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Research Paper

Wear resistance of a pressable low-fusing ceramic opposed by dental alloys

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ARTICLE INFO

Article history:
Received 20 September 2013
Received in revised form
10 December 2013
Accepted 17 December 2013
Available online 25 December 2013

Keywords:
Ceramics
Dental alloys
Dental restoration wear
Hardness tests

ABSTRACT

Dental alloys have increasingly replaced by dental ceramics in dentistry because of aesthetics. As both dental alloys and ceramics can be present in the oral cavity, the evaluation of the wear resistance of ceramics opposed by dental alloys is important. The aim of the present study was to evaluate wear resistance of a pressable low-fusing ceramic opposed by dental alloys as well as the microhardness of the alloys and the possible correlation of wear and antagonist microhardness. Fifteen stylus tips samples of pressable low-fusing ceramic were obtained, polished and glazed. Samples were divided into three groups according to the disk of alloy/metal to be used as antagonist: Nickel–Chromium (Ni–Cr), Cobalt–Chromium (Co–Cr) and commercially pure titanium (cp Ti). Vickers microhardness of antagonist disks was evaluated before wear tests. Then, antagonist disks were sandblasted until surface roughness was adjusted to 0.75 μm. Wear tests were performed at a speed of 60 cycles/min and distance of 10 mm, in a total of 300,000 cycles. Before and after wear tests, samples were weighted and had their profile designed in an optical comparator to evaluate weight and height loss, respectively. Ni–Cr and cp Ti caused greater wear than Co–Cr, presenting greater weight ($p = .009$) and height ($p = .002$) loss. Cp Ti microhardness was lower than Ni–Cr and Co–Cr ($p < .05$). There is a positive correlation between weight and height loss ($p < .05$), but weight ($p = .204$) and height ($p = .05$) loss are not correlated to microhardness. The results suggest that pressable low-fusing ceramic presents different wear according to the dental alloy used as antagonist and the wear is not affected by antagonist microhardness.

1. Introduction

Dental ceramics have increasingly used in dentistry as an alternative for dental alloys because of aesthetics. Extensive research has been conducted to improve physical and mechanical properties of dental ceramics and overcome their limitations (Oh et al., 2002). However, ceramic abrasiveness against natural dentition or other restorations remains as a limitation (Al-Hiyasat et al., 1999; Fisher et al., 1983; Hudson et al., 1995).

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http://dx.doi.org/10.1016/j.jmbbm.2013.12.018

Low-fusing ceramic materials have been developed in attempt to decrease the abrasiveness of dental ceramics because of its lower hardness, lower concentration of crystal phase and smaller crystal sizes (Oh et al., 2002). If some authors related that low-fusing feldspathic ceramics are less abrasive to enamel (Alarcon et al., 2009; Derand and Vereby, 1999; Hacker et al., 1996; Metzler et al., 1999), other argued that fusing temperature did not affect wear of opposing enamel (Clelland et al., 2001).

Although the use of dental alloys has decreased in dentistry, cobalt–chromium (Co–Cr) and nickel–chromium (Ni–Cr) alloys have been extensively used because of their high modulus of elasticity, corrosion resistance, hardness and low cost (Wataha, 2002). In the last decades, commercially pure titanium (cp Ti) has also been used because of its biocompatibility, physical and mechanical properties (Rodrigues et al., 2002). Thus, dental ceramic restorations will maybe oppose dental alloys.

It was previously assumed that hardness was related to the abrasiveness of the material, but recent studies have demonstrated that there are other factors related to the abrasiveness of a ceramic material, such as microstructure, porosities, crystal sizes, surface roughness and environment. The relation between hardness and wear is not valid for brittle materials because wear occurs by subsurface fractures and not by plastic deformation as in metals (Oh et al., 2002). Additionally, titanium and its alloys have shown their abrasiveness more related to their microstructures than to their hardness (Faria et al., 2011).

Because clinical methods for wear evaluation are complex and time consuming (Atai et al., 2007; Rosentritt et al., 2012) and some factors inherent of each patient (swallowing force and oral environment) cannot be controlled (Condon and Ferracane, 1997; Elmaria et al., 2006), in vitro studies are interesting by permitting to simplify the oral condition and compare different dental materials (Atai et al., 2007).

The aim of the present study was to evaluate wear resistance of a pressable low-fusing ceramic opposed by cp Ti, Ni–Cr and Co–Cr alloys. The null hypothesis is that wear resistance of a pressable low-fusing ceramic is affected by hardness of different antagonists.

2. Materials and methods

A pressable low-fusing ceramic (Luminesse Low-Fusing & Pressable Porcelain, Talladium Inc., Valencia, CA, USA) was tested against three different dental alloys: commercially pure titanium (cp Ti, Tritan, Dentaurum, Germany), nickel–chromium alloy (Ni–Cr, Vera Bond II, Aalba, USA) and cobalt–chromium alloy (Co–Cr, ModellguB, Degudent, Brazil).

Two types of specimens were prepared for wear tests: fifteen stylus tips specimens of pressable low-fusing ceramic and five disks (13 mm diameter and 2 mm thickness) of each antagonist material (cp Ti, Ni–Cr and Co–Cr alloys).

Wax patterns of stylus tips specimens were invested with Galaxy Universal Investment (Talladium Inc., Valencia, CA, USA). After 45 min, investment blocks were inserted into the oven and submitted to the heating cycle recommended by the manufacturer to eliminate the wax. When 800 °C was reached, the investment block, ceramic ingots and piston were inserted into the press furnace (Alumini Sinter Press, EDG Equipments and Controls, São Carlos, SP, Brazil) and ceramic pressing was started, following the manufacture recommended cycle. From the initial temperature of 750 °C under vacuum, it was increased at 60 °C/min until reaching 940 °C, when was maintained for 25 min; then pressing was performed with 60 psi pressure. After pressing and cooling at room temperature, specimens were divested with airborne-particle abrasion using 100 μm glass beads (30 psi = 2.12 kgf/cm^2) (Renfert, Hilzingen, Germany).

For disks, wax patterns were invested in Rematitan Plus (Dentaurm, Pforzhein, Germany) for cp Ti castings, and Rema Exakt (Dentaurum, Pforzheim, Germany) for Ni–Cr and Co–Cr alloy castings. Cp Ti was cast by plasma, in the machine (EDG Equipments e Controls Ltd., São Carlos, SP, Brazil) where the melting was made by arc melting in a vacuum and argon inert atmosphere, with injection of the alloy into the mold by vacuum–pressure. Ni–Cr and Co–Cr alloys were cast by oxygen-gas flame, with injection into the mold by centrifugation. After casting, disks were divested and airborne-particle abraded with 100 μm aluminum oxide particles (80 psi = 5.62 kgf/cm^2).

Disks were embedded in PVC rings using autopolymerizing acrylic resin in order to be mounted on the wear testing apparatus. After polishing with silicon carbide papers in the sequence 180, 320, 400 and 600, disks were blasted with 100 μm aluminum oxide particles (80 psi = 5.62 kgf/cm^2) until surface roughness of 0.75 μm was reached (ISO/TS 14569-2 2001).

Stylus tips specimens were polished using specific kit for ceramic polishing (EVE Ernst Vetter GmbH, Pforzheim, Germany), and two layers of glaze (Luminesse Super Glaze Paste, Talladium Inc., Valencia, CA, USA) were applied. Specimens were then putted at specific matrixes for positioning in the wear testing apparatus.

Disks and stylus tips specimens were subjected to two-body wear tests (Fig. 1) using a wear testing apparatus developed in Department of Dental Materials and Prosthodontics of Dental School of Ribeirão Preto, University of São Paulo. In this machine, a motor moved a lever arm with a 60 cycles/min speed (1 Hz), which was similar to the average human masticatory frequency (Kim et al., 2009). The recipient with five stylus tips specimens was connected to the lever arm, performing a 10 mm linear course, which resulted in a linear speed of 20 mm/s. The antagonistic disks were fixed in adjustable vertical loading poles. When the poles were released, their total weight (20 N) was transferred to the stylus tips specimens. Each simulated chewing cycle included 3 types of movement: a downward vertical movement (occlusion), a 10 mm lateral movement (eccentric loading), and an upward vertical movement (disocclusion). During occlusion and lateral movements, the total 20 N load was applied over the stylus tips specimens, and during the disocclusion movement, specimens were completely unloaded. Five stylus tips/disks assemblies were tested simultaneously. During the tests, the specimens were completely immersed in deionized water, and 300,000 cycles were performed, representing one year of masticatory function (Quek et al., 2006).

At the beginning and at the end of the wear tests, specimens' profiles were traced using an optical comparator