Discoloration of auto-polymerized resin applied using a brush-on technique

Yohei Sato, DMD, PhD, Hikari Chiba, DMD, PhD, Tomoko Osada, DMD, PhD, Ema Muraishi, DMD, Chikahiro Ohkubo, DMD, PhD, and Toshio Hosoi, DDS, PhD

Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine, Yokohama, Japan

Purpose: The discoloration of auto-polymerized resin has frequently been observed after denture repair. This study is an investigation of the discoloration of auto-polymerized resin applied using a brush-on technique.
Materials and Methods: Rectangular resin plates were fabricated so that five auto-polymerized resins (Unifast II, Unifast Trad, Provinice, Metafast, and Miky) could be packed in a mold (15x30x1 mm) using a brush-on technique (resin brush, horsehair) in six increments for each mold. As controls, the five resins were poured in the molds after the polymer and monomer were mixed at 0.5 mL/g for 10 s. After polymerization, half of the resin plates were covered with aluminum foil. All the plates were soaked in distilled water (37°C) and exposed to xenon light for 24 hours according to ISO 7491. They were soaked in water again for 5 days. After removing the aluminum foil, the discoloration was measured using a color difference meter (Shade eye system) three times for each specimen. The color differences (ΔE: n=5) were analyzed by ANOVA/Tukey's test (α=0.05).
Results: For the brush-on technique, Provinice had the greatest color change of any of the resins tested. There were significant differences between the brush-on technique and the controls for Unifast II and Miky.
Conclusion: The brush-on technique resulted in fewer color changes than the mixing technique on all resins except for Provinice, as shown by the fact that many porosities were found in the control specimens.
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Key Words: autopolymerized acrylic resin, brush-on technique, color change, discoloration

Introduction

A series of studies on auto-polymerized resins using a brush-on technique was conducted for chair-side denture repair.[1-4] The characteristics of auto-polymerized repair resins, namely, mechanical strength,[4] dimensional accuracy,[2] fluidity,[1] and handling efficiency,[3] were compared, and points were suggested for clinical and laboratory procedures. However, the problem of discoloration of auto-polymerized resins after denture repair remains unresolved and has not been sufficiently investigated, although heat-polymerized resin and pour-type resin have been thoroughly examined.[5-10] In particular, the discoloration of pink auto-polymerized resin used for denture repair has not been studied in depth; however, there have been a few reports regarding ivory resin.[11-13]

Several experimental methods have been used in research on the discoloration of resins. They include the following: 1, soaking in stain solution;[14] 2, soaking in warm water (60°C) for one month;[15,16] 3, exposure to sunlight and ultraviolet rays;[17-21] 4, soaking in warm water and synthetic saliva of 37°C for a long time.[22,23] Alternatively, ISO 7491, a dental material-determination system of the color stability of dental polymeric materials, was enacted as a tone stability examination standard.

One reason for the discoloration would be the lower degree of polymerization of auto-polymerized than heat-polymerized resins. However, few details are known about the discoloration of repair resins. The purpose of this study was to investigate the discoloration of commercial auto-polymerized acrylic resins using brush-on and conventional mixing techniques.

Materials and Methods

The auto-polymerized resins used in this study are listed in Table 1.

Table 1. Auto-polymerized resins used in this study.

Brand name	Manufacturer	Shade	Lot number
Unifast II	GC, Tokyo, Japan	#3 Pink	Powder 0503172, Liquid 0504261
Unifast Trad	GC	#3 Pink	Powder 0504261, Liquid 0503221
Provinice	Shofu, Kyoto, Japan	U3	Powder 020507, Liquid 030555
Metafast	Sun Medical, Moriyama, Japan	#2 Pink	Powder 41101, Liquid 41103
Miky	Nissin, Kyoto, Japan	#2	Powder PEIL, Liquid ELG

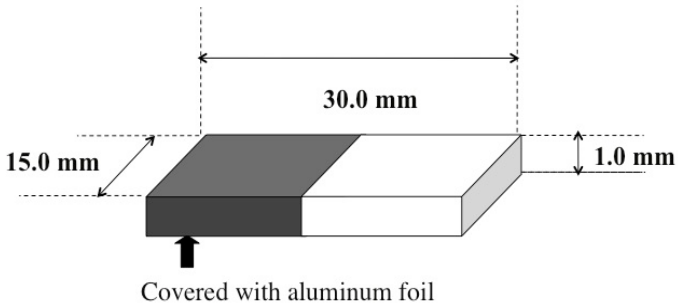

Fig. 1. Illustration of the specimen.

Specimen fabrication

As shown in Fig. 1, rectangular resin plates were fabricated so that five auto-polymerized resins could be applied in a mold (15x30x1 mm) using a brush-on technique (resin brush, horsehair; Seiundo, Tokyo, Japan). The resin slurry was applied six times for each mold. As controls, the five resins were poured into the molds after the polymer and monomer were mixed at 0.5 mL/g for 10 s according to the manufacturer's recommendation. After polymerization, half of the resin plates were covered with aluminum foil (Myfoil, Sumikei Aluminum-Foil Co., Ltd., Tokyo, Japan). All the plates were soaked in distilled water (37°C). Five specimens were made for each resin; a total of 50 specimens were fabricated.

Discoloration test

All the specimens were exposed to xenon light using a xenotest apparatus (Suntest CPS, Heraeus Kulzer, Hanau, Germany) for 24 hours according to ISO 7491. They were then soaked in water again for 5 days. After the aluminum foil was removed, the discoloration was measured using a color difference meter (Shade eye system, Shofu, Kyoto, Japan) three times for each specimen. The color differences of the five resins (ΔL^*, Δa^*, Δb^*: n=5) were analyzed by ANOVA and Tukey's multiple comparisons test at a significance level of $\alpha=0.05$. Between the brush-on and conventional mixing techniques, discoloration (ΔE^*: n=5) was analyzed by the t-test at a significance level of $\alpha=0.05$. After the discoloration test, each specimen was macroscopically observed to confirm the presence of porosities and color changes.

Results

Table 2 shows three color change factors, namely, lightness (ΔL^*, chromatic changes), red-green color change (Δa^*), blue-yellow color change (Δb^*), and discoloration (ΔE^*) of five resins. The discoloration (ΔE^*) of each resin using both the brush-on technique and the mixing technique is shown in Fig. 2.

All of the resins demonstrated color changes toward green and yellow. The lightness (ΔL) of Provinice was significantly greater than that of all the resins tested using the brush-on technique ($p<0.05$). In contrast, the red-green color change (Δa) of Provinice was the smallest. Miky had the greatest blue-yellow color change (Δb) of all the resins tested except for Trad using the mixing technique. Of the brush-on technique, Provinice had the greatest color change (ΔE) of all the resins tested ($p<0.05$). There were significant differences in color changes (ΔE) between the brush-on technique and the mixing technique for Unifast II and Miky ($p<0.05$).

Table 2. Chromatic and color changes of the auto-polymerized resins.

		Unifast II	Unifast Trad	Provinice	Metafast	Miky
Mixing technique	ΔL*	5.37 (6.89)	0.44 (1.19)	4.20 (1.85)	1.03 (1.11)	2.11 (0.77)
	Δa*	-1.14 (0.99)^{a}	-1.18 (3.57)^{a}	-7.82 (0.81)	-0.31 (2.19)^{a}	-1.318 (1.12)^{a}
	Δb*	0.83 (1.06)^{a}	1.82 (2.47)^{ab}	0.31 (0.73)^{a}	1.21 (1.34)^{a}	4.28 (0.93)^{b}
Brush-on technique	ΔL*	1.24 (0.76)^{a}	-0.81 (1.9)^{a}	4.25 (1.68)	0.21 (0.91)^{a}	0.73 (1.18)^{a}
	Δa*	-1.18 (0.73)^{a}	-0.92 (2.7)^{a}	-8.92 (0.88)	-0.10 (1.99)^{a}	-0.86 (0.58)^{a}
	Δb*	1.13 (0.77)^{a}	0.95 (1.2)^{a}	0.04 (0.85)^{a}	0.54 (1.02)^{a}	2.91 (0.42)

Means and standard deviations in parentheses. Identical letters in same rows are not significantly different ($p>0.05$).

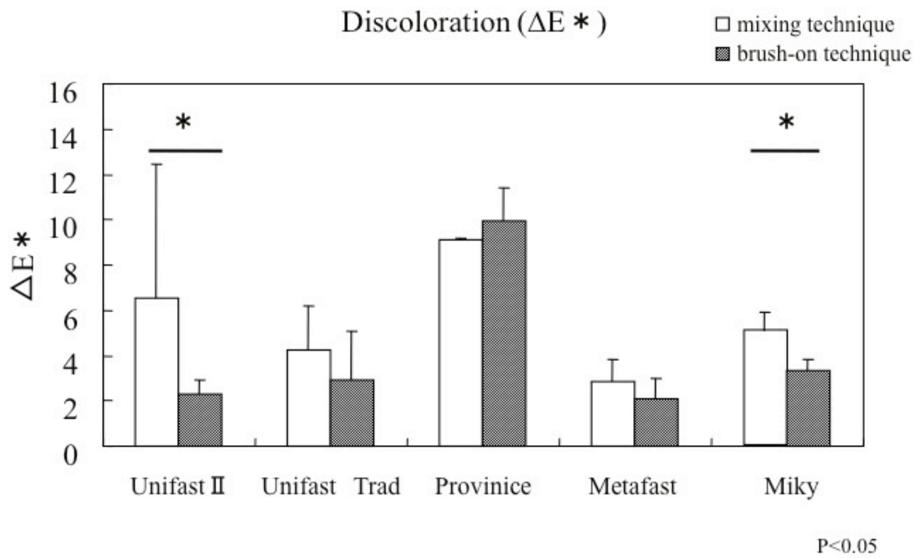

Fig. 2. Discoloration (ΔE*).

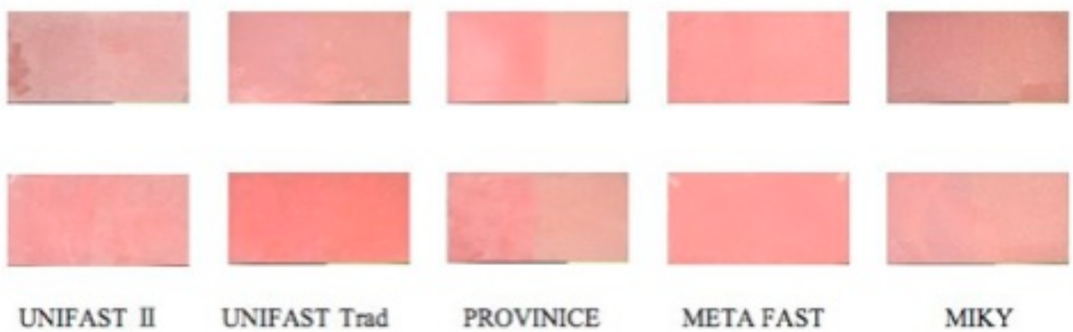

Fig. 3. Specimens after being exposed to xenon light. Upper, mixing technique; Lower, brush-on technique

Macroscopic observations of each resin surface are shown in Fig. 3. A significant amount of porosity was observed in the Unifast II specimens using the mixing technique. Although Provinice had severe discoloration, there was little discoloration in Metafast. When Miky was prepared with the mixing technique, many small porosities and a color change toward yellow were observed.

Discussion

Ivory auto-polymerized resin has been used for provisional, short-term restoration. However, pink auto-polymerized resin with a gingival color has been utilized for long-term denture repair and attachment set-up. When such resin is applied in the vicinity of the anterior tooth, the discoloration may significantly affect the esthetics. Therefore, not only the mechanical strength of auto-polymerized resin but also its color stability has to be investigated.

Generally, the discoloration of the resin is determined by two factors, i.e., the decrease of Δa^* from the red-to-green direction and the rapid increase of Δb^* from the blue-to-yellow direction. In previous studies, the color difference was determined by visual inspection. Eye perception may be clinically sufficient because discoloration can be determined by the eye, even if it is without a high degree of precision. In this study, macroscopic observations and measurements with apparatuses were performed, and both results were similar.

The mixing technique showed a greater Δb^* value than that of the brush-on technique of all resins tested except for Unifast II. As a reducing agent *tert*-amine is contained in most auto-polymerized resins. The *tert*-amine would contribute to the change to yellow. However, barbituric-acid derivatives, used for Unifast II as a polymerization initiator, have demonstrated excellent tone stability; therefore, Unifast II had a smaller Δb^*.

The brush-on technique yielded a smaller color difference than the mixing technique on all resins except for Provinice. Particularly, there were significant differences between the brush-on technique and the mixing technique for Unifast II and Miky ($p<0.05$). The reason is that the monomer/polymer ratio for the brush-on technique (0.31 to 0.38 mL/g) was less than that for the mixing technique (0.5 mL/g). The greater L/P ratio may contribute to lower mechanical strengths and less color stability. Significant porosity was observed in the Unifast II and Miky specimens using the mixing technique. Similarly, these specimens showed greater ΔL^* (brightness) in the mixing technique. Osada et al.[4] examined the bending strength of the same resins used in this study. The bending strength of Miky was significantly lower using the brush-on technique ($p<0.05$). Many porosities in Miky affected the bending strength and discoloration. In contrast, the greater ΔL^* (brightness) of the Provinice would be caused by the bleaching. It was assumed that the kind of colorant in Provinice could be easily discolored by the xenon light.

The brush-on technique resulted in fewer color changes than the mixing technique on all resins except for Provinice, as shown by the fact that many porosities were found in the control specimens. Provinice had the lowest resistance to light, and Miky showed the greatest color change to yellow among all the resins tested.

References

1. Kamada N, Ohkubo C, Shimpo H, et al. Fluidity and hardening time of autopolymerized denture repair acrylic resin: A comparison of brush-on technique and mixing technique. Prosthodont Res Pract 2008; 7: 19-23.
2. Hanatani S, Shibuya N, Muraishi E, et al. Dimensional accuracy of autopolymerized resin applied using the brush-on technique. Int Chin J Dent 2009; 9: 9-13.
3. Suzuki Y, Chiba H, Kamada N, et al. Handling efficiency of autopolymerized resin applied using the brush-on technique. Int Chin J Dent 2009; 9: 33-8.
4. Osada T, Ishimoto T, Aoki T, et al. Bending strengths and hardness of autopolymerized acrylic resin. Int Chin J Dent 2010; 10: 1-5.
5. Purnaveja S, Fletcher AM, Ritchie GM, Amin WM, Moradians S, Dodd AW. Color stability of two self-curing denture base materials. Biomaterials 1982; 3: 249-50.
6. May KB, Razzoog ME, Koran A 3rd, Robinson E. Denture base resins: Comparison study of color stability. J Prosthet Dent 1992; 68: 78-82.
7. Buyukyilmaz S, Ruyter IE. Color stability of denture base polymers. Int J Prosthodont 1994; 7: 372-82.
8. Hasegawa A, Katsu M, Hoshiai K, Hiranuma K. Color stability of self-curing resins with barbituric acid derivatives. J Jpn Prosthodont Soc 1998; 42: 11-9.
9. Anil N, Hekimoglu C, Sahin S. Color stability of heat-polymerized and autopolymerized soft denture liners. J Prosthet Dent 1999; 81: 481-4.

10. Hong G, Murata H, Li Y, Sadamori S, Hamada T. Influence of denture cleansers on the color stability of three types of denture base acrylic resin. J Prosthet Dent 2009; 101: 205-13.
11. Doray PG, Li D, Powers JM. Color stability of provisional restorative materials after accelerated aging. J Prosthodont 2001; 10: 212-6.
12. Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. J Prosthet Dent 2004; 91: 447-52.
13. Guler AU, Kurt S, Kulunk T. Effects of various finishing procedures on the staining of provisional restorative materials. J Prosthet Dent 2005; 93: 453-8.
14. Hirano S, Saitoh M, Nishiyama M, Hirasawa T. Chronological color differences on resin composites immersed in several food-simulating solutions. J J Dent Mater 1997; 16: 472-8.
15. Asmussen E. An accelerated test for color stability of restorative resins. Acta Odontol Scand 1981; 39: 329-32.
16. Asmussen E. Factors affecting the color stability of restorative resins. Acta Odontol Scand 1983; 41: 11-8.
17. Powers JM, Fan PL, Raptis CN. Color stability of new composite restorative materials under accelerated aging. J Dent Res 1980; 59: 2071-4.
18. Ferracane JL, Moser JB, Greener EH. Ultraviolet light-induced yellowing of dental restorative resins. J Prosthet Dent 1985; 54: 483-7.
19. Wozniak WT, Moser JB, Willis E, Stanford JW. Ultraviolet light stability of composite resins. J Prosthet Dent 1985; 53: 204-9.
20. Doray PG, Wang X, Powers JM, Burgess J. Accelerated aging affects color stability of provisional restorative materials. J Prosthodont 1997; 6: 183-8.
21. Uchida H, Vaidyanathan J, Viswanadhan T, Vaidyanathan TK. Color stability of dental composites as a function of shade. J Prosthet Dent 1998; 79: 372-7.
22. Yamashita N. The color stability of light-cured composite veneering materials: Part 1 The influence of post-curing. J Jpn Prosthodont Soc 1994; 38: 291-7.
23. Inokoshi S, Burrow MF, Kataumi M, Yamada T, Takatsu T. Opacity and color changes of tooth-colored restorative materials. Oper Dent 1996; 21: 73-80.

Correspondence to:
Dr. Yohei Sato
Department of Removable Prosthodontics, Tsurumi University School of Dental Medicine
2-1-3, Tsurumi, Tsurumi-ku, Yokohama 230-8501, Japan
Fax: +81-45-573-9599 E-mail: yohee.japan@gmail.com

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