Bending strengths and hardness of autopolymerized acrylic resin

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Purpose: Resins for denture repair must have higher bending strengths and similar hardness compared to denture base resins. This study evaluated the bending strengths and hardness of autopolymerized acrylic resin applied using the brush-on technique.
Materials and Methods: Square resin rods (2x2x25 mm) and blocks (15x15x5 mm) were fabricated for measuring the bending strengths and hardness, respectively, of five autopolymerized resins (Unifast II, Unifast Trad, Provinice, Metafast, and Miky). Two procedures for applying the autopolymerized resins were tested in this study: the brush-on technique and the conventional mixing (monomer/polymer: 0.5 mL/g) technique. The bending strengths of the resins (crosshead speed: 5 mm/minute) were measured with a three-point bending test using autography. The Vickers hardness (1.96 N, 10 s) was also measured using a hardness tester according to JIS 6518. The data (n=5) were analyzed by ANOVA/Tukey's test (α=0.05).
Results: There were no significant differences ($p>0.05$) for both bending strengths and hardness between the brush-on technique and the conventional mixing technique. The bending strengths of Unifast Trad were significantly greater than those of Miky ($p>0.05$). Unifast II had the greatest hardness among all the resins tested.
Conclusion: Although the monomer/polymer ratio for the brush-on technique was lower than for the conventional mixing technique, similar bending strengths and hardness values were found for both techniques.
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Key Words: autopolymerized acrylic resin, bending strength, brush-on technique, hardness

Introduction

In prosthetic practice, the breakage of denture bases has frequently been observed. Broken dentures are usually repaired chairside with autopolymerized resin using the brush-on technique.[1-3] These resins must have sufficient mechanical properties and strong adhesion to denture base resins in order to prevent the breakage that is commonly found. The mechanical properties of polymerized resin are affected by factors such as the operator's skill, the differences between the original denture base resins and the repaired resins, and the repair conditions.[4-6]

Kamada et al.[7] investigated the repair procedures by evaluating the fluidity and hardening time of autopolymerized acrylic resins applied using the brush-on technique. They found great differences in these characteristics among the autopolymerized acrylic resins tested. The hardening time for the brush-on technique was shorter than for the conventional mixing technique. Hanatani et al.[8] reported that the dimensional accuracy of the autopolymerized resins applied using the brush-on technique was better than that of the conventional mixing technique. This finding was attributed to the fact that the polymer and monomer ratio was lower and also the polymerization shrinkage was minimized using the brush-on technique. Suzuki et al.[9] evaluated the handling efficiency of autopolymerized resin applied using this technique and concluded that the handling efficiency of the autopolymerized resin using the brush-on technique depended on the skill of the operators rather than the resins and brushes.

Although the brush-on technique has been used mainly for chairside denture repair, the mechanical properties of the repair resins applied with this technique are not well known. The aim of this study was to investigate the bending strengths and hardness of commercial autopolymerized acrylic resins applied using the brush-on technique.

Materials and Methods

Five autopolymerized resins, namely, Unifast II (GC Dental Industrial Corp., Tokyo, Japan), Unifast Trad (GC Dental Industrial Corp.), Provinice (Shofu Inc., Kyoto, Japan), Metafast (Sun Medical Co., Ltd., Moriyama, Japan), and Miky (Nissin, Kyoto, Japan) were tested in this study (Table 1).

Table 1. Autopolymerized resins used in this study.[8]

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
Metafast	Sun Medical Moriyama, Japan	#2 Pink	0.7	Powder 41101 Liquid 41103
Miky	Nissin Kyoto, Japan	#2	0.5	Powder PEIL Liquid ELG

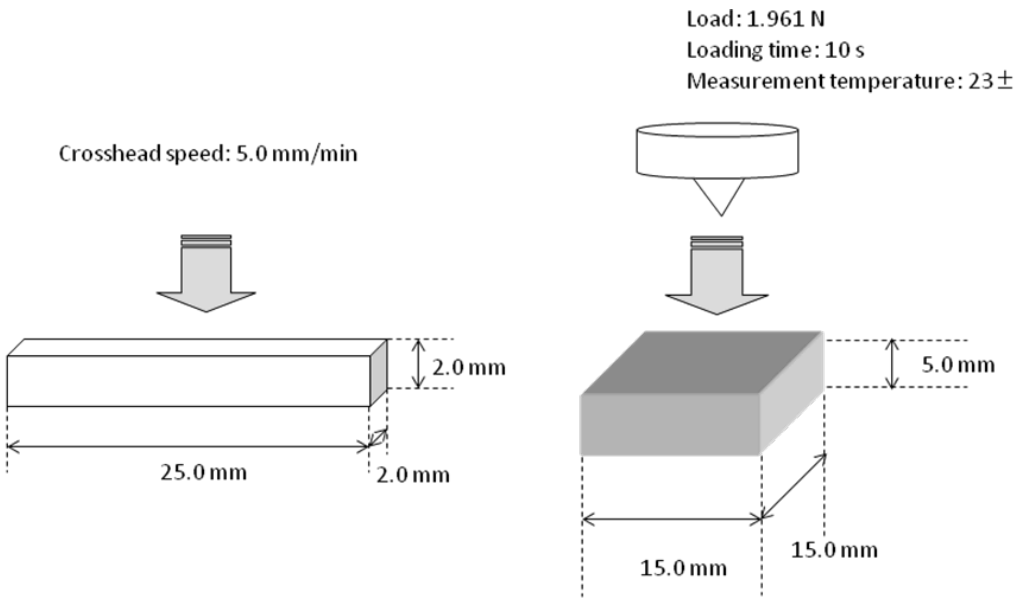

Fig. 1. Illustration of the rod and block specimens

Specimen fabrication

Silicone molds were prepared for two types of specimens, rod (2x2x25 mm) and block (15x15x5 mm), to measure the bending strengths and hardness, respectively (Fig. 1). Two procedures, the brush-on technique and the conventional mixing technique, were evaluated. In the brush-on technique, the brush was soaked in monomer and then dipped into the polymer according to the manufacturer's recommendations. The resin slurry was packed into the rod and block molds in 3 and 10 increments, respectively. In the mixing technique, the monomer and polymer were mixed at the manufacturer's recommended ratio (P/L: 0.5 mL/g) for 10 s and then poured into each type of mold within 10 s. After removal from the molds, the resin rods and blocks were finished and polished using #2,000 abrasive paper. Five specimens were fabricated for each of the resins (total of 50 rod and 50 block specimens).

Measurement of bending strengths and hardness

After the resin rods were soaked in distilled water (37°C) for 48 hours, they were mounted in a screw-driven mechanical testing apparatus (Instron 5565, Instron, Canton, MA, USA). The bending strengths were determined by the breaking loads (N) and elastic moduli (GPa) using a three-point bending test (25 mm between the supporting points) at a crosshead speed of 5 mm/minute.

The resin blocks were soaked in distilled water (37°C) for 24 hours. According to JIS 6518, the Vickers hardness of the five resins was measured using a hardness tester (HMV, Shimadzu, Kyoto, Japan) with a load of 1.96 N held for 10 s. The hardness numbers were obtained from five specimens of each kind of resin at three arbitrarily chosen sites per specimen. The data (n=5) on both the bending strengths and hardness were analyzed by ANOVA and Tukey's multiple comparisons test at a significance level of α=0.05.

Results

Bending strengths

The breaking loads and elastic moduli of the five resins packed using both techniques are presented in Figs. 2 and 3, respectively. There were no significant differences for both the breaking load and elastic modulus ($p>0.05$) between the brush-on technique and the conventional mixing technique.

The bending strengths of all the resins ranged from approximately 13 N to 22 N. For the brush-on technique, Unifast Trad and Metafast had significantly greater strengths than those of Miky ($p<0.05$). For the mixing technique, there were significant differences between Miky and the other resins, and between Unifast and Unifast Trad ($p<0.05$). The elastic moduli of all the resins ranged from approximately 2.7 GPa to 3.5 GPa. There were no significant differences for both techniques among all the resins tested ($p>0.05$).

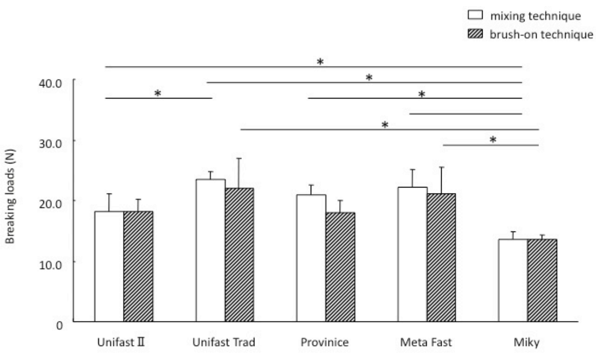

Fig. 2. Breaking loads

∗ P<0.05
n = 5

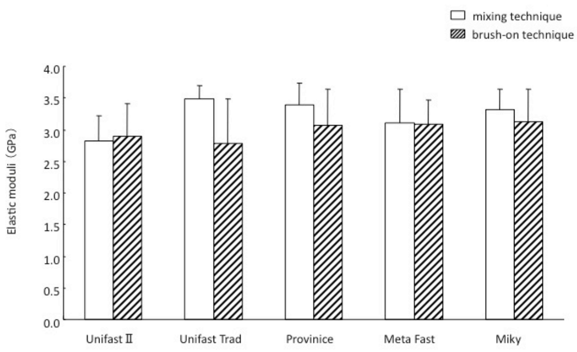

Fig. 3. Elastic moduli

∗ P<0.05
n = 5

Hardness

The hardness of each resin is shown in Fig. 4. Similar to the bending strengths, there were no significant differences between the two techniques ($p>0.05$). Although Unifast II (mixing technique) had the greatest hardness and Unifast Trad (brush-on technique) demonstrated the lowest hardness, no remarkable differences were found.

For the brush-on technique, there were significant differences between Unifast II and Metafast, and between Unifast II and Unifast Trad ($p<0.05$). For the mixing technique, significant differences were found between Unifast II and Unifast Trad, Unifast II and Provinice, and Unifast Trad and Miky ($p<0.05$).

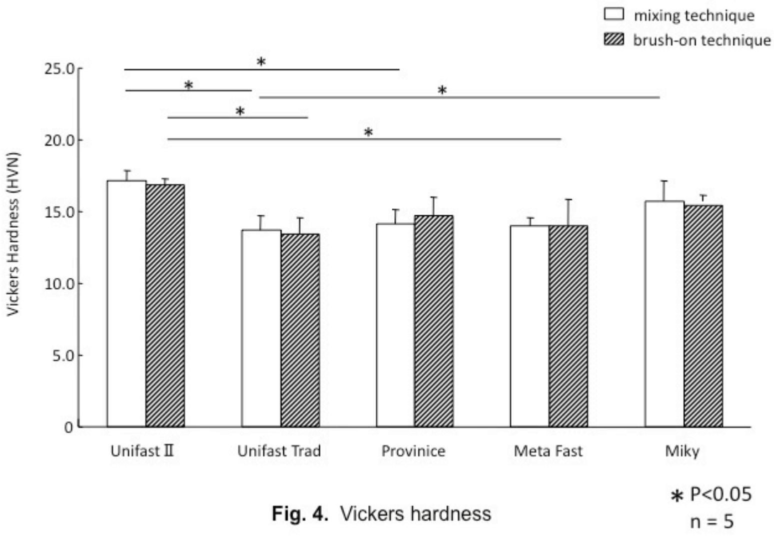

Fig. 4. Vickers hardness

Discussion

Compared to the mixing technique, the polymer and monomer ratio (P/L) of the brush-on technique is lower and inconsistent. In addition, the transpiration of monomer and non-swelling polymers occurs during handling. However, no clear differences in hardness and bending strengths were found between the two techniques tested. As for the resin after polymerization, it was shown that the strengths became approximately constant regardless of the powder/liquid ratio. Differences were found between some resins, but all of them exceeded the minimum permitted level for clinical use.

Unifast Trad indicated the highest bending strengths, and Miky demonstrated the lowest among all the resins tested for both techniques. In contrast, the hardness was the greatest for Unifast II and the worst for Unifast Trad. The main component of the monomers of all the resins is methyl methacrylate (MMA) and of the polymers is methacrylic acid ester. Unifast II, Unifast Trad, Provinice, and Metafast contain methacrylic acid ester copolymers, and Miky is composed of poly(methyl methacrylate) (PMMA) and poly(ethyl methacrylate) (PEMA).[10,11] The polymers of Miky consist of two polymer chains (PMMA and PEMA) intertwined with each other. In contrast, the other four products contain both MMA and EMA. It is suggested that the difference in the type of polymerization might influence the bending strength, so the polymer component in Miky may decrease its bending strengths. However, the relationship of the hardness among the products tested is obvious. The presence of porosity and non-swelling polymers might also contribute to the differences in the strengths.

All the specimens were fabricated with resins that included color pigment (pink) for denture base repair. Differences between the resins might be apparent if clear resin was used. In addition, repaired dentures require not only the mechanical strengths of the autopolymerized resins but also bonding strength to the denture base resin. Further testing using repaired specimens, in which autopolymerized resins are applied to the original denture base resin, is necessary to evaluate the total properties for chairside denture repair.

Although the monomer/polymer ratio of the brush-on technique was lower than for the conventional mixing technique, similar bending strengths and hardness values were found for both techniques.

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