Caspian Journal of
Dental Research

Original Article

Three-body wear of different composites resins

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Abstract

Introduction: Low resistance of composite resins to abrasion is a primary concern in the application of these materials for posterior restorations which are prone to high occlusal loads. This study compared the wear resistance of three types of composites.

Methods: In this laboratory experiment, five specimens of each of the three types of composites (z250, Heliomolar, Opallis) were prepared separately in brass molds. Composites were placed in 1-mm layers and were cured for 40 seconds. Using an abrasive device, Pedeb 1, with a chrome-cobalt abrasor, the specimens were abraded under a 20-MPa force, after 5000, 20000, 40000, 80000, 120000 abrasive rotations. Before and after all abrasion cycles, the specimens were weighed with an electronic balance with a precision of 10^{-4} g. The collected data were analyzed using paired samples statistics t-test and ANOVA analysis.

Results: All the specimens showed a reduction pattern from the initial weights to weights after 120000 abrasive rotations. With more abrasive rotations, greater weight reduction occurs and this is of statistical significance. ANOVA analysis showed no significant difference between the three types of composites; yet, the z250 and Heliomolar groups were associated with the least and the greatest amount of wear, respectively.

Conclusions: In all specimens, significant weight reduction occurred after abrasion but there were no significant differences between the 3 types of composites.

Keywords: Abrasion, Composite, Three-body wear.

Received: 22 Apr 2012 **Revised:** 3 Jun 2012 **Accepted:** 16 Jun 2012

Introduction

During the recent years, the exceeding expectations of patients regarding the esthetic and strength of anterior and posterior restorations have resulted in an increase in application of composites for posterior restorations. Despite several advantages of composite resins, these restorative materials have certain problems for restoration of posterior teeth, namely low wear resistance (1). Although the failure of composite restorations has decreased, certain factors including high coefficient of thermal expansion, shrinkage stress due to polymerization, microleakage, wear, incomplete curing, recurrent caries, post-restoration sensitivity, color change, and others are still considered as possible reasons for composite restoration failure. Even though several solutions have been suggested for reducing composite wear, this problem still remains unsolved (1-3). It is noteworthy that the importance of wear from

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[DOR: 20.1001.1.22519890.2012.1.1.9.5]

[DOI: 10.22088/cjdr.1.1.36]

the clinical point of view, is mainly related to loss of esthetic and function of the restoration and there exists little information regarding the systemic effects of swallowed/inhaled particles cut off composite surface during abrasion (4). Formerly, due to excessive wear of composite restorations, these materials were contraindicated for posterior applications in which occlusal loads were higher. However, the composites today are modified to be more resistant to wear (5).

Introduction of composite resins with great wear resistance has been a considerable improvement in tooth-colored restorations (6). The amount of wear in direct composite restorations is directly related to filler size, polymerization quality, and efficiency of light curing unit. It has been proven that there is no relation between stiffness, modulus of elasticity, and wear resistance and abrasion behavior has been considered as a failure of key elements in composites (2, 3, 6).

Therefore, abrasion, stiffness, and physical strength of separate issues are assessed as a clinical quality. In a study conducted by Kiremitici et al. beta-quartz glass insert-resin composite restorations showed a promising two-year clinical performance (7). Xu et al. appraised the three-body abrasion in an in vitro study and demonstrated that composite resins reinforced with silica whiskers had more abrasion resistance compared to composites reinforced with glass particles (8). Nagarajan et al. reported that the differences in filler size and chemical composition of glass fillers had no effect on the wear behavior of medium filled composites.

Nevertheless, wear rates of medium filled composites (with 75-76% filler) were significantly higher than highly filled composites (9). Knobloch et al. evaluated the two-body wear of 4 laboratory-processed composites (Targis, Concept, Belleglass, Artglass) and 2 direct placement composites (Heliomolar, Herculite), using enamel as a positive control. The amount of wear in concept was the least (limited to enamel) and all the other types of composites were associated with significantly greater amounts of wear (10). Considering the increasing application of novel direct placement composites, this study was designed to evaluate the wear resistance of the three types of direct composites.

Methods

In this experiment, the three types of composites were opted (Opallis, Heliomolar, Z250; all in shade A3). Five specimens were provided from each group. Specimens were prepared in 2×10×10-mm cubes in a brass mold. The mold consisted of two separate symmetrical complementary pieces with 3 specimen preparation sites, which could be fixed together by 2 screws. The 3 specimen preparation sites were located at 1-cm distance from each other and had equal heights and widths (1×1 mm), while the depths were variables between 1-3 mm. The 2-mm deep site was used in this experiment. The composites were placed in layers (1mm each) and the curing time was 40 seconds.

A low-power light curing unit was used (400 mW/cm^2; Astralis7, Vivadent, Liechtenstein). In order to provide a smooth surface and eliminate air contact, the specimens were covered with a glass lamella during curing. Each specimen was numbered using a ¼ round bur on the inferior surface and they were all stored for 14 days in normal saline in an incubator (37°C).

Before applying abrasive forces, all samples were dried with air spray and drying paper. The samples' weights were measured with an electronic balance (Sartorius AG, Göttingen, Germany) with a precision of 10^{-4} g and were collected. Each specimen was located in an abrasive test device; Pedeb 1 (designed and made by H.A.). Pedeb 1 is made of two parts; a rotator on which samples are located, and a pneumatic system.

The chrome-cobalt abrasor with a cross section of 1.98 mm^2 is attached to the latter and can constantly apply a 4-kg force to the specimens. These two parts are fixed in a cabinet and a counter on the rotator calculates the number of rotations. To simulate three-body abrasion, the reservoir at the site of specimens was filled with an abrasive solution, prepared by diluting toothpaste (Paveh, Paksan co., Iran) at a ratio of 1:2 with normal saline. The specimens were then abraded under a 20-MPa force, for 5000, 20000, 40000, 80000, 120000 abrasive rotations. Following each rotation cycle, all specimens were dried precisely and weighed. To determine the significance of weight difference between the specimens before abrasion and after different abrasive rotations, paired samples statistics t-test and ANOVA analysis were used.

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[DOI: 10.22088/cjdr.1.1.36]

Results

In all specimens, before 120000 rotations, weights were reduced and this reduction was statistically significant in all types of composites. In Z250 group, weights before abrasion were significantly different with those after 5000 and 20000 abrasive rotations and so were the weights after 5000 rotations with those after 20000 rotations (table 1). In Heliomolar and Opallis groups, weights after all abrasive rotations were significantly different with one another, except when the weights before abrasion were compared to those after 5000 rotations. The least and the greatest amount of abrasion was found in z250 and Heliomolar groups, respectively.

Table 1. The average of weight difference between each of the abrasion cycles and pre-abrasion.

Abrasion Cycle	Group	Mean±SD	±SE	P value
5000	Z250	0.00035±0.0002	0.00015	0.622
	Heliomolar	0.00006±0.000089	0.00004	
	Opallis	0.00012±0.00013	0.00005	
20000	Z250	0.0004±0.00058	0.00025	0.796
	Heliomolar	0.0004 ±0.00028	0.00012	
	Opallis	0.0003 ±0.00016	0.00007	
40000	Z250	0.0007 ±0.00056	0.00025	0.500
	Heliomolar	0.0008 ±0.00038	0.00017	
	Opallis	0.0005 ±0.00023	0.0001	
80000	Z250	0.0008 ±0.00061	0.00027	0.363
	Heliomolar	0.0012 ±0.00042	0.00019	
	Opallis	0.0009 ±0.00025	0.00011	
120000	Z250	0.0011 ±0.00071	0.00032	0.207
	Heliomolar	0.0017 ±0.00061	0.00027	
	Opallis	0.0013 ±0.00028	0.00012	

Discussion

The clinical abrasion of composite restorations in posterior teeth has been the primary concern in decision making for replacement of amalgam restorations with composites. Therefore, the manufacturers have applied different chemical modifications to enhance the abrasive behavior and physical-mechanical properties of composites.

Nevertheless, composites have remained sensitive and vulnerable to occlusal overloading (11, 12). This might be due to the fact that an ineliminable element of composites is the resin matrix which is greatly sensitive to abrasion.

Moreover, despite the fact that complete polymerization of composites, especially light-cured composites enhances wear resistance in these materials, the current light curing devices and techniques do not allow for complete polymerization of monomers into polymers (13-15). In order to provide sufficient wear resistance for composite materials, it is essential to minimize the distance between filler particles. Silanes can also play a quite efficient role. Experiments have considered high polymerization contractions, air trapping in composite material, large size of restorations as other factors responsible for increasing wear and failure (7). As a result of time and cost-consuming nature of clinical studies, laboratory simulations have been used extensively; however, simulation of the exact conditions of mouth environment can be quite challenging. In certain situations, it might be possible to simulate more or less precise mechanisms of abrasion. In the current experiment, an abrasive device, pedeb 1, was used to create three-body abrasion.

Yap et al. used a stainless steel abrasor with a rough end (cross section 1mm^2) and a 1.6-kg force to evaluate the abrasive behavior of composite materials. It is believed that while antagonists like enamel eventually polish the composite surface and create limited abrasion, a stainless steel can provide standard contact forces on specimens (11, 16).

In the present study, brass molds were used to prepare cube shaped specimens, all of which were stored in incubator for 14 days before abrasion. This is a common procedure in laboratory studies (7, 16, 17).

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Studies have revealed that light curing units provide different degrees of polymerization in different depths. Hence, investigators assess the abrasion behavior of materials in different abrasive cycles.

The current study used 5000, 20000, 40000, 80000, 120000 abrasive rotations (18). Since every method and abrasive device has its own characteristics, the absence of studies on Pedeb 1 in literature does not allow for comparison of the current findings with other experiments.

Alaghemand et al. used this device to evaluate the amount of wear in composites polymerized with either a halogen or a LED light-curing unit (19). The results were comparable in both groups. All specimens in the present study showed a reduction pattern from the initial weights to weights after 120000 abrasive rotations.

With more abrasive rotations greater weight reduction occurs and this is of statistical significance. The direct relation between abrasion and weight of specimens, approved in almost all previous studies suggests weight as a potential factor for the evaluation of the amount of wear (7, 16-18).

ANOVA analysis showed no significant difference among the three types of composites; yet, the z250 and Heliomolar groups were associated with the least and the greatest amount of wear, respectively. High filler content (60%), fine size of filler particles (µm), and BCMA monomer with a high molecular weight might have resulted in the least amount of wear in z250 composite specimens.

Acknowledgements

The authors would like to thank the research council of Babol University of Medical Sciences for a grant.

Funding: This article was extracted from an MD students thesis (No 266) of Faculty of Dentrstry Babol University of Medical Sciences.

Conflict of interest: There was no conflict of interest.

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[DOI: 10.22088/cjdr.1.1.36]