Dimensional accuracy of autopolymerized resin applied using the brush-on technique

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Purpose: The brush-on technique was developed to compensate for polymerization shrinkage. In this study, we assess the dimensional accuracy of autopolymerized resin applied using a brush-on technique.
Materials and Methods: Each of five autopolymerized resins, Unifast II (GC), Unifast Trad (GC), Provinice (Shofu), Metafast (Sun Medical), and Miky (Nissin), was applied three times inside a ceramic cylinder (10 mm internal diameter; 5 mm width) using a brush-on technique (horsehair resin brush, Seiundo). As controls, the five resins were applied inside cylinders after the polymer and monomer were mixed at 0.5 mL/g for 10 s. After polymerization, the cylinders were cut into 3-mm wide pieces using a precision cutting machine. The maximum gaps between the ceramics and resins were measured using a scanning electron microscope at a magnification of x500. The dimensional accuracy (n=5) was assessed as the shrinkage percentage (the gaps divided by the internal diameter of the tubes). The data were analyzed by ANOVA/Tukey's test ($\alpha=0.05$).
Results: Excluding Metafast, the brush-on technique differed significantly from the controls ($p<0.05$). Using the brush-on technique, Metafast had the greatest shrinkage, and Unifast had the lowest shrinkage. However, there was no significant difference among all the resins tested ($p>0.05$).
Conclusion: The dimensional accuracy of the autopolymerized resin using the brush-on technique was better than that of the conventionally mixed polymer and monomer because the polymer and monomer ratio using the brush-on technique was lower and polymerization shrinkage was minimized due to the brush-on technique.
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Key Words: autopolymerized acrylic resin, brush-on technique, dimensional accuracy, polymerization shrinkage.

Introduction

Autopolymerized acrylic resins are constantly used for the repair and adjustment of removable dentures or provisional restorations.[1-4] Generally, two methods for autopolymerized acrylic resin are used, namely, the conventional mixing technique and the brush-on technique.[5] In the "mixing technique," the polymer and monomer are mixed in a rubber cup at their standard liquid/powder (L/P) ratio and then poured into a repair portion or formed as resin dough. Another technique was developed half of a century ago.[6] To compensate for polymerization shrinkage, autopolymerized acrylic resins were used to fill a tooth cavity.[5,6] An animal hair brush is soaked in the monomer and then dipped into the polymer powder. A bead of slurry resin attached to the end of the brush is then placed into the cavity. These procedures are repeated at 10- to 15-second intervals. Although autopolymerized acrylic resins are currently never used as filling materials, the brush-on technique is still widely used in clinical and laboratory procedures, namely, for the repair of broken dentures, the extension of denture flanges, the additional repair of retainers or artificial teeth, and the adjustment of individual trays for abutment impressions.

Regarding the autopolymerized resins used in the clinic chair-side, the following characteristics are required: satisfactory handling efficiency, suitable fluidity and hardening time, greater hardness, stiffness, and adhesive strength to acrylic resin, lower dimensional accuracy, and better color stability.[5,7-11] In the case of the brush-on technique, Kamada et al.[12] evaluated the fluidity and hardening time of autopolimerized acrylic resin. However, its dimensional accuracy was well known, even though the brush-on technique was developed to reduce the shrinkage of this resin. The purpose of this study was to assess the dimensional accuracy of autopolymerized resin using the brush-on technique.

Materials and Methods

Specimen preparation

The five autopolymerized resins used in this study are listed in Table 1. A ceramic tube (10 mm internal diameter; 5 mm width) was prepared for this study (Fig. 1). After the cylinder was placed on the glass plate, each of the five autopolymerized resin was applied three times inside the cylinder using the brush-on technique (horsehair resin brush; Seiundo, Japan) until the cylinder was full of resin. As controls, the five resin slurries (approximately 0.1 g) were applied inside the cylinders after the polymer and monomer had been mixed at 0.5 mL/g for 10 s (mixing technique). The cylinder was maintained at room temperature (23±1°C; humidity: 50-60%), and polymerization was completed. After that, the ceramic cylinders were cut into 3 mm-wide pieces using a precision cutting machine (Accutom-5, Struers, Ballerup, Denmark) (Fig. 2). A total of 25 specimens, five of each type, were fabricated.

Table 1. Autopolymerized resins used in this study.

Trade name	Manufacturer	Color	L (mL) / P (g)	Lot number
Unifast II	GC Tokyo, Japan	#3 Pink	0.5	Powder 0503172 Liquid 0504261
Unifast Trad	GC	#3 Pink	0.5	Powder 0504261 Liquid 0503221
Provinice	Shofu Kyoto, Japan	U3	0.5	Powder 020507 Liquid 030555
Meta Fast	Sun Medical Moriyama, Japan	#2 Pink	0.7	Powder 41101 Liquid 41103
Miky	Nissin Kyoto, Japan	#2	0.5	Powder PEIL Liquid LELG

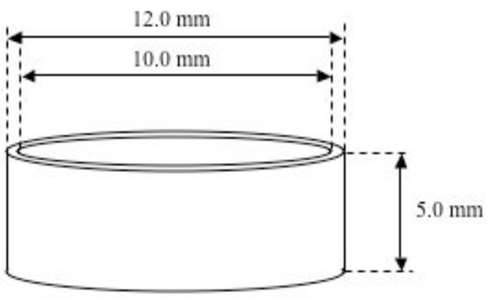

Fig. 1. Illustration of a ceramic cylinder.

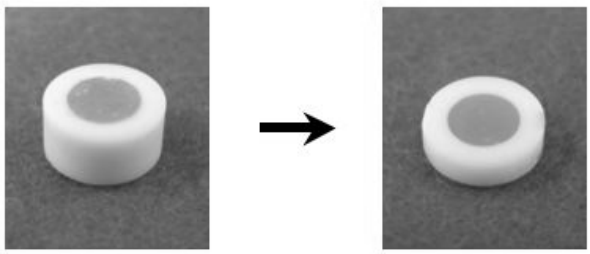

Fig. 2. Ceramic cylinders were cut into 3-mm wide pieces.

Measurements of dimensional accuracy

The cutting surfaces of the cylinders were observed using a scanning electron microscope (SEM; JSM 5600LV, JEOL, Akishima, Japan) at a magnification of x500. The maximum gaps between the internal surface of the ceramic tube and resins were measured using SEM images (Fig. 3). The dimensional accuracy was assessed as the shrinkage percentage by dividing the gaps by the internal diameter (10.0 mm) of the cylinders.

The data obtained were analyzed by one-way ANOVA and Tukey's multiple comparison test at a significance level of α=0.05.

Results

Fig. 4 shows the polymerization shrinkage of autopolymerized resins using both the brush-on and mixing techniques. Excluding Metafast, the brush-on technique indicated significantly lower shrinkage than the mixing technique ($p<0.05$). Using the brush-on technique, the shrinkage percentages of all resins were approximately 0.5% or less. Metafast and Unifast II had the greatest shrinkage, and Unifast Trad had the lowest shrinkage. However, there was no significant difference among all the resins tested ($p>0.05$). In contrast, the shrinkage percentages of all resins were approximately 0.6% or more using the mixing technique. Although Miky showed the greatest shrinkage and Metafast showed the lowest shrinkage, no significant difference was found in any of the resins tested ($p>0.05$). Hence, the difference in shrinkage between the two techniques was the smallest with Metafast.

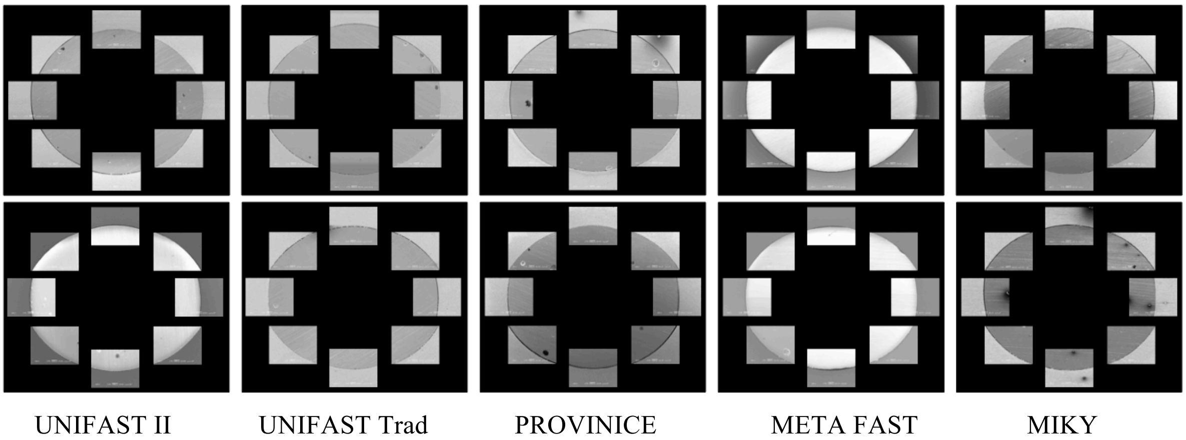

Fig. 3. The gaps between the internal surface of the ceramic cylinder and the resins were measured using SEM images. Upper, Mixing technique; Lower, Brush-on technique.

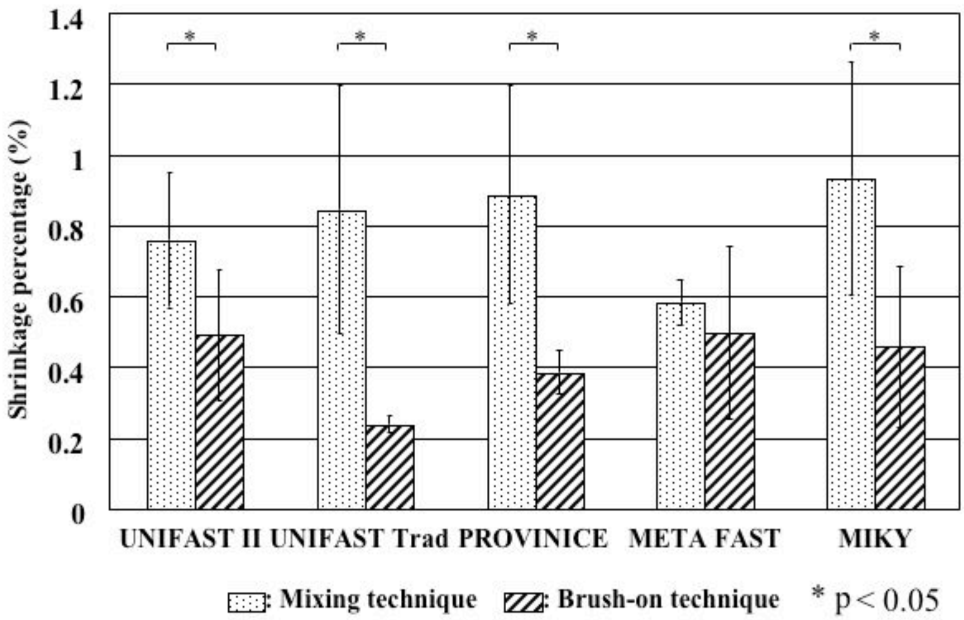

Fig. 4. Polymerization shrinkage of autopolymerized resins using both the brush-on and mixing techniques.

Discussion

The L/P ratio of the brush-on technique is not constant and depends on the quality of the brush and the skill of the operators. Shirato[5] reported the L/P ratio of both techniques for autopolymerized resins (brush-on technique: 0.31-0.38 L/P, mixing technique: 0.5 L/P). As reported above, the brush-on technique was developed by Nealon to compensate for the polymerization shrinkage by filling little by little, and its L/P ratio is lower than that for the mixing technique. Therefore, the brush-on technique indicated significantly less dimensional accuracy than the mixing technique ($p<0.05$) excluding Metafast.

Generally, the autopolymerized resin had a positive correlation with the polymerization temperature and dimensional accuracy.[13] Autopolymerized resins indicate the greatest shrinkage at the highest temperatures. In our previous study,[12] the polymerization temperatures of both the brush-on and mixing techniques were very similar, whereas the hardening times differed. Therefore, the correlation between the dimensional accuracy and polymerization temperature was not obvious in this study.

Usually, two colors of autopolymerized resins, namely, ivory for artificial teeth and pink for denture bases, are used for prosthetic treatment. There are few differences in the characteristics of each resin by the color pigments they contain. Pink resins were used in this study on the assumption that dentures were being repaired. Thus, the study is limited to the results for denture repair.

Unifast Trad using the brush-on technique showed the least shrinkage (approximately 0.2%). However, the other properties, such as hardness, adhesive strength, color stability, and bending strength, are also important factors to consider when selecting resins.

Within the limitations of this study, the dimensional accuracy of the autopolymerized resin using the brush-on technique was better than that of the conventionally mixed polymer using the monomer technique. This finding is attributed primarily to the fact that the polymer and monomer ratio using the brush-on technique is lower and that the polymerization shrinkage was minimized due to the brush-on technique.

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