Research Journal of Medical Sciences 1 (2): 147-151, 2007

Dental Materials Wear under Different PH

Smata Lakhdar and Bouzid Said
Laboratory of Physic and Mechanics of Materials,
Department of Fine Mechanics and Optics,
University of Setif, 19000, Algeria

Abstract: This study was evaluated the wear resistance of 2 dentals materials in different pH medium. Wear of on dental resin (Super Lux) and on dental resin composite (VHL Hybrid) was measured with time. Wear tests were conducted using a conventional tribotesters. The wear device works like the pin-on-disk where a human tooth slides on the dental material sample. Two wear modes were considered: Dry and lubricated sliding. For the last mode, water (pH7), base (pH14) and acid (pH1.5) were used as lubricant. Wear depth (height loss) was measured using micrometric dial comparator. In general, the results show that the wear curves tend to a linear function and have similar trend and the wear quantity increases with time. Put aside the acid, the 2 other lubricants (bases and water) were minimized wear compared to the dry mode. The last mode gave a wear weaker than that of the acid and it for the used materials. In the other hand, the resin composite had the lower material loss than the dental resin and it for modes of wear considered.

Key words: Dental resin, dental resin composite, wear, micrometric dial comparator

INTRODUCTION

Developments in resin chemistry and filler materials have led to the production of dental composites with improved physical and mechanical properties, which may be considered suitable for the restoration of teeth (Silvaa *et al*., 2006). Restorative dental materials are desired to have mechanical properties comparable to those of enamel and dentin. The goal of successful restorative treatment is the effective replacement of natural tooth structure. To effectively replace tooth structure, the restoration must be durable and functional (Bedran *et al*., 2004). The wear behaviour of dental materials is an important factor for understanding the degradation level under clinical conditions. In the oral cavity, the durability of a restoration is influenced by many factors which contribute to the wear of enamel, restorative materials and dentin. The nature of the occlusal contacts with antagonist teeth (attrition), chewing of food items, toothbrushing with toothpaste, inhalation of dust (abrasion) acidic attack due to the consumption of certain fruits and beverages, inhalation of industrial acids or vomiting and regurgitation of gastric juice as in the case of bulimia are fators who support the wear of dental materials (Heintze *et al*., 2006). These products present different pH and all of these variables participate in the wear process. It is know that wear is a loss of material that occurs through contact of two or more surfaces (Say *et al*., 2003). It is a phenomenon that occurs whenever a surface is exposed to another surface or to chemicaclly active substance (Heintze *et al*., 2005). Material loss occurs through microploughing, microcutting, microcracking and microfatigue (Heintze *et al*., 2005, 2006; Hu *et al*., 2004a).

In the dental literature many types of antagonists can be found: aluminum oxide (Kunzelmann *et al*., 2005), human enamel (Xu *et al*., 2004a, b) carbide steel To approach the reality of the oral medium, the use of a human tooth is recommended for this study.

In this sense, the aim of this study was to evaluate the wear resistance of 2 dental materials in different pH.

MATERIALS AND METHODS

Two dental materials were used in this study: one resin (Super Lux) and one composite (VHL Hybrid). Four cylindrical test specimens (8 mm in diameter ×5 mm in hight) of each material were made according to the manufacturers' instructions. The material was placed into a split-ring stainless-steel mould, covered with a glass plat and pressed by hand to extrude excess materials.

After the products were completely polymerised, the specimens were separated from the mold. The disks were first polished using silicon carbide papers with grits of

Corresponding Author: Smata Lakhdar, Laboratory of Physic and Mechanics of Materials,
Department of Fine Mechanics and Optics,University of Setif, 19000, Algeria

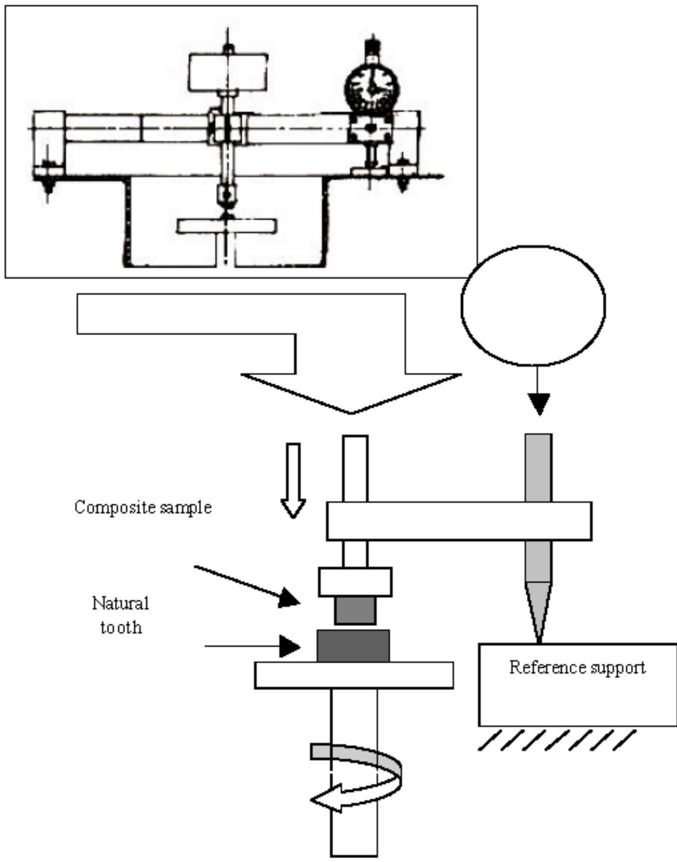

Fig. 1: Wear device

400, 800 and 1200. They were then finished using diamond polishing compounds to ensure smooth surfaces with reduced surface defects. All specimens were visually inspected for defects and those with visible flaws were discarded.

Wear tests were conducted using a conventional tribotesters. Figure 1 shows the schematic diagram of the wear apparatus. The wear device works like the pin-on-disk where a human tooth slides on the dental material sample with a known contact area. A human tooth is mounted on a rotating Table driven by a motor. The sample is fixed on a piston which can move vertically. The geometric contact is flat on flat. The sample and the antagonist (human tooth) are positioned accurately against each other before starting the experiment. The vertical distance between antagonist and sample can be adjusted. The vertical load is induced by a pin holder using different dead weights. The wear (height loss) can be determined by measuring the change in length of specimen during the course of the experiment.

The decrement of length (i.e., cumulative wear) during the test was continuously measured with a micrometric dial comparator with an accuracy of 0.001 mm and was recorded as a function of the time wear. The tests were carried out under applied load of 16 N and rotation speed of 119 rpm, at room temperature (20-25°C) in laboratory air. The test was run for 0 to 30 min depending on the time required to produce 0 to 35 µm decrement of specimen length. Wear height were conducted in dry and wet sliding. For the lubricated mode, wear is measured under three pH (water pH 7, base pH 14 and acid pH 1.5).

RESULTS AND DISCUSSION

The frictional apparatus illustrated schematically in Fig. 1 has been used to study the behavior to the wear of two dental materials under different pH. This device is based on different approaches for both wear simulation and wear analysis, including chewing simulators, rotating disk machines, pin on disk, etc. Most often, the approaches are related to wear mechanisms that occur in the mouth. Figure 2 indicates the influence of sliding speed on the wear variation of dental resin versus time wear for dry and wet sliding. In general, the wear curves

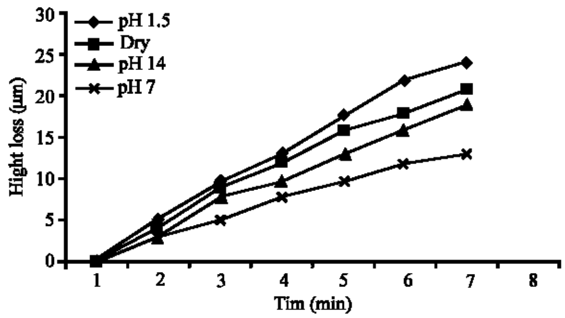

Fig. 2: Variation of height loss with time of dental resin in dry and three pH mediums

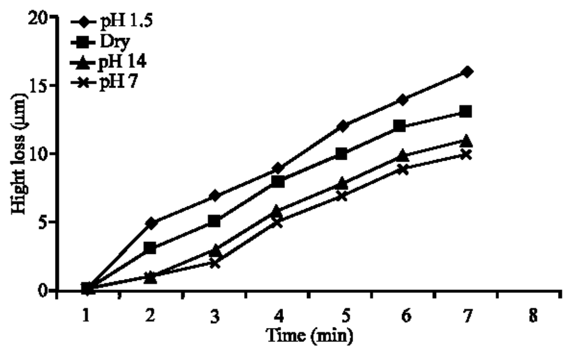

Fig. 3: Variation of hight loss with time of resin composite in dry and three pH mediums

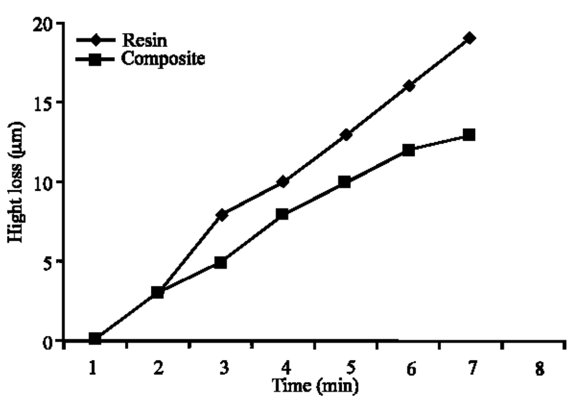

Fig. 4: Variation of hight loss with time of dental resin and resin composite in dry mode

(height loss) tend to a linear function and have similar trend. The wear quantity increases with time and becomes dependent on this parameter. It is noted that wear under the pH 1.5 is most important that the others. Wear under the dry mode (unlubricate sliding) comes in second position after that from the acid. Wear under the basic solution is less weak and for wear in water is weakest of the first three measurements.

For the same conditions, a resin composite was used in place of dental resin. This behavior appears on Fig. 3. The results presented in this figure show that the curves of accumulated wear have a linear form and increase with time similarly to preceding measurements following the different pH and the dry sliding. Figure 4 indicates the effect of dental materials on the wear versus time. This figure gave a wear of the resin more important than that of the composite.

Wear has been recognized as meaning the phenomenon of material removal from a surface due to interaction with a mating surface. Wear is the result of material removal by physical separation due to microfracture, by chemical dissolution, or by melting at the contact interface.The chemical dissolution was observed in the case of wear in the acidic medium (pH 1.5). This mode gave the most important wear in comparison with wear under the other pH. This is caused by the acidity of the medium which reacts with material used. In more of the mechanical action of the tribotesters (the normale load and the rotation speed), there is the action of the acid called chemical erosion (Witt *et al.*, 2003). Also, the acidic solution was used to etch dentin and enamel (Grayson *et al.*, 1997). Without the first test, the unlubricated condition provided the greatest wear. During this dry sliding, adhesive wear might have operated simultaneously with abrasive mechanisms. As the load and tangential force (sliding) were applied, adhesively-bonded contact junctions made between the two unlubricated surfaces might have been ruptured and detached, generating larger friction coefficient and material loss after many repeated passes of the load (Turssia *et al.*, 2006). If, in the first pass, the elastic limit is exceeded an element of plastic deformation will take place and thus when the load is removed some system of residual stresses will remain in the material. In the second pass of the load the material is subjected to the combined action of the applied contact stresses and the system of residual stress left behind from the first pass.

With regard to the pH 14, the reaction of the basic solution with dental materials is very weak that with the solution acid. It gave a less weak wear than wear under the dry mode. Contrarily to this, the reaction of materials with the basic solution is stronger than with water.

Chemically, the degradation event involves a chain scission process during which polymer chains of the specimens are cleaved to form oligomers and finally to form monomers (Carrilho *et al.*, 2004). This is the consequence of the absorption of water by polymer of the samples. As polymers contain hydrolyzable bonds, their most important degradation mechanism is chemical, via hydrolysis (Carrilho *et al.*, 2004). The water is acting as a carrier for staining agents in water sorption (Schulze *et al.*, 2003). Also, water sorption of the polymer matrix of the specimens results a plasticization of polymer matrix (Narva *et al.*, 2004). The combination of factors related to water sorption and hydrolysis can change the mechanical properties of glass ionomer over time (Attar *et al.*, 2003). The alteration of the mechanical properties of some resin composites has been attributed to the plasticizing effect of water (Carrilho *et al.*, 2004) where the reduction of flexural and compressive strenght, with time, was attributed to water sorption by resin which can act as a plasticizer (Bapna *et al.*, 2000). Water sorption causes a softening of the resin component by swelling the polymer network and reducing the frictional force polymer chains (Carriko *et al.*, 2004). The same phenomenon was mentionned where the water softens composites by penetrating the matrix and leaching unreacting monomer and unbound components (Tjandrawinana *et al.*, 2005). The plasticizers are responsible for maintaining material softness and a large quantity of plastizer in the polymer involves a softness of the resin (Pinto *et al.*, 2004). This has as a consequence the diminution of wear under the pH7 compared to the other liquids. (VHL Hybrid) is more resistant to wear.

This study showed that resin composite (VHL Hybrid) is more resistant to wear than dental resin (Super Lux). This is normal view the composition of the two materials. Dental materials are formuled with a variety of chemical and structural variations that may be related to their specific applications. Resin materials generally consist of powder and liquide components. The composition of resin composites is essentially comprised of a resin matrix (organic phase) filler matrix coupling agent (interface), filler particles (dispersed phase) and other minor additives including polymerization initiators, stabilizers and coloring pigments (Yap *et al.*, 2004). The loading force applied to a composite restoration is completely transferred from the matrix to the stronger, harder filler particles (Heintze *et al.*, 2006). It was suggested that wear resistance is improved by using smaller average filler particles size (Say *et al.*, 2003). By using smaller filler particles, the inter-particle spacing in the resin matrix was reduced and this improves the wear (Hu *et al.*, 2004b). The smaller filler particles become more closely packed and the resin between the fillers becomes protected from further abrasion from neighboring particles (Clelland *et al.*, 2005). The results of the current study suggest that during wear process, the large particles are easily detached than the fine particles. Associated with the shearing action (sliding speed and applied load), these particles cause the matrix abrasion. However, more the resin matrix is reinforced by the fine particles and more the material becomes wear resistant.

In general, the wear curves (height loss) tend to a linear function and have similar trend. The wear quantity increases with time and becomes dependent on this parameter. An increase in the wear height (height loss) as sliding time is increased was noticed. These results are in agreement with those reported by other investigators which found that the wear volume in a dental composite increased linearly with the number of cycles, which was proportional to the sliding distance or sliding time (Callaghan *et al.*, 2006).

CONCLUSION

This study was evaluated the wear resistance of two dentals materials in different pH medium. From the results obtained, we can say that:

- Wear increases proportionally with time for both media.
- Wear in the acidic medium gave the most important wear in comparison with wear under the other pH
- Wear under the basic mode is weakest that under the other solutions

REFERENCES

Attar, N., L.E. Tam and D.M. Comb, 2003. Mechanical and physical properties of contemporary luting agents. J. Prosthet. Dent., 89: 127-134.

Bapna, M.S., C.M. Gadia and J.L. Drummond, 2000. Effect of aging and cyclic loading on the mechanical properties of glass ionomer cements. Eur. J. Oral Sci., 110: 330-334.

Bedran-de-Castro, A.K.B., P.E.C Cardso, L.A.F. Ambrosano and L.A.F. Pimenta, 2004. Thermal and mechanical load cycling on mickroleakage and shear bond srength to dentin. Operative Dentistry, 29: 42-48.

Callaghan, D.J., A. Vaziri and H. Nayeb-Hashemi, 2006. Effect of fiber volume fraction and length on the wear characteristics of glass fiber-reinforced dental composites. Dent. Mater., 22: 84-93.

Carrilho, M.R.O., R.M. Carvalho, F.R. Tay and D.H. Pashley, 2004. Effect of storage media on mechanical properties of adhesive systems. Am. J. Dent., 17:104-108.

Clelland, N.L., M.P. Pagnotto, R.E. Kerby, R.R. Seghi, 2005. Relative wear of flowable and highly filled composite. J. Prothet. Dent., 93: 153-157.

De Witt, A.M.J.C., E.A.P. De Maeyer and R.M.H. Verbeeck, 2003. Surface roughening of glass ionomer cements by neutral NaF solutions. Biomaterials, 24: 1995.

Grayson, W.M.J., N. Inai, I.C.W. Magidi and M. Balooch, 1997. Dentin demineralization: Effects of dentin depth, pH and different acids. Dent. Mat., 13: 338-343.

Heintze, S.D., G . Zappini and V. Rousson, 2005. Wear of ten restorative materials in five wear simulators-esults of a round robin test. Dental Mat., 21: 304-317.

Heintze, S.D., G. Zellweger, A. Cavalleri and J. Ferracan, 2006. Influence of the antagonist material on the wear of different composites using two different wear simulation methods.Dent Mat., 22: 166-175.

Kunzelmann, K.H., B. Jelen, A. Mehl and R. Hickel, 2001. Wear evaluation of MZ100 compared to ceramic CAD/CAM materials. Int. J. Comp. Dent., 4: 171-184.

Pinto, J.R.R., M.F. Mesquita, M.A.A Nobilo and G.E.P. Henriques, 2004. Evaluation of varying amonts of thermal cycling on bond strength deformation of two resilient denturee liners. J. Prosthet Dent., 92: 288-293.

Say, E.C., A. Civelek, M. Ersoy and Guleryuz, 2003. Wear and microhardness of different resin composite materials. Operative Dentistry, 28: 628-634.

Schulze, K.A., S.J. Marshall, S.A. Gansky and G.W. Marshall, 2003. Color stability and hardness in dental composites after accelerated aging. Dent. Mat., 19: 612-619.

Silvaa, A.L.F., G.D.S. Pereirab, C.T.S. Diasc and L.A.M.S. Paulilloa, 2006. Effect of the composite photoactivation mode on microtensile bond strength and Knoop microhardness. Dent Mater., 22: 203-210.

Tjandrawinana, R., M. Irie and K. Suzuki, 2005. Flexural properties of eight flowable light-cured restorative materials, in immediate vs 24 h water storage. Operative Dentistry, 30: 239-249.

Turssia, C.P., J.J. Faraoni and M. Menezes, 2006. Analysis of potential lubricants for in vitro wear testing. Dent. Mat., 22: 77-83.

Xu, H.H.K., J.B. Quinn and Giuseppetti, 2004. Three-body wear of dental resin composites reinforced with silica-fused whiskers. Dent. Mat., 20: 220-227.

Xu, H.H.K., J.B. Quinn and Giuseppetti, 2004. Wear and mechanical properties of nano-fused whisker composites. J. Dent. Res., 83: 930-935.

Yap, A.U.J., C.H. Tan and S.M. Chung, 2004. Wear behavior of new composite restoratives. Operative Dentistry, 29: 269-274.

Zanter, K., A.M. Kielbassa, P. Martus and K.H. Kunzelmann, 2004. Wear of aluminum oxide antagonists by commercially avaible composites and compomers. Am. J. Dent., 17: 285-290.