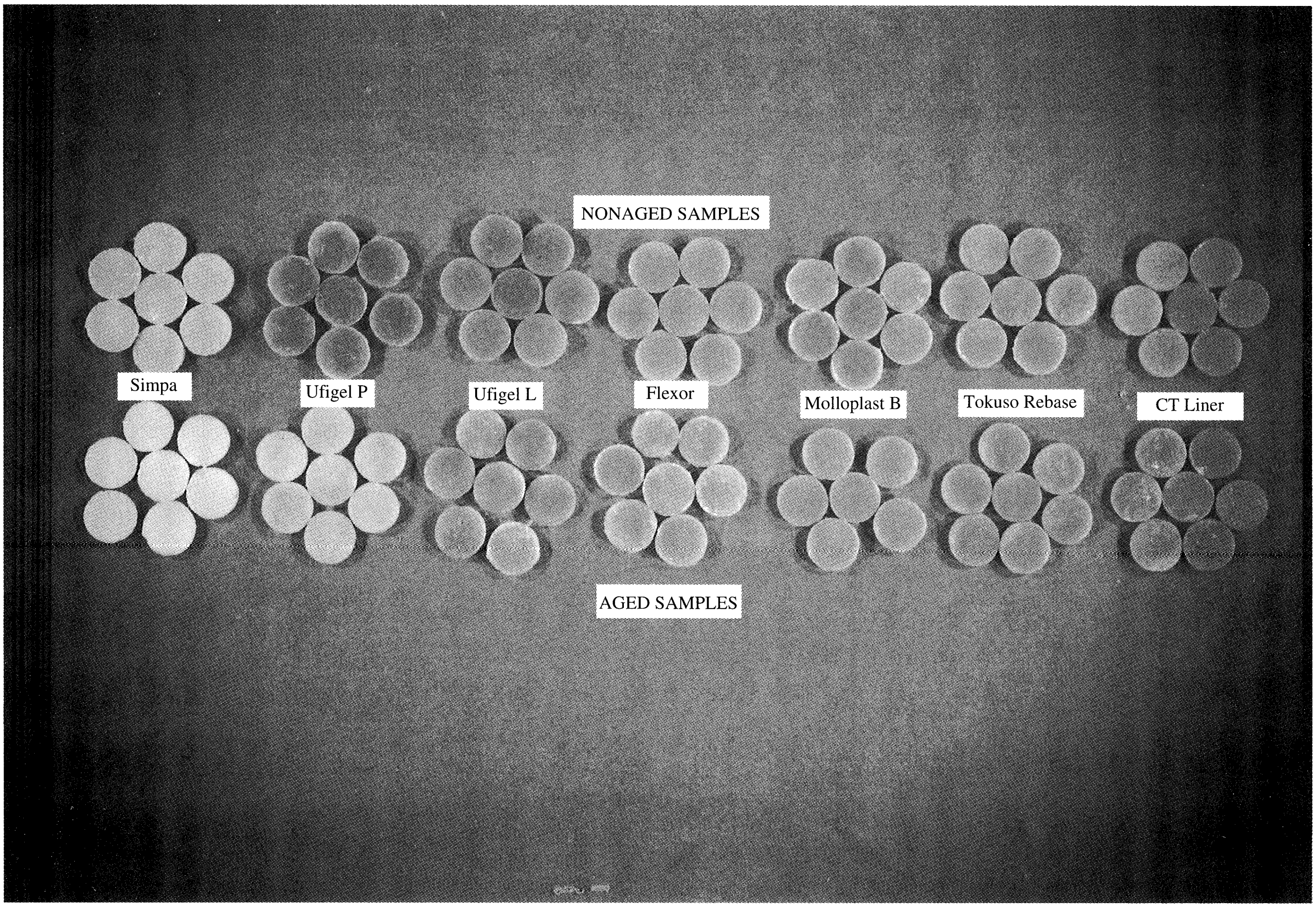

Fig. 1 Aged and non-aged samples.

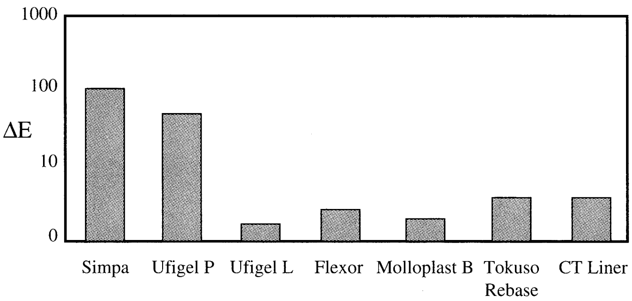

Fig. 2 The color changes in denture lining materials after accelerated aging.

it can be estimated (14). This is in contrast to good knowledge about how the aging process changes the physical and mechanical properties of soft liners (2,11,12).

Shotwell *et al.* (14) investigated color change in some naked soft liners. In this study, liners were applied over hot curing acrylic disks which were fabricated at a standard thickness for providing clinical suitability. Thus, the color changes in base materials were also taken into consideration as being different from other studies.

The cold curing soft liners showed the greatest color changes in this study; a visible whiteness was observed in Simpa after a short time. The color change in hot curing soft liners was noticeable according to the National Bureau of Standards. An appreciable color change comparable to that of hot curing liners was also seen in hard liners.

This similarity showed that colorants used in hot curing soft liners and hard liners were more durable to the aging process. It is considered necessary for colorants of cold curing soft liners to be reinforced, because these liners were found not to be color stable, even though all of the soft liners investigated silicone-based. We belive that more studies should be done on the mechanism of action of accelerated aging on color stability.

Conclusions

1. Cold curing soft liners showed the most unstable color characteristics.
2. Hot curing soft liners and hard liners were similar to each other with respect to color stability.
3. Hot curing soft liners and hard liners were more reliable with respect to color stability.

References

1. Craig, R.G. (1993) Restorative Dental Materials. 9th ed., Mosby-Year Book, St. Louis, 533-535
2. Dootz, E.R., Koran, A. and Craig, R.G. (1993) Physical property comparison of 11 soft denture lining materials as a function of accelerated aging. J. Prosthet. Dent. 69,114-119
3. Bunch, J., Johnson, G.H. and Brudvik, J.S. (1987) Evaluation of hard direct reline resins. J. Prosthet.

Dent. 57, 512-519

4. Mahila, E. and Honka, O. (1979) Clinical study of a heat-cured silicone soft lining material. J. Oral. Rehabil. 6, 199-204
5. Wagner, W.C., Kawano, F., Dootz, E.R. and Koran, A. 3rd (1995) Dynamic viscoelastic properties of processed soft denture liners: Part II - Effect of aging. J. Prosthet. Dent. 74, 299-304
6. Wyszecki, G. and Stiles, W.S. (1985) Color science: Concepts and method, quantative formula. 2nd ed. John Wiley & Sons, New York, 950
7. Bouma, P.J. (1971) Physical aspect of colour. 2nd ed., St. Martins Press, New York, 280
8. Nimeroff, L. (1968) Colorimetry. DC: National Bureau of Standards Monograph no. 104. Washington, 47
9. Powers J.M., Dennison, J.B. and Koran, A. (1978) Color stability of restorative resins under accelerated aging. J. Dent. Res. 57, 964-970
10. Craig, R.G., Koran, A., YU, R. and Spencer, J. (1978) Color stability of elastomers for maxillofacial appliances. J. Dent. Res. 57, 866-871
11. Noie, F., O'Keefe, K.L. and Powers, J.M. (1995) Color stability of resin cements after accelerated aging. Int. J. Prosthodont. 8, 51-55
12. Kawano, F., Koran, A., Nuryanti, A. and Inoue, S. (1997) Impact absorption of four processed soft denture liners as influenced by accelerated aging. Int. J. Prosthodont. 10, 55-60.
13. Fruits, T.J., Duncanson, M.G. and Miranda, F.J. (1997) *In vitro* weathering of selected direct esthetic restorative materials. Quintessence Int. 28, 409- 414
14. Shotwell, J.L., Razzoog, M.E. and Koran, A. (1992) Color stability of long-term soft denture liners. J. Prosthet. Dent. 68, 836-838
15. Wagner, W.C., Kawano, F., Dootz, E.R. and Koran, A. 3rd. (1995) Dynamic viscoelastic properties of processed soft denture liners: Part I - Initial properties. J. Prosthet. Dent. 73, 471-477
16. Flinn, R.A. and Trogan, P.K. (1993) Engineering materials and their applications. Houghton Mifflin, Boston, 539-540