Clinical significance

Two types of hard resin for crowns and bridges were investigated. The results of each investigation changed according to the products used, and the proper use for each case and application was suggested.

Abstract

Purpose: Hard resins for crowns and bridges are widely used for esthetic restorations. The objective of this study was to evaluate the mechanical properties of new commercial hard resins and to compare the results with those of the other hard resins previously investigated.

Methods: Dentin and enamel made with two new hard resins (Epricord®: EP, Kuraray, Co., Ltd., Osaka, Japan and Prossimo®: PR, GC, Co., Ltd., Tokyo, Japan) were used in this study. Regarding the fundamental characteristics, the thermal expansion/shrinkage coefficient, the filler content, the polymerization shrinkage, and the wear were examined. Regarding the strength of resin, the bending strength, hardness, compression strength, elastic modulus, and fracture strength of a jacket crown were measured.

Results: These resins showed comparatively lower levels than the other hard resins regarding the bending strength, hardness, compression strength, and fracture strength of the jacket crown. The total filler content rate and wear amount of these resins exhibited similar values to those of the other resins. The thermal expansion/shrinkage coefficients of these resins exhibited higher values than those of the other resins. EP showed a different tendency from PR about the compression strength, elastic modulus, and polymerization shrinkage.

Conclusions: PR and EP did not show dramatically better physical properties. However, the results of each examination in this study may be acceptable clinically.

Key words: hard resin for crown and bridge, mechanical property, resin facing cast crown, resin jacket crown

Introduction

Hard resins for crowns and bridges have many advantages over dental porcelain. They are moderately tough, and they can be used with any metal, in contrast to veneered materials. Hard resins for crowns and bridges are competitively priced and do not require advanced technology or special equipment for their fabrication. In addition, most health insurance plans in Japan will cover their use. For the reasons above, hard resins make a practical choice for use in crowns and bridges.

However, hard resins for crowns and bridges became widely recognized only after the 1980s. This is because, until that time, an organic compound filler had been used instead of polymethyl methacrylate (PMMA) powder. Consequently, the wear resistance and discoloration proof of hard resins for crowns and bridges were improved. A new poly-functionality monomer and filler technology were developed, and much improved resins with superior physical properties were marketed. Such a material is indispensable when the restoration of front teeth is required. Two reasons that hard resins are being widely used in the clinical field are discussed here. The first is that, the polymerization method was changed into optical polymerization from heating polymerization. It became simpler and did not require as much operation time from technicians. The second is that the mechanical properties were improved. This is particularly important, as hard resins can now be used to make facing crowns and jacket crowns. Furthermore, hard resins may also be used for the restoration of bridge units.
molar occlusions, for which metal had been used in the past.\(^4\)

Hard resins are changing from a material that was mainly used for esthetic reasons to a material that has considerable strength. Therefore, more attention is being given to hard resins, which will most likely become more prominent in prosthetic dentistry in the near future. However, despite the large number of new products, there are not much objective data. Therefore, it is difficult for a clinician to understand the difference between products.

Eight types of commercial hard resins have been investigated.\(^5\) The following fundamental properties of these resins were examined: the thermal expansion/shrinkage coefficient; curing shrinkage rate; and wear amount. The bending strength, Vickers hardness, compressive strength, elastic modulus, and fracture strength of a jacket crown made from these resins were measured for their strength. The objective of this study was to evaluate the properties of new hard resins. The results are compared with those of the other types of hard resins.

### Materials and Methods

**Materials**

The new hard resins (Epricord\(^6\): EP, Kuraray, Co., Ltd., Osaka, Japan and Prossimo\(^6\): PR, GC, Co., Ltd., Tokyo, Japan) were used in this study (Table 1). Dentin and enamel pastes of A3 (VITA Lumin shade) for each resin were tested.

**Methodology**

Identical methods for sample production and examination of the hard resin\(^5\) were used, and an outline is shown below.

**Thermal expansion/shrinkage coefficient measurement.** The specimens were prepared as cylinders of \(\phi 5 \times 20\) mm. The thermal expansion/shrinkage coefficient was measured using a thermal expansion meter (DL-9000, Ulvac-Riko, Inc., Yokohama, Japan) with a test force of \(4.9 \times 10^{-2}\) N and a change of temperature of 30°C to 60°C. Three specimens were used for each type of resin.

**Filler analysis. Measurement of the total filler content rate:** An amount of 0.4 g of an unpolymerization paste of each hard resin was measured. For 30 min, a centrifugal separator with methanol was used to separate the filler and resin monomers. The supernatant fluid was removed, and the solution was dried in the 85°C drier for 2 h. The remaining solids, which were weighed again, were the total filler weight. The percentage of the solid weight relative to the initial paste weight was converted into the total filler rate. The measurements were performed three times for each material.

**Measurement of the inorganic filler content rate:** An amount of 0.4 g of each hard resin paste was measured. After incinerating the resin at 550°C for 2 h, the remaining ashes, which were weighed again, were converted into inorganic filler weight. The percentage of the ash weight relative to the initial paste weight was converted into the inorganic filler content rate. Measurements were taken three times for each material. It was determined that the organic component content rate in the organic compound filler was the remainder after deducting the inorganic filler content rate from the total filler content rate.

**Measurement of the polymerization shrinkage.** A CCD laser displacement sensor (sensor head, LK-030: amplifier unit, LK-2000: analog controller, RD-50R: Keyence, Osaka, Japan) was used to measure the curing shrinkage rate. The polymerization contraction (coefficient of linear contraction) was calculated by measuring the thickness before (thickness: about 2 mm) and after polymerization of the resin paste. Three specimens were used for each type of EP. The results of PR were quoted from the previous study.\(^7\)

**Wear test.** In the wear test, each enamel hard resin was examined using a two-body sliding type device\(^8\) (Yoshimitsu: this type can be used to measure 3 pairs simultaneously). One of two kinds of specimens had a uniform size of 10 mm × 15 mm in length and width, respectively, and 1.5 mm in thickness. The surface of the specimens was flattened so that the specimens could be pressed against a glass plane, polymerized by light-curing, and not ground. As the other of two kinds of specimens, i.e., opposing specimens were fabricated into hemispheres of 3 mm in diameter using enamels of an extracted maxilla premolar. The opposing specimens were centrally positioned on each sliding test

### Table 1  Materials investigated.

<table>
<thead>
<tr>
<th>Material</th>
<th>Lot No.</th>
<th>Manufacturer</th>
<th>Curing method</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epricord</td>
<td>DA3</td>
<td>Kuraray</td>
<td>Light (3 min)</td>
<td>EPD</td>
</tr>
<tr>
<td></td>
<td>E1</td>
<td></td>
<td></td>
<td>EPE</td>
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<tr>
<td>Prossimo</td>
<td>DA3-C</td>
<td>GC</td>
<td>Light (3 min)</td>
<td>FPD</td>
</tr>
<tr>
<td></td>
<td>E3</td>
<td></td>
<td></td>
<td>PRE</td>
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</tbody>
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\(^5\) Izumida et al., J Jpn Prosthodont Soc 52: 521-528, 2008

\(^6\) Epricord: EP, Kuraray, Co., Ltd., Osaka, Japan and Prossimo: PR, GC, Co., Ltd., Tokyo, Japan

\(^7\) For 30 min, a centrifugal separator with methanol was used to separate the filler and resin monomers. The supernatant fluid was removed, and the solution was dried in the 85°C drier for 2 h. The remaining solids, which were weighed again, were the total filler weight. The percentage of the solid weight relative to the initial paste weight was converted into the total filler rate. The measurements were performed three times for each material.

\(^8\) A CCD laser displacement sensor (sensor head, LK-030: amplifier unit, LK-2000: analog controller, RD-50R: Keyence, Osaka, Japan) was used to measure the curing shrinkage rate. The polymerization contraction (coefficient of linear contraction) was calculated by measuring the thickness before (thickness: about 2 mm) and after polymerization of the resin paste. Three specimens were used for each type of EP. The results of PR were quoted from the previous study.
specimen. They were vertically loaded and tested at 4.9 N in water. The test was conducted at a rate of 60 cycles per minute and strokes of 3 mm each. The cycling procedure was carried out for 50,000 cycles under water. Three specimens were used for each type of enamel resin.

The wear track was defined as the distance from the surface of specimens to the base of the deepest defect generated by a wear-testing device. The depths of the worn specimens were measured using a surface-coarseness measurement machine (Surfcom 550A, Tokyo Seimitsu, Tokyo, Japan). The height of the worn area of contact of the worn human enamel after the wear test was also measured using an omnipotent projector (V-16 type, Nikon Co., Tokyo, Japan). Three measurements for each sample were taken, and the average value represented the amount of wear. Dentin and enamel pastes of EP were tested. The results of PR were quoted from the previous study.7

**Bending strength test.** Using a hard resin paste, specimens with a beam cross section of 1.0 × 8.0 mm and a length of 20 mm were prepared for flexural strength tests. The surfaces of the specimens were made to be flat so that they could be pressed against a glass plane and polymerized by light-curing. In addition, the surfaces of these hard resins were ground flat using a conventional, mechanically polishing technique after light-curing. Each specimen was attached to a jig, and the interload point distance was 13.5 mm. Three-point bending strength tests were carried out on each specimen using a universal testing machine (AGIS10kN, Shimadzu, Kyoto, Japan) operated at a cross-head speed of 2.5 mm/min. The three-point flexural strength was calculated from the maximum load at which the specimen was broken. Five specimens were used for each type of resin.

**Vickers hardness test.** The surface hardness values (micro Vickers hardness number) of hard resins were measured after the bending strength test. A bending strength test and a Vickers hardness test were conducted on the same specimen. The test was performed using a micro Vickers hardness testing machine (MVK-H type, Akashi, Yokohama, Japan) with a test force of 0.98 N, a loading speed of 10 μm/s, and a load retention time of 15 s. Five specimens were used for each type of resin.

**Compressive strength test.** Using a hard resin paste, specimens with a cylindrical shape, a diameter of 6.0 mm, and a length of 12 mm after polymerization polishing were prepared for the compressive strength test. The compressive strength tests were carried out on each specimen using a servo pulsar (EHF-EG20kN-10L, Shimadzu) operated at a speed of 0.5 mm/min. The modulus of elasticity was computed with the compression strength. Five specimens were used for each type of resin.

**Fracture strength test of a jacket crown.** Crown specimens were fabricated from dentin and enamel hard resin pastes. Experimental abutments were fabricated simulating the maxillary left central incisal tooth. Specimens were prepared with a shoulder width of 1.0 mm and a taper of 6 degrees, making the thickness of the resin jacket crown have a labio/lingual width of about 1.5 mm and a proximal/incisal length of about 2.0 mm. Each of the completed crowns was luted to a metal (GP metal®, Dentsply-Sankin K.K., Tokyo, Japan) die using zinc-phosphate cement (Elite Cement 100®, GC, Co., Ltd.). Constant finger pressure was applied for 3 min, and the die was stored at 23°C for 24 h. Fracture strength testing was carried out on all specimens using a universal testing machine operated at a cross-head speed of 2.5 mm/min. The static load was applied to the incisal edge at an angle of 45 degrees to the tooth’s axis, and the breakage load was measured. All crowns were loaded until catastrophic failure occurred. The testing machine automatically recorded the fracture force. Five specimens were used for each type of resin.

**Results**

**Measurement of the thermal expansion/shrinkage coefficient**

The results of the thermal expansion coefficient
and thermal shrinkage coefficient measurements are shown in Fig. 1. The thermal expansion coefficient of the dentin resin of Epricord® (EPD) was 71.7(±6.6) × 10⁻⁶/°C, that of the enamel resin of Epricord® (EPE), 76.7(±6.6) × 10⁻⁶/°C, that of the dentin resin of Prossimo® (PRD), 75.8(±1.4) × 10⁻⁶/°C, and that of the enamel resin of Prossimo® (PRE), 73.4(±1.4) × 10⁻⁶/°C. No significant difference was found among the four types.

The thermal shrinkage coefficient of EPD was 87.5(±2.0) × 10⁻⁶/°C, that of EPE, 94.2(±4.2) × 10⁻⁶/°C, that of PRD, 83.1(±1.0) × 10⁻⁶/°C, and that of PRE, 81.4(±1.3) × 10⁻⁶/°C. No significant difference was found among the four types. EPE and PRD were significantly larger than PRE. There was no significant difference between PRD and PRE.

**Filler analysis**

The total filler content rate and inorganic filler content rate are shown in Fig. 2. The total filler content rate of EPD was 76.0(±0.1) wt%, that of EPE 76.0(±0.2) wt%, that of PRD 64.7(±0.4) wt%, and that of PRE 64.6(±0.5) wt%. No significant difference was found among the four types.

The inorganic filler content rate of EPD was 48.5(±0.1) wt%, that of EPE 48.2(±0.1) wt%, that of PRD 34.8(±0.1) wt%, and that of PRE 35.0(±0.5) wt%. No significant difference was found among the four types.

**Measurement of the polymerization shrinkage**

The results of the polymerization shrinkage measurement are shown in Fig. 3. The polymerization shrinkage of EPD was 0.53(±0.12)%, and that of EPE 0.63(±0.10)%. There was no significant difference between EPD and EPE.

**Wear test**

The amount of wear of human enamel and that of the enamel hard resin are shown in Fig. 4. The amount of wear of human enamel was 58(±6.2) µm in EPE. The amount of wear of EPE was 22(±3.7) µm.

**Bending strength test**

The results of the bending strength test are shown in Fig. 5. The bending strength of EPD was 74.1(±2.3) MPa, that of EPE 80.4(±3.0) MPa, that of PRD 80.8(±8.4) MPa, and that of PRE 79.6(±3.4) MPa. There was no significant difference among EPD, EPE, and PRE. EPD was significantly smaller than PRD, and EPE was significantly smaller than PRD. There was no significant difference between PRD and PRE.
Vickers hardness test
The results of the Vickers hardness test are shown in Fig. 6. The Vickers hardness of EPD was 46.1 (±0.7), that of EPE 48.3(±0.5), that of PRD 23.9 (±1.2), and that of PRE 25.0(±0.9). EPD was significantly smaller than EPE. EPD was significantly larger than PRD and PRE, and EPE was significantly larger than PRD and PRE. There was no significant difference between PRD and PRE.

Compressive strength test
The results of the compression strength and modulus of elasticity tests are shown in Fig. 7. The compression strength of EPD was 446(±23) MPa, that of EPE 438(±63) MPa, that of PRD 304(±45) MPa, and that of PRE 291(±50) MPa. There was no significant difference between EPD and EPE. EPD was significantly larger than PRD and PRE, and EPE was significantly larger than PRD and PRE. There was no significant difference between PRD and PRE.

Fracture strength test of a jacket crown
The results of the fracture strength test of a jacket crown are shown in Fig. 8. The fracture strength of EP was 421(±30.4) N, and that of PR was 323 (±61.7) N. EP was significantly larger than PR.

Discussion
Of the various examinations performed in the present study, the thermal expansion/shrinkage coefficient, filler content, polymerization shrinkage, and wear are involved in the fundamental characteristics of resin. On the other hand, the bending
strength, hardness, compression strength, modulus of elasticity, and fracture strength test of a jacket crown are related to the strength of resin.

1. Fundamental characteristics

The thermal expansion/shrinkage coefficient of hard resins was measured at a temperature of 30 to 70°C. The temperature in the oral cavity was simulated. The materials used to make facing crowns should undergo no exfoliation of the hard resin from metal and no destruction of the hard resin as a result of the exfoliation. Therefore, regarding the thermal expansion/shrinkage coefficient of hard resin, it is desirable that it be the same degree as that in one that includes metal. Since the thermal expansion coefficient of a gold-and-silver palladium alloy is \(19 \times 10^{-6}/°C\), according to past reports, Estenia® (Kuraray, Co., Ltd.) appears to have the nearest value (23 \(\times\) 10\(^{-6}/°C\)).\(^6\) Estenia® is considered to be superior to other resins as a material to make facing crowns. The thermal expansion/shrinkage coefficient values of EP and PR were comparatively larger than those of Estenia®; however, these values were similar to those of other resins.\(^6\) This is because the matrix monomer used for Estenia® is urethane tetramethacrylate (UTMA), and that used for the other resins that include EP and PR is urethane dimethacrylate (UDMA).\(^4\)

The total filler consists of an inorganic filler and an organic filler.\(^9\) The composition of the total filler of PR was similar to that of the enamel resin of Axis® (GC, Co., Ltd.).\(^6\) The composition of the total filler of EP was similar to that of the dentin resin of Axis®, which included more inorganic ingredients than the enamel resin of Axis®. Since PR and EP contain comparatively more organic matter ingredients, they are considered to offer ease of handling as well as a smooth surface after polishing. Moreover, EP is considered to respond better to changes because it includes more inorganic ingredients than PR.

Hard resins undergo contractions in the process of polymerization. In order to compensate for the polymerization shrinkage, a resin paste is generally composed of a small amount of matrix resin and a significant amount of filler.\(^9\) However, if the amount of filler in the resin paste is excessive, the object polymerized using only optical irradiation will achieve inadequate hardness. Changing the polymerization conditions is necessary to achieve adequate hardness. As reported above, EP has more inorganic filler ingredients than PR. Therefore, it is considered that there is less polymerization shrinkage with EP than with PR.\(^7\) On the other hand, there is less polymerization shrinkage with PR than with the enamel resin of Axis®, although there was no difference in the amount of filler content between PR and the enamel resin of Axis®.\(^6\) Therefore, the polymerization shrinkage value is not determined by the amount of filler alone.

The mechanism of wear shows different patterns. Mixed wear patterns exist within the oral cavity. Therefore, it is difficult to analyze the wear in the oral cavity. In this research, wear tests were performed under the assumption that the wear of hard resins was directly caused by the cusp of the antagonistic enamel of natural dentition without a bolus of food.\(^8,11\) Estenia® was considered to show a lesser amount of wear with a high filler content, and, therefore, the antagonistic enamel of natural dentition showed larger amounts of wear than Estenia®. However, in this wear test, no different amounts of wear among EP, PR, and Estenia® were noted, and the amount of wear of the enamel to EP, PR, and Estenia® did not differ, either.\(^7\) Therefore, the relation between the amount of wear and the filler content was not necessarily in agreement.\(^9\) Although the filler content is considered to be a factor affecting the wear, the results also indicated that the filler content is not the only factor.

Regarding the fundamental characteristics, the thermal expansion/shrinkage coefficient, the filler content, the polymerization shrinkage, and the wear were examined. Hard resin consists of a filler and matrix resin as the main ingredients. The filler of hard resin has a high weight percentage, which greatly influences the fundamental characteristics. When the rate of the filler in the resin is large, the thermal expansion/shrinkage coefficient and wear become small. However, when the amount of filler is excessive, the permeability of light decreases. Polymerization by optical irradiation alone becomes difficult in this case. Therefore, there is a limit to the amount of filling that can be used, and the total content of filler is 60–80% of pastes in many cases. The total filler content of EP and PR was the same rate as that of other hard resins. However, even when the total amount of filler was comparable, the fundamental characteristics of the resin differed. This is considered to be influenced, among other factors, by the type of filler,\(^10\) the particle size, the surface, the combined state with the matrix resin,\(^12\) and the difference in the refractive index of the filler in the optical irradiation and the
monomer, in addition to the amount of filling.

2. Strength

The bending strength of Estenia\(^6\) had a much higher value than that of other resins (180–190 MPa).\(^6\) The bending strength of the other resins was 50–140 MPa.\(^6\) The bending strength of dental porcelains was measured under the same conditions used in our previous research (70–160 MPa).\(^13\) The bending strength of Estenia\(^6\) was determined to be much higher than that of dental porcelains. Moreover, the bending strength of dental porcelains and hard resins, except for the enamel of Axis\(^6\), which had the lowest value, was the same. Although PR and EP had the same bending strength as dental porcelains, they showed smaller values than Estenia\(^6\), Art glass\(^6\) (Heraeus Kulzer GmbH, Hanau, Germany), Eye sight\(^6\) (Kanebo, Tokyo, Japan), Gradia\(^6\) (GC, Co., Ltd.), and Cesead II\(^6\) (Kuraray, Co., Ltd.).\(^6\)

The micro Vickers hardness of Estenia\(^6\) had a much higher value than that of other resins (about 170).\(^5\) The micro Vickers hardness of the other resins was 24–65.\(^5\) The wear of a prosthesis and an antagonist are considered to influence the micro Vickers hardness, and it is desirable for the value of restorative materials to generally resemble the value of human enamel. The value of hardness was about 300 for human enamel and about 130 for a Type \(\beta\) gold alloy;\(^14\) although the value of Estenia\(^6\) was close to that of the Type \(\beta\) gold alloy, the other resins showed lower values. However, according to past research,\(^15\) performed by exchanging human enamel and hard resins, there were no differences in the amount of wear between them. Therefore, it can be concluded that hardness is not the only factor influencing wear.

Generally, the compression strength is about 100 MPa for acrylic resin\(^14\) and about 330 MPa for porcelain used in dentistry.\(^16\) The compression strength of the hard resins used in past research was 260–510 MPa,\(^6\) close to the value of porcelain, and PR and EP were within this range as well. Generally, the elastic modulus is about 2 GPa\(^14\) for acrylic resin and about 100 GPa\(^14\) for a Type \(\beta\) gold alloy. The elastic modulus of the hard resins used in past research had a higher value than that of acrylic resin (2–10 GPa).\(^5\) PR and EP were also in this range, and the value of PR was larger than those of Cesead II\(^6\), Solidx\(^6\) (Shofu, Inc., Kyoto, Japan), Axis\(^6\), Art glass\(^6\), Eye sight\(^6\), EP, and Compo Plus\(^6\) (Ducera Dental GmbH & Co., KG., Rosbach v.d.H., Germany). The value of EP was smaller than those of Gradia\(^6\), Estenia\(^6\), PR, Cesead II\(^6\), Solidx\(^6\), Axis\(^6\), Art glass\(^6\), and Eye sight\(^6\). Moreover, the comparatively high elastic modulus of hard resin had a value of 1/10 or less compared with that of a Type \(\beta\) gold alloy. When hard resin is used to make a resin jacket crown, the resin jacket crown may be deformed by the load. Therefore, we believe that a metal backing and assured adhesion for a prepared tooth are necessary when restoring teeth using hard resins.

The value of PR was 325 N, and that of EP was 421 N in the fracture strength test of the jacket crown. The fracture strength of the hard resins reported in previous studies was in the range of 380–670 N.\(^5,6,6\) Therefore, the value of PR was generally lower than that of the other resins. Even when compared with the fracture strength (440–630 N\(^10\)) of various types of all ceramic crowns reported in previous research, PR showed a low tendency. If hard resin has a comparatively low elastic modulus, a resin jacket crown will undergo remarkable deformation at the site of occlusal force. Therefore, the fracture strength of a resin jacket crown is smaller than that of all ceramic crowns.

Regarding the strength of resin, the bending strength, hardness, compression strength, elastic modulus, and fracture strength of a jacket crown were measured. PR showed comparatively higher levels than the other hard resins regarding the elastic modulus. However, PR showed comparatively lower levels than the other hard resins regarding the bending strength, hardness, compression strength, and fracture strength of the jacket crown. EP showed comparatively higher levels than the other hard resins regarding the compression strength. However, EP showed comparatively lower levels than the other resins regarding the bending strength, hardness, elastic modulus, and fracture strength of the jacket crown. The intensity of hard resin is considered to improve when the rate of the filler in the resin paste increases.\(^17\) However, when a significant amount of inorganic filler exists in the resin paste, since light cannot easily reach the inside of the paste, polymerization of the resin paste by optical irradiation may be difficult. Consequently, the hard resins may not be sufficiently polymerized, which may cause strength reduction. In Estenia\(^6\), which contains a significant amount of inorganic filler for this reason, a matrix monomer called UTMA was used, and a polymerization method with a dual-cure type with light and heat was ad-
opted. With hard resins other than Estenia®, including PR and EP, it is considered that trouble-free polymerization becomes possible by exchanging a part of an inorganic filler with an organic one. PR and EP have higher proportions of organic compound fillers than other hard resins, but they have comparatively lower proportions of inorganic fillers. Therefore, PR and EP showed comparatively low intensity.

In this study, PR and EP did not show dramatically better physical properties, i.e., fundamental character and intensity, than other hard resins examined in our previous study. However, hard resins are clinically used as a part of the complicated crown form. In a great number of clinical cases, hard resins need retention beads for the mechanical hold and chemical adhesive between metal and opaque resin. For these reasons, the results of each examination in this research may be acceptable clinically. However, it is important to fully understand the characteristics of a material, to judge them synthetically in actual use, and to choose a suitable material. Therefore, hard resin should be studied further with regard to manipulation, surface quality by wear of an antagonist, color fastness, and color tone harmony in addition to the aspects analyzed in this study.

**Conclusion**

In this study, the mechanical properties of two types (EP and PR) of the latest commercial hard resins were evaluated, and the results were compared with those of the other types of commercial hard resins previously investigated. Below is a summary of our findings: PR and EP did not show dramatically better physical properties. However, the results of each investigation in this study may be acceptable clinically. The results of each investigation changed according to the products used, and proper use for each case and application was suggested.

**References**