Fatigue strength and wear resistance dental resin composite with cluster filler

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1.Introduction

Resin composite has been used frequently as a dental restorative material in recent years because of its good aesthetics and operability. However, its strength has not been sufficiently high. In this research, in order to develop a resin composite with high strength, we tried to improve the strength of resin composite. Test piece were prepared with various types of fillers under various mixing ratios. And the fatigue strength of these test pieces were evaluated by the three-point bending fatigue test and the wear test.

2. Experimental procedures

2-1. Material

In this study, a resin composite was used, in which the monomers shown in Table 1 and the fillers shown in Table 2 were blended. A cluster filler was obtained by the following procedure a fine indefinite shaped silica filler with a particle diameter of 0.2 to 0.6 μm were sintered to 2, 3.5, 5 and 10 μm by a sol-gel method. All fillers were treated with silane coupling.

Table 1 Monomer used in this study.

Material	Designation	Content ratio [mass%]
Urethane Dimethacrylate Polymers	UDMA	69.5
Tetraethyleneglycol dimethacrylate	TEGDMA	29.5
Camphoroquinone	CQ	0.5
Ethyl 4-(Dimethylamino) benzoate	EDB	0.5

Table 2 Fillers used in this study.

Material	Size (μm)	Configuration
Cluster filler (CF10)	10	Indefinite
Cluster filler (CF5)	5	
Cluster filler (CF3.5)	3.5	
Cluster filler (CF2)	2	

2-2. Test piece

Unpolymerized resin composite was poured into a mold and polymerized and cured for 2 minutes with a photopolymerization machine (αLIGHTIIN). After polymerization, the test piece was removed from the mold and finished by removing burrs with # 800 emery paper. After that, the test piece was sealed in a push vial and kept in a water bath at 37 °C. (± 1 °C.) for a predetermined time. The test piece shape is a 2 × 2 × 25 [mm^3] rectangular shape. Table 3 shows the proportions of fillers in the resin composite used in this test.

Table 3 Materials used in this study.

Designation	CF10	CF5	CF3.5	CF2
CF2	-	-	-	100
CF10	100	-	-	-
Dual A	-	-	80	20
Dual B	20	-	80	-
Dual C	80	-	-	20
Dual D	20	-	-	80
Dual E	-	80	20	-
Dual F	80	20	-	-

3. Test method

3-1. Three-point bending fatigue test

An electromagnetic fatigue testing machine (MMT-100N) was used for the three-point bending fatigue test. The load waveform is a sinusoidal wave, the frequency of load cycle is 2 Hz, the gauge length of test piece is 20 mm, and the stress ratio is 0.1. By surrounding the test piece with an acrylic plate and connecting the ceramic heater (MS-1) and thermocouple placed in it to the electronic temperature controller (E5CN), the fatigue test is preformed under temperature control. Furthermore, warm air was circulated by a fan to keep the temperature at 37 °C ± 1 °C.

3-2. Wear test

Suga Abrasion Tester (NUS-ISO-3) was used for the abrasion test. # 800 emery paper was used as the wearing material. Under a load of 29.4 N, the mass of the test piece was measured using a general-purpose electronic balance (GF-300: A & D Co. Ltd.) at every 1000 cycles of wear. The wear test was performed up to 3000 cycle of wear.

4. Test results

4-1. Fatigue test

The relationship between the stress range and the number of cycles to failure obtained from the fatigue test is shown in Fig.1 as S-N curves. The right arrow symbol in the figure indicates that the test piece is not broken.

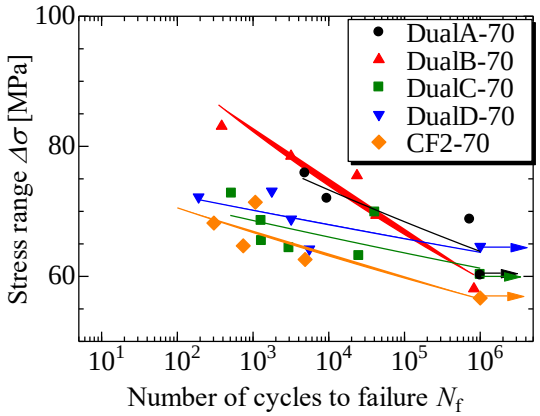

Fig.1 Influence of filler contents ratios on fatigue strength of resin composites.

The filler filling rate in the fatigue test was selected as 70 mass%. The dual hybrid resin composite containing multiple types of fillers showed stronger fatigue strength than the single combination type. It was found that blending multiple fillers with different particle sizes results in higher strength than that of single blending type.

4-2. Wear test

The wear test of the dual hybrid resin composite was carried out, and the relationship between the total amount of wear and the number of cycles obtained was shown in Fig.2.

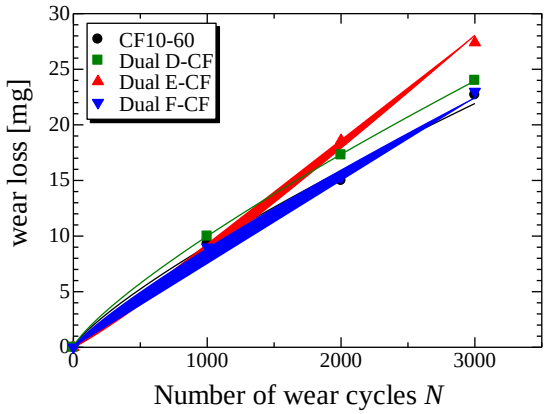

Fig.2 Influence of filler contents ratios on wear strength of resin composites.

The filler filling rate in the wear test was selected as 60 mass%. The amount of wear of CF10-60 and DualF-CF, which are resin composites containing a large amount of filler with large particle size, was small, this resin composite shows the high wear resistance. From these results, it was found that the abrasion resistance was not affected by the combination of two or more fillers, and that it only depended on the particle size of the filler.

5.Conclusion

We investigated the effect of filler content on the hybrid resin composite using cluster filler. From the test results of the dual hybrid resin composite containing two types of cluster fillers, it was found that the fatigue strength is improved by processing dual hybridization such as mixing multiple fillers with different particle sizes.

The wear resistance was not improved by dual hybridization. From these results, it was found that the best compounding ratio of the resin composite with high strength is 20 mass% of 10 μm of cluster filler and 80 mass% of 2 μm.

References

[1] T. Sakaguchi and I. Nishikawa, Influence of ethanol solution on fatigue strength of resin composite with hybrid cluster filler, The Journal of the Japanese Society for Dental Materials and Devices, (2016) Vol.35 No.2 94