ASSESSMENT OF VARIATIONS IN WEAR TEST METHODOLOGY

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ABSTRACT

The properties of composite resin for dental fillings were improved by development, but its weakness continues to be its wear strength. Several tests have been proposed to evaluate wear in composite resin materials. The aim of this study was to verify how polishing and the type of abrasive can influence the wear rate of composite resin. The test was carried out on two groups. In one group we employed an ormocer and a hybrid composite that was polished only with 600 and 1200 grit abrasive papers, whereas in the other group the composite was polished with the same abrasive paper plus a 1 µm and 0.25 µm grit diamond paste. A three-body wear test was performed using the metal sphere of the wear test machine, the composite and an abrasive. A diamond paste and aluminum oxide dispersion were used as abrasive. Analysis of the results showed that there was no difference between polishing techniques, but revealed a difference between abrasives.

Key words: composite resins, dental polishing, composite wear.

AVALIAÇÃO DAS VARIAÇÕES NA METODOLOGIA DO TESTE DE DESGASTE

RESUMO

Com a evolução dos compósitos para restaurações dentárias várias propriedades sofreram melhoras, porém o desgaste sofrido pelo material continua conduzindo a falha de várias restaurações. Existem vários testes propostos para avaliar o desgaste sofrido por estes materiais. O objetivo deste trabalho foi verificar como o polimento e o tipo de abrasivo pode influenciar o desgaste deste material. Para realização dos testes utilizou-se um ormocer e um compósito híbrido, que foram polidos com lixa de granulação 600 e 1200 e com as lixas seguidas de pano de polimento e pasta de diamante de granulação 1 µm e 0,25 µm. Foi realizado um desgaste tri-corpóreo que envolvia a esfera metálica da máquina de desgaste, o compósito e um abrasivo. Como abrasivo foram utilizados uma pasta de diamante e uma dispersão de alumina. Através dos resultados podemos concluir que a diferença no polimento não afetou os resultados, mas que existiu diferença entre os testes realizados com a pasta de diamante e a dispersão de alumina.

Palavras chaves: composite resin; dental polishing; composite wear.

INTRODUCTION

Restorative material wear in the oral cavity is related to various factors: the cavity preparation characteristics, material composition and interaction of physical, chemical, biological and mechanical factors as well as the tooth/restorative material bond[1]. In 1989, the ADA[2] published a set of rules stating that in order for a material to be indicated for unrestricted use in posterior teeth it must have a maximum wear of 100 µm after four years of clinical use. Wear in posterior tooth restorations is due to abrasion and friction from masticatory forces. Restorative material wear causes loss of anatomic shape and fracture in the restoration body and margin[3]. As wear can lead to restoration failure, it has been studied extensively, but there are several types of wear tests and the results are very diverse. In its specification No.27[4], the ADA does not recommend resistance to abrasion and wear tests for resin based dental materials, because it states that no laboratory test satisfactorily reproduces the clinical results. On the other hand, clinical tests involve many variables and normally have a long period of evaluation, which makes them difficult to use, since new products are frequently launched on the market[5,6]. There is still no clinical test to measure restoration wear and laboratory tests provide higher values than those found *in vivo*[7].Various *in vitro* tests have been described[5,6,8]. In vitro tests are normally classified as two-body and three-body. The three-body wear reproduces the oral condition better[6,9], because it produces the contact of two materials with some substance that imitates the food bolus. The aim of this study was to assess how the type of polishing and type of abrasive influence material wear.

MATERIALS AND METHODS

The test specimens for this test were prepared using a 4 x 8 x 30 mm silicone mold. One test specimen for each material and each test was used. As wear is a surface phenomenon, and the size of the test specimen would not alter the property, we chose to perform the test in a single specimen. This modality enabled us to make several measurements, reducing the variables involved during polymerization of the material. The composites used were an ormocer (Admira, Voco, Cuxhaven, Germany) and a hybrid composite (Concept, Vigodent, Rio de Janeiro, Brazil). They were used to fill the mold and were covered with a transparent polyester strip to obtain a surface as smooth as possible. Polymerization was done in three stages, on the top and bottom surfaces, since the test specimen measured 30 mm and the tip of the light polymerizer only 10 mm. After fabricating the test specimens, they were polished in a polishing machine (Teclago, Rio de Janeiro, Brazil), using 600 and 1200 grit 3M abrasive papers. In one group, only this polishing was used, whereas in the other group, abrasive paper strips followed by a polishing cloth with 1 μm and 0.25 μm grit diamond paste were used**.** After polishing, the test specimens were immersed in high purity alcohol and ultrasound cleaned. The wear tests began with the use of diamond paste as abrasive placed on the specimen polished with abrasive paper strips only at the beginning of the test. Cycles of 100, 200, 300, 400 and 500 turns were used for ormocer and cycles of 100, 200 and 300 turns were used for the hybrid composite. With the hybrid composite, cycles of up to only 300 turns were employed, because, due to great dispersion of the data, it was decided to assess the results first and then continue with the tests. The wear tests were performed using equipment that works with the three-body abrasion system. The equipment is composed of a test tube holder coupled to a vertical load device and a wear system consisting of a sphere supported on three rollers, in which one of the rollers rotates to drive the sphere/roller assembly. The abrasive is fed by an injector nozzle at the sphere/test tube interface, and the lubricant simply by gravity. The working principle involves pressing the test specimen with weights of standardized masses onto a rotating sphere, with a constant feed of liquid abrasive at the test specimen/sphere interface. The abrasive substances used were 0.25 mm grit diamond paste or 1 mm aqueous aluminum dispersion. The arm is displaced and the specimen is placed on the sphere. This sphere moves on three rollers. The sphere rotates on its own axis at a speed of 50 turns/min (Fig. 1). The arm stays in position by the force of a 100 g weight. The abrasive substance is placed between the material to be tested and the metal sphere. To carry out the tests with diamond paste, the test specimen was positioned and the abrasive paste was placed on the sphere. Two conditions of paste placement were analyzed, i.e. only at the beginning of the process and replacement after every 100 cycles. Wear was recorded after 100, 200, 300, 400, 500 and 1000 cycles. Ten measurements were taken for each cycle. The worn region leaves a crater on the surface, shown in Fig. 2. These craters were measured in the Paint program (Microsoft®, USA) in pixels. When the aluminum dispersion was used as abrasive, a device was installed to produce continuous dripping of the dispersion throughout the entire wear process. This device was made with a beaker with a side outlet where a hose was connected. This hose had a flow regulator and a needle at its end, from which the dispersion was dripped onto the metal sphere (Fig. 3). To prevent rapid aluminum settling, the dispersion was kept under magnetic agitation. Wear values were obtained for 100, 300, 500, 700 and 1000 cycles. After each measurement, the test specimen and sphere were removed and cleaned with soft paper towels. At the end of all the cycles, the specimen was removed and

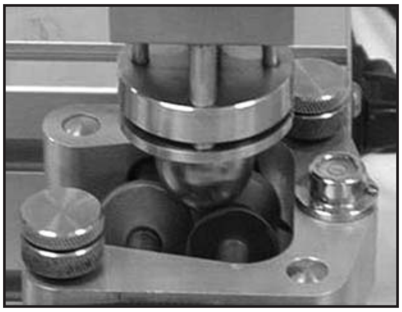

Fig. 1: The metal sphere on the wear machine rollers.

Fig. 2: The test specimen fixed to the wear machine, showing the craters formed.

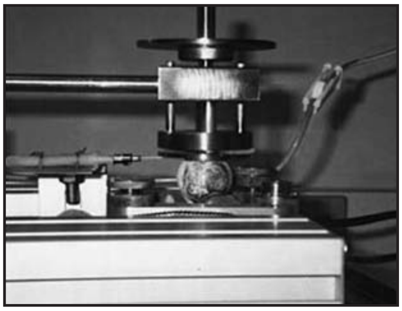

Fig. 3: Wear test with aluminum needle dripping aluminum and 100 g weight.

washed under running water and neutral soap to remove paste residues. As the position of the measurements was randomly determined, the test specimen was mapped after the cycles were run, to identify the markings. The test specimens were examined under the optic microscope to obtain the images, acquired at 25 times magnification (Fig. 4 and 5) The craters were measured in the Paint program in pixels. Wear rate was calculated based on the crater diameter, the radius of the sphere and the number of turns, the crater depth, the volume of material removed and the distance run in each cycle. The surface of the worn material was analyzed by scanning electron microscopy (SEM).

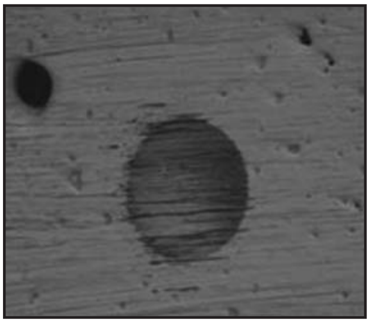

Fig. 4: Optic microscopy of the ormocer surface after 500 turns, after wear with diamond paste.

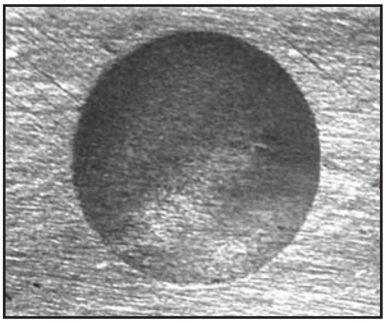

Fig. 5: Optic microscopy of the ormocer surface after 500 turns, after wear with aluminum dispersion.

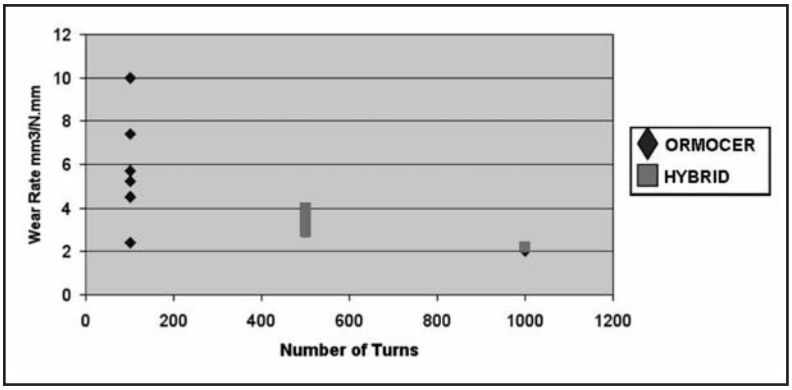

Fig. 6: Wear rate graph (mm3/N.mm) of ormocer and hybrid composite using diamond paste as abrasive.

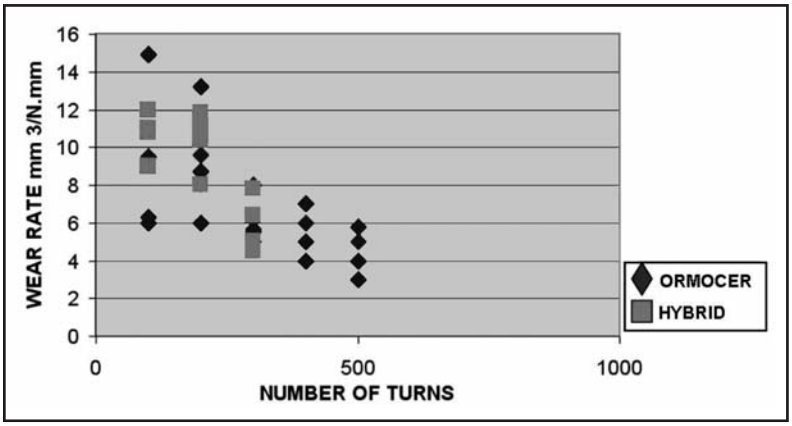

Fig. 7: Ormocer wear rate (mm3/N.mm) with cycle of 500 turns.

RESULTS

In addition to the dispersion of data, Fig. 6 shows a drop in the wear rate with the number of turns for both materials. Two changes were made to examine whether the dispersion was related to the material characteristics or to the methodology. New test specimens were made and polishing was improved; in addition to the abrasive papers described in the methodology, 1 µm and 0,25 µm grit diamond paste was used. Furthermore, abrasive paste was now placed after every 100 turns. The test with ormocer was performed with the two types of polishing without stopping to put on more paste, and then repeated with ormocer polished with abrasive paper associated with a polishing cloth and diamond paste, stopping after every 100 cycles to put on more paste during 500 cycles. Fig. 7 shows that the difference in polishing did not alter the dispersion of data a great deal. However, when the abrasive paste was replaced after every 100 turns, the dispersion of values diminished. Thus, this methodology was adopted for the subsequent tests, and new measurements were taken with 100, 500 and 1000 cycles using ormocer and the hybrid composite. Fig. 6 shows that dispersion persisted for the cycles of 100 turns but decreased with the increase in cycles. Fig. 8 shows that the wear rate of the test specimens worn with aluminum dispersion increased with the number of turns, whereas in the case of wear with diamond paste wear rate diminished as the number of turns increased. Fig. 4

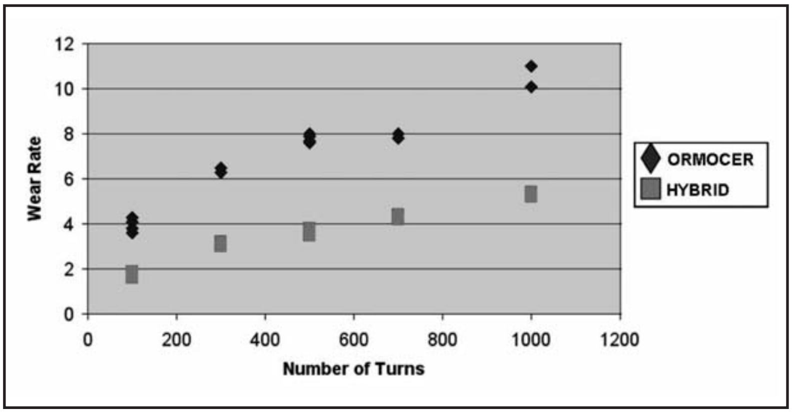

Fig. 8: Wear rate graph (mm3/N.mm) of ormocer (Admira) and hybrid composite (Concept) in cycles of 100, 300, 500, 700 and 1000 turns using aluminum dispersion.

and 5 shows the hollow formed in the material ormocer after 500 turns. The smaller hollow corresponds to wear with diamond paste (Fig. 4). In addition, the wear with aluminum dispersion (Fig. 5) produced craters with more regular edges than wear with diamond paste (Fig. 4). Gee et al.[10] found that the grittier abrasives caused hollows with more irregular borders.

DISCUSSION

When diamond paste was used to perform wear, great dispersion was found in the wear rate values of the ormocer material in the 100 turn cycle. As the number of cycles was increased, dispersion diminished and there was no statistical difference between wear rate values of the hybrid composite and the ormocer. A difference in wear was observed between hybrid composite and ormocer in the test with aluminum. Conversely, no difference was found in the test with diamond paste. A possible explanation for this finding could be that this difference only occurs when the material has already undergone a certain degree of wear. Tagtekin et al.[11] assessed the wear of ormocer and a hybrid composite (Amelogen), with a system that involved an aluminum sphere and the composite tested without abrasive. These authors found no difference between the wear of the two materials. The higher wear rate with aluminum dispersion could perhaps be explained by the fact that even while attempting to control the process to dispense a minimum amount of aluminum, a large quantity of abrasive was used. Although the diamond paste is harder and would be expected to cause greater wear, a much larger quantity of aluminum dispersion was used, causing an increase in wear rate. A factor that could change the wear of the restorative materials is immediate polishing after the restoration. The rotary instruments used for polishing in dentistry generate scratches that make the material less resistant to wear. Ratanapridakul et al.[12] tested the wear of a material with and without polishing. These authors found higher wear values for the material that was polished (140 mm) than for the unpolished material (80 mm). In the present study no differences in wear rate were observed between the two types of polishing techniques employed. When wear was assessed using the diamond paste, a reduction in the wear rate was observed when the cycles increased from 100 to 1000 turns, both in ormocer and the hybrid composite. Similar behavior was observed by others authors in their wear tests[13,14,15]. Copello[16] assessed two composites for indirect use in dental restorations using the same methodology with diamond paste used herein. He found that the wear rate had a tendency to diminish and stabilize when the test specimens were cleaned only at the end of the process. Fragments and particles released during the wear process stayed on the surface of the material, altering the dynamics of the process and giving the system more wear resistance. He also stated that it was necessary to conduct further tests in which there was no accumulation of residues. Nagarajan et al.[17] observed the worn area by SEM, and by infrared spectroscopy and analyzed the water where the wear process occurred. They concluded that composite wear occurs through a complex process that involves tribochemical reactions between the load particles and water, forming superficial films containing a mixture of load fragments and reaction products. This could also explain the increase in wear rate when the test was done with aluminum dispersion. In addition to potential differences in the reactions between the tested material and diamond paste or aluminum dispersion, aluminum was used in an aqueous dispersion that constantly cleaned the specimen. The results found with this system showed an increase in the wear rate with the cycles. The wear mechanism is very complex and multifactorial[18]. This makes it very difficult to study and to design a standard test, particularly for materials that will be used in an environment with as many intervening variables as the oral cavity. According to Leinfelder and Suzuki[6], the clinical tests are expensive and take a long time to conduct. The composites change rapidly and *in vivo* tests are unable to accompany this constant development, therefore *in vitro* tests are important. They affirmed that *in vitro* tests must be of the three-body type, since whatever happens in the oral cavity takes place through this mechanism. Moreover, these authors affirmed that the *in vitro* test they performed during 400.000 cycles with a load of 75 N, using an aqueous solution of PMMA pears, gave the same wear values as the in vivo test they conducted during three years.

CONCLUSIONS

The wear tests with different abrasive solutions give different wear rate values. The wear rate increased when the test was done with aluminum and diminished when it was done with diamond paste. Thus, it could be concluded that, the same material may respond in different ways according to the methodology employed. Further research is necessary to seek a test that reproduces the wear mechanism, so that these tests can be standardized and provide greater reliability in research.

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