Development of new hybrid indirect composite resin for crown-TWiNY（Part4）Relationship between the refractive indices of resin components and the transparency of the resins /Kato T, Hoshikawa T, Nagai M, Yamamoto S (Yamamoto Precious Metal Co., Ltd.) : In this study, the influence on the transparency of the resin composite of the refractive index of a resin matrix (before and after polymerization), of the refractive index, and of the particle size of the inorganic filler were examined in order to develop a new indirect composite resin, TWiNY which maintains high transparency throughout the entire polymerization process. Through this study, it was found that it is necessary to take into consideration the effect of light scattering due to the primary particle size of the filler, as well as to adjust the refractive index of the filler, in order to produce a highly transparent resin composite.

[Abstract]

One of the major issues emerging with regard to resins for use in crowns is the light transmittance (transparency) of the resin under photopolymerization, and its aesthetic characteristics. The transparency of a resin depends on the degree of difference between the respective refractive indexes of the matrix material (monomer and nano filler) of which the resin is mainly composed and that of the filler, along with the particle diameter of the filler and its content by percentage. Also, the refractive index of the matrix material increases substantially when the monomers undergo polymerization. In this investigation, with the development of a resin achieving high transparency as the objective, the influence on transparency of the refractive index of the resin matrix (before and after polymerization), and the refractive index and particle diameter of inorganic fillers, was studied in detail during the resin photopolymerization process (before-during-after).

[Materials and Methods]

Table 1 shows the composition and refractive index of the indirect composite resin used in this investigation.

Table 1: Composition and Refractive Index of the Indirect Composite Resin

	Structural component	Content [wt%]	Refractive index [nd^{25}]	
			Before polymerization	After polymerization
Resin matrix	UDMA	78.9		
	Colloidal silica	14.8	1.480	1.509
	γ-MPTS	4.9		
	Camphor Quinone	0.4		
	DMAEMA	1.0		
Filler	SiO_2	87.1	1.494	
	Al_2O_3	0.8		
	ZrO_2	12.1		

The resin matrix material was of a photopolymerized type strengthened with nano filler (SiO_2; diameter: 15 nm). Before polymerization, the refractive index was 1.480; on the other hand, it became 1.509 after polymerization. With the development of a resin achieving consistent light transmittance before and after polymerization as the objective, the refractive index of the filler was set at (1.480 + 1.509) / 2 = 1.494.

First, SiO_2-Al_2O_3-ZrO_2-type sol-gel particles were synthesized through coprecipitation process; they then underwent aggregation, firing and coupling treatment to create an aggregated inorganic filler (secondary particle diameter: approx. 35 μm) [1].

Resin (filler content by percent: 50 wt %) was prepared by use of a vacuum kneading machine, loaded in a metal mold (circumference: 15 mm; thickness: 0.8 mm), both sides of the mold were covered with a transparent film, and test pieces for transmittance measurement were created. Transmittance before and after photopolymerization was measured using a turbidimeter (NDH2000, produced by Nippon Denshoku).

[Results and Discussion]

Table 2 shows the specific surface area of the filler and the transmittance achieved by the resin under these conditions. Total light transmittance (natural dental enamel: approx. 70% / 0.8 mm) showed practical applicability, but a marked decrease in parallel transmittance accompanied the increase in primary particle diameter (Rayleigh scattering [2), 3)] : deterioration of aesthetic quality).

Table 2: Specific Surface area of Filler and Optical Characteristics of the Resin

			Firing temperature [°C]				
			900	1000	1100	1150	1200
Specific surface area [m^2/g]			85.1	48.7	22.5	12.8	4.8
Calculated particle diameter [nm]			30	60	120	210	560
Transmittance of Resin [%]	Before polymerization	Total Light	74.5	77.6	73.3	68.4	60.8
		parallel	57.5	25.5	10.7	5.7	4.4
	After polymerization	Total Light	81.5	75.5	78.0	76.0	68.6
		parallel	63.1	41.0	33.9	16.9	7.8

Next, we investigated the light transmittance of the matrix material undergoing photopolymerization, process of increase in refractivity index from 1.480 before polymerization to 1.509 after polymerization.

Each matrix with a refractive index of 1.48 – 1.52 was created by blending TEGDMA, UDMA and Bis-GMA, and the results achieved with the filler (Table 2, firing temperature: 1100 ˚C; 50 wt %) are shown in Figure 1. Parallel transmittance values were consistent with expectations, but higher values were displayed when the disparity between the refractive indexes of the filler and matrix were smaller, and thus lower values were displayed when the disparity was higher. The transmittance of the resin was higher when undergoing photopolymerization, implying that an adequate case depth was achieved.

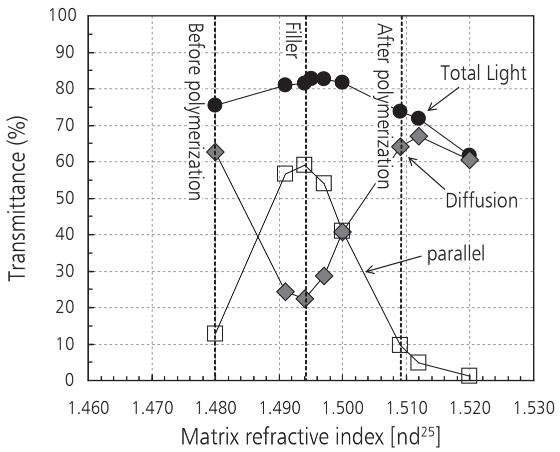

Figure1: Characteristics of Optical Transmittance of filler (firing temperature: 1100˚C; content by percentage: 50 wt%)

From the above results, it is apparent that in order to create a resin with high transparency throughout to the resin photopolymerization process (before-during-after), it is necessary not only to carefully calibrate the changes of the refractive index of the matrix material that accompany polymerization, along with calibrating the refractive index of the filler, but it is also necessary to take into consideration the influence that the primary particle diameter exerts on permeabilitytransmittance values.

[Reference]

1) Hosokawa T, Miyazaki A, Kato T, Anraku T, Yamamoto S: Japanese Patent Number: 4502673
2) Fujita M, al.: *Journal of the Japanese Society for Dental Materials and Devices*, 5 (3), 427-434, 1986
3) Miyazaki A. et al.: Journal of Nippon Academy of Dental Technology, 22 (1), 112-117, 2001