WEAR PROPERTIES OF NANOFILLED AND MICROFILLED COMPOSITE RESTORARIVE MATERIALS

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ABSTRACT: The purpose of this in vitro study was to compare the two-body wear resistance of nanofilled (3M ESPE Filtek Silorane) and microfilled (3M ESPE Filtek Z250) composite restorative materials. Eight standardized disc shape specimens (6mm diameter X 8mm height) were prepared from two composite materials. Specimens were subjected to chewing simulation using a chewing simulator (F=49N (vertical 6 mm, horizontal 2 mm) 2,4 X 10^5 cycles and frequency 1,6 Hz) and simultaneous thermal cycling (3000 cycles, 5°C/55°C, 1min/cycle). AL_2O_3 balls were used as antagonists for every experiment chewing cycle. Mean volume loss values were determined using 3D laser scanning device. Mean values and standard deviations were calculated and statistical analysis was performed using one-way Anova and Tukey's test (α=,05). Vicker hardness values for Filtek Z250 (about 69HV) and for Filtek Silorane (about 45HV) were measured. Mean volume loss of Filtek Z250 (3,8µm^3 p=.021) is measured to be lower than Filtek Silorane (5,9µm^3 p=.017). In this study, suggested the excellent two body wear behaviour of the microfilled Filtek Z250. However, this study isn't correlations linear between filler volume values and two body wear resistance

Key words: Two-body Wear, Composite Restorative Materials, Chewing Simulation, Thermal Cycling

INTRODUCTION

The use of light-activated resin composites has dramatically increased in the past years as a response to an increased demand for esthetic restorations.(Kurachi, Tuboy, Magalhaes, & Bagnato, 2001) Dental resin composites are heterogenous materials, usually consisting of three major components, namely resin matrix, inorganic fillers, and a silane coupling agent.(Bicer, Karakis, Dogan, & Mert, 2015) The amount and size of filler particles incorporated in the resin matrix determine the type, and ultimately, the most advantageous clinical application of each composite. Wear is the net result of a number of fundamental processes: abrasion, adhesion, adhesive effects between two contacting surfaces, fatigue and corrosive effects, which act in various combinations depending upon the properties of the materials. Abrasion and attrition have largely been accepted as the primary clinical wear mechanisms for dental resin composites(Bicer et al., 2015; Harsha & Tewari, 2003; Heintze, Zellweger, Cavalleri, & Ferracane, 2006; Lim, Ferracane, Condon, & Adey, 2002). Wear of teeth and restorative materials is the result of different complex processes that depend primarily on the abrasive nature of food, the properties of the antagonistic material, the thickness and hardness of enamel, the chewing behaviour along with parafunctional habits, and neuromuscular forces.(Johansson, Haraldson, Omar, Kiliaridis, & Carlsson, 1993; Kim, Kim, Chang, & Heo, 2001; Mair, Stolarski, Vowles, & Lloyd, 1996) Therefore, it is clinically crucial issue to predict wear behavior of different composite restorative resins used in oral environment. Although most in vivo wear is three-body wear, however, wear at the occlusal contact areas (OCA) that stabilizes the vertical distance between the mandible and the maxilla is correlated with two-body wear simulations.(Bicer et al., 2015) Despite the improvement in wear resistance of restorative materials, wear continues to be a problem.(Bicer et al., 2015) Until recently, much of the published clinical data on composite restoratives have focused on generalized contact free abrasion (CFA) of the material.(Bicer et al., 2015) Although this type of wear pattern is clinically important, localized OCA wear, which is directly attributed to the presence of a contacting cusp on the occlusal restorations, may be of great concern.(Yap, Chew, Ong, & Teoh, 2002) A number of publications have suggested that OCA wear may be two to three times greater than CFA wear.(Lutz, Phillips, Roulet, & Setcos, 1984; Willems, Lambrechts, Braem, & Vanherle, 1993) If the amount of OCA wear, which may be accelerated by the chemical environment, is of sufficient magnitude appreciable changes in occlusion may develop.(Bicer et al., 2015) It has been demonstrated that dental restorative materials show different wear mechanisms under different in vitro wear conditions.(Hu, Shortall, & Marquis, 2002), and that none of the existing wear devices can simulate the clinical wear process completely realistically. (Condon & Ferracane, 1996) However, the clinical evaluation of wear is expensive and time consuming, and various important variables such as chewing forces or environmental factors cannot be controlled sufficiently.(Condon & Ferracane, 1996) Thus, despite of the complexity of the clinical wear processes, laboratory mastication simulation allows the investigation of single parameters of the wear processes, though it has to be borne in mind that even in vitro wear simulations show considerable variability.(Heintze, 2006) The objective of a laboratory simulation is to produce wear that correlates well with clinical performance and that can predict survival time.(DeLong et al., 2012; Souza et al., 2010) Ideal dental restorative materials yield wear resistance similar to that of tooth tissues. For improving the wear resistance of restorative materials and for minimizing filler exfoliation during wear processes, filler shape, size and volume have been modified extensively in the recent years (Christensen, 2007). In addition, several innovative dental restorative materials for application in posterior restorations have been introduced, featuring ormocer and Silorane technology. However, particularly for Silorane-based materials, the information on wear resistance that is available in the literature is very limited, and profound analysis of the wear behaviour of these materials has been demanded.(Christensen, 2007) Thus the purpose of this study is to evaluate effect of two-body wear on microfilled(3M ESPE Filtek Z250), and nanofilled(Filtek Silorane 3M ESPE) composite restorative materials.

METHODS

Information provided by material manufacturers for materials used in this study are given in Table 1. A total of 16 specimens (6mm diameter and 8mm height) consisting of 8 specimens for each material were prepared following the manufacturer's instructions. All of the specimens were stored in distilled water for one week at 37 °C prior to two-body wear tests. In this study, a chewing simulation device designed to investigate dental materials was employed. The specimens and antagonists were mounted in chewing simulator using a ball-on-block design and were loaded pneumatically with vertical load of 49 N for 2,4 x 10^5cycles at a frequency of 1.6 Hz (1 mm lateral movement 2 mm mouth opening).

Table 1 Composite restorative materials used in this study

Materials	Manufacturer /Type	Filler	Matrix	Filler Volume(%)
Filtek Silorane	3M ESPE / Nanofilled	Quartz fillers, Yttrium fluoride	Siloranes	76
Filtek Z250	3M ESPE / Microfilled	ZrO_2, SiO_2	Bis-GMA, UDMA, Bis-EMA	60

RESULTS AND FINDINGS

One-way ANOVA indicated significant differences in Vicker hardness(HV) between the three restorative materials. Mean vicker hardness values ranged between approximately 49 and 69 HV were measured. (table 2)

Table 2 Vickers hardness of the restorative materials that were used in this study

Materials	Mean Vickers Hardness (SD)
Filtek Silorane	49,15(2,1)
Filtek Z250	69,25(1,4)

The results of the qualitative SEM analysis are presented in fig1 (respectively a: Filtek Silorane, b: Filtek Z250), showing image pairs of contact areas and wear track areas on specimens after chewing actions. Fig1(a) showed the contact area delineated by a sharp line from the polished specimen surface. However, Fig 1(b) which represents microfilled resin (Filtek Z250) showed significantly less wear of track by a sharp line from the polished surface than fig1(a) Filtek Silorane composite materials.

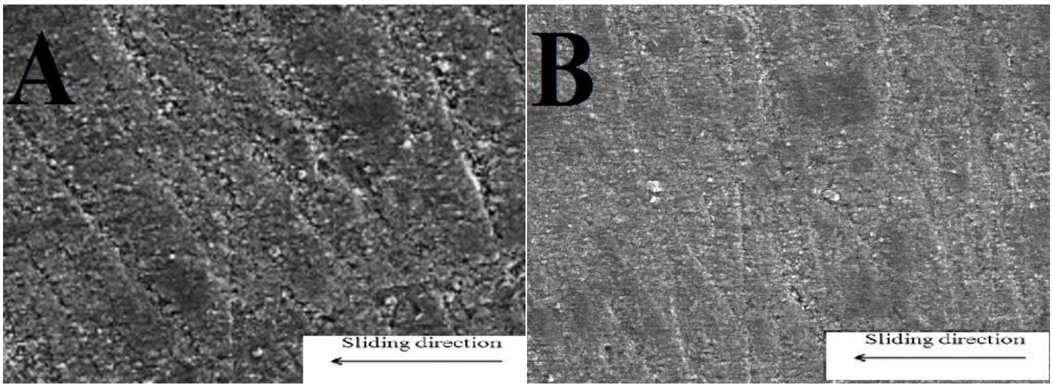

Figure 1. Respectively A:Filtek Silorane, B: Filtek Z250 (After 2,4X10^5 49 N chewing simulation and 3000 thermal cycles, 5°C /55 °C, 1 min/cycle)(HV:10kV mag: 500X 400µm)

Mean volume loss of Filtek Z250 (3,8µm^3 p=.021) is measured to be lower than Filtek Silorane (5,9µm^3 p=.017). In this study, suggested the excellent two body wear behaviour of the microfilled Filtek Z250. Moreover, each composite resin showed a distinct performance, which suggests that results were dependent upon each composite resin formulation. Other investigation has been reported that the filler particles play a particular important role for both hardness and wear resistance.(Cao, Zhao, Gong, & Zhao, 2013)The effect of filler volume on wear resistance follows a linear relationship, with high volumes decreasing wear rates due to lower expanse of resin unprotected by filler particles(Condon & Ferracane, 1997) which was supported by other researchers.(Heintze, Zellweger, & Zappini, 2007)However, regression analysis showed no correlation linear between filler volume values and two body wear resistance for the composite restorative materials investigated in this study. This can be explained as Filtek Z250 could most likely be attributed to the unique polymer structure which consist of well-dispersed microsize fillers.

It is difficult to reproduce the oral environment exactly in any two body wear testing system. Direct prediction of clinical wear resistance deduced from the present wear data results is thus not possible. Wear is a multifactorial process that probably cannot be described adequately with one material characteristic only (Koottathape, Takahashi, Iwasaki, Kanehira, & Finger, 2014). Thus further investigations is needed to examine characteristics such as three body wear, fatigue wear and fracture properties.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn: Among the composite materials used this study the microfill composite resin Filtek Z250 showed the least mean volume loss which was significantly lower than that of material of Filtek Silorane. Among the composite materials used this study isn't correlations linear between filler volume values and two body wear resistance.

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