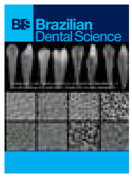
Brazilian Dental Science
Ciência Odontológica Brasileira

unesp
UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"
Instituto de Ciência e Tecnologia
Campus de São José dos Campos



ORIGINAL ARTICLE

doi: 10.14295/bds.2017.v20i1.1329

The dental alloys determine the choice of composite resins to be used. Wear of dental alloys against composite resins

As ligas odontológicas determinam a escolha das resinas compostas a serem utilizadas. Desgaste de ligas odontológicas contra resinas compostas

Izabela Cristina Maurício MORIS[1], Matheus SAKUMA[1], Adriana Cláudia Lapria FARIA[1], Ana Paula MACEDO[1], Ricardo Faria RIBEIRO[1], Renata Cristina Silveira RODRIGUES[1]

1 – Department of Dental Materials and Prosthodontics – Dental School of Ribeirão Preto – University of São Paulo – Ribeirão Preto – SP – Brazil.

ABSTRACT

Objective: The aim of the present study was to evaluate wear resistance of two composites resins against alternative alloys. **Material and Methods:** Fifteen stylus tips samples of composite resin were obtained for each resin Z250 and charisma (CHA). Samples were divided into three groups according to the disk of alloy to be used as antagonist: Nickel-Chromium (Ni-Cr), Cobalt- Chromium (Co-Cr) and commercially pure titanium (cp Ti). Wear tests were performed at a speed of 265 cycles/min and distance of 10mm, in a total of 40,000 cycles. Before and after wear tests, samples were weighed and had their profile designed in an optical comparator to evaluate weight and height loss, respectively. **Results:** For weight and height loss, wear of Z250 was lower than CHA for Co-Cr antagonist, but greater for cp Ti. CHA presents a more regular surface without cracks and similar aspect for all antagonists. Z250 showed some cracks, mainly against cp Ti and Ni-Cr. **Conclusion:** Within the results of the present study, it was concluded that CHA is suitable against cp Ti, and Z250 for association with Co-Cr alloy while any composite resin can be used against Ni-Cr.

KEYWORDS

Composite resins; Dental alloys; Dental restoration wear.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar a resistência ao desgaste de duas resinas compostas contra ligas alternativas. **Materiais e Métodos:** Quinze amostras de corpo cônico foram obtidas das resinas Z250 e charisma (CHA). As amostras foram divididas em três grupos de acordo com o disco da liga a ser utilizada como antagonista: Níquel-Cromo (Ni-Cr), Cobalto-Cromo (Co-Cr) e titânio comercialmente puro (Ti cp). Os testes de desgaste foram realizados na velocidade de 265 ciclos/minuto e distância de 10mm, totalizando 40.000 ciclos. Antes e após os testes de desgaste, as amostras foram pesadas e tiveram seu perfil desenhado em projetor de perfil para avaliar a perda de peso e de altura, respectivamente. **Resultados:** Para a perda de peso e de altura, o desgaste de Z250 foi menor do que CHA para o antagonista de Co-Cr, mas maior para o Ti cp. CHA apresenta superfície mais regular, sem fendas, e aspecto semelhante para todos os antagonistas. Z250 apresentou algumas fendas, principalmente contra Ti cp e Ni-Cr. **Conclusão:** Baseado nos resultados deste estudo, concluiu-se que CHA é mais apropriada contra Ti cp, e Z250 para associação com liga de Co-Cr enquanto qualquer resina composta pode ser utilizada contra Ni-Cr.

PALAVRAS-CHAVE

Resinas compostas; Ligas dentárias; Desgaste de restauração dentária.

INTRODUCTION

In the last decade, composition of composite resins has changed to improve clinical appearance (aesthetic), physical and mechanical properties. Then, all cavity classes can be restored with composites resins. However, its low clinical wear resistance still contributes to material failures [1-3].

Wear happens because movement of contacting surfaces, during occlusion, chewing, brushing or parafunctions, leads to gradual removal of material, and possibly functional and aesthetic problems to patient [4].

Wear of composite resins depends on their filler particles, specially size, shape and type of filler components, resin matrix formulation and degree of polymerization [5-8]. Some studies [9,10] showed that higher filler content (particles) results in greater wear resistance while higher viscosity generally results in lower wear resistance [11]. A study that evaluated wear of different composite resins argued that filler should be a softer glass to reduce abrasion, and if harder filler were used, the filler should be nano-sized [12].

Composite resins should resist wearing similarly to tooth, ensuring clinical longevity when material is used against healthy teeth. However, other materials, such as ceramic, resin and metallic alloys, may also be antagonists.

Nowadays dental alloys, such as nickel-chromium (Ni-Cr) and cobalt-chromium (Co-Cr), has often been used for oral rehabilitation as an alternative to noble alloys, playing an important role due to high elastic modulus, corrosion resistance, surface hardness, low cost [13], and possibility of association with resin or ceramic. Similarly, commercially pure titanium (cp Ti) has also been widely used because of biocompatibility, physical and mechanical properties [14].

The contact between resin restorations and metallic alloys can occur in the presence of metallic onlays/inlays or fixed prostheses against resin restorations; or retaining clasps of removable partial denture frameworks with class V restoration and contour correction to prepare support teeth. Nevertheless, wear of composite resin contacting metallic alloys is still discussed and poorly understood. Then, this study aimed to evaluate wear resistance of two composites resins against alternative alloys (Ni-Cr, Co-Cr and cp Ti). The null hypothesis is that both composite resins resist to wear similarly.

MATERIAL AND METHODS

Two composite resins, presented in Table I, were tested against three different dental alloys: Ni-Cr (Vera Bond II, Aalba Dent. Inc., USA), Co-Cr (Vera PDI, Aalba Dent. Inc., USA), and cp Ti (Tritan, Dentaurum, Germany).

Two types of specimens were prepared for wear tests (Figure 1): fifteen stylus tip (r = 1.0mm) specimens of composite resin, and five disks (20mm diameter and 3mm thickness) of each antagonistic material (Ni-Cr, Co-Cr and cp Ti).

Stylus tips specimens were obtained inserting composite resins by incremental technique in a matrix (Figure 2) and

Table I - Restorative materials tested

Composite resin	Classification	Organic matrix	Inorganic content	Manufacturer
Filtek Z250 (Z250)	Microhybrid	Bis-GMA, UDMA, Bis-EMA	Zirconium/Silica (0.01 a 3.5 µm). 60%volume	3M ESPE, St Paul, MN, USA
Charisma (CHA)	Microhybrid	Bis-GMA, TEGDMA	Barium glass, aluminum fluoride (0.02-2 µm). Silicium dioxide (0.02-0.07 µm) 64% volume	Heraeus Kulzer GmbH, Hanau, Germany

polymerizing for 20 seconds (Ultralux, Dabi Atlante, Ribeirao Preto, Brazil) according to manufacturer recommendations. After removal from matrix, specimens were immersed in distillated water at 37°C for seven days [6].

Wax patterns of antagonistic disks were invested in Rematitan Plus (Dentaurm, Pforzhein, Germany) for cp Ti castings, and Crom-O-Cast (Polidental Ind. E Com. Ltda., Cotia, SP, Brazil) for Ni-Cr and Co-Cr alloy castings. After wax elimination and thermal expansion of the investment, disks were cast by plasma, in the machine (EDG Equipamentos e Controles Ltda., Sao 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. After casting, disks were divested, polished with silicon carbide papers in the sequence 180, 320, 400 and 600, and blasted with 100μm aluminum oxide particles (80 psi = 5.62kgf/cm^2) (Asfer, Sao Caetano do Sul, Sao Paulo, Brazil) until a surface roughness of 0.75μm was

Figure 1 - Stylus tip sample and antagonistic disk.

reached (ISO/TS 2001). Disks were embedded in PVC rings using autopolymerizing acrylic resin (Jet, Artigos Odontológicos Clássico, Sao Paulo, Brazil) in order to be mounted on the wear testing apparatus.

After seven days of immersion in water, composite resin specimens were weighed using a 0.0001g precision balance (Bel Engineering, Monza, Italy) and had their profiles traced using an optical comparator (Nikon Profile Projector, 6C, Nikon, Tokyo, Japan) at 20X magnification on a transparent sheet. A device was used to standardize the position of the samples before and after the test.

Disks and stylus tips specimens were subjected to two-body wear tests using a wear testing apparatus (Figure 3) developed in Department of Dental Materials and Prosthodontics of Dental School of Ribeirao Preto, University of Sao Paulo, described in previous studies [15,16]. The stylus tips specimens were mounted on the vertical arm of the wear testing apparatus under a load of approximately 5N while the disks were mounted on an orifice present in a box which moved horizontally causing a sliding motion. The grinding distance was 10mm and each entire sequence of motion constitutes one cycle. A total of 40,000 cycles were carried at 4.4 Hz (265 cycles/minute) for each set of samples [15,16]. For two-body wear test, the samples contacted each other directly, immersed in tap deionized water.

After wear tests, specimens were weighed again and the weight loss was evaluated.

Figure 2 - Obtaining stylus tip sample of composite resin. A) Inserting composite resins by incremental technique in a matrix; B) Polymerization of the composite resin; C) Stylus tip sample of composite resin.

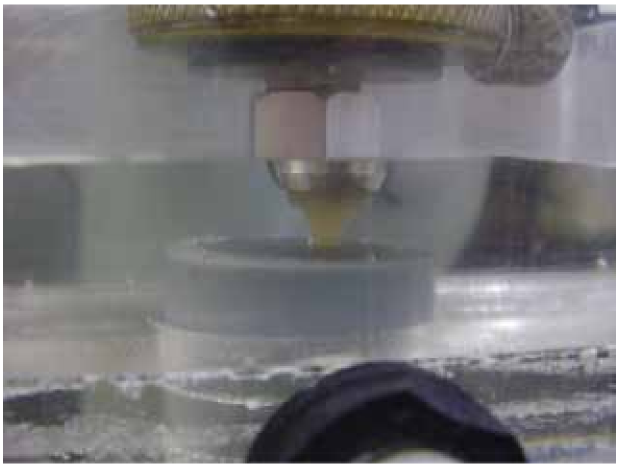


Figure 3 - Wear testing apparatus.

Additionally, specimens had their profiles traced on a transparent sheet. The height loss was measured using 0.01mm precision pachymeter (Mitutoyo Sul Americana Ltda., Suzano, Brazil) and the wear resistance was measured as weight and height loss [16].

To evaluate the surface of the specimens submitted to wear tests, one stylus tip and one disk of each experimental group were examined using scanning electron microscope (SEM, EVO 50H Electron Microscope, Zeiss, Oberkochen, Germany).

The effect of the antagonistic material on wear of composite resins was evaluated using two-way analysis of variance (ANOVA) and post-hoc Bonferroni´s test (α=0.05) using the software SPSS for Windows (IBM SPSS software, IBM Corporation, NY, USA). Height loss and weight loss were submitted to Pearson´s correlation tes t (α=0.05).

RESULTS

Wear results, measured as weight and height loss, are presented in Figures 4 and 5, respectively.

Significant difference at the interaction resin*antagonist for weight (p=.014) and height loss (p<.05) showed that Z250 and CHA worn differently depending on the antagonist used.

Comparison of resin weight loss is presented at Table II. Wear of Z250 was lower than CHA for Co-Cr antagonist, but greater for cp Ti. Similar to weight loss, height loss comparison (Table III) showed that Co-Cr worn more CHA than Z250 and cp Ti, inversely, worn more Z250 than CHA. There is positive correlation between height and weight loss (p<.05).

The worn surface of CHA and Z250 against different antagonists is shown in Figure 6. CHA presents a more regular surface without cracks and similar aspect for all antagonists. Z250 showed some cracks, mainly against cp Ti and Ni-Cr, suggesting delamination of particles from matrix. Antagonists interfered with crack frequencies, which were more common at cp Ti, followed by Ni-Cr while cracks were not so evident at worn surface tested against Co-Cr.

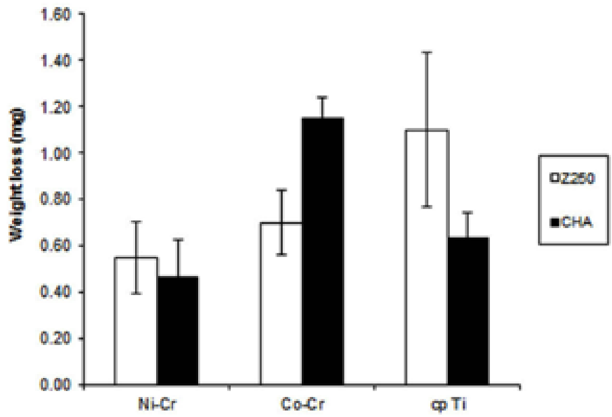


Figure 4 - Weight loss results.

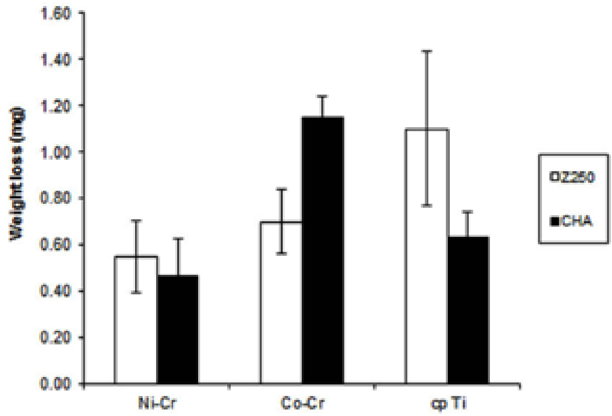


Figure 5 - Height loss results.

Table II - Statistical comparison of weight loss

Antagonist	Comparison	Mean difference	p value	Confidence interval	
				Lower limit	Upper limit
Ni-Cr	Z250 x CHA	.083	.682	-.329	.496
Co-Cr	Z250 x CHA	-.450	.034	-.862	-.038
cp Ti	Z250 x CHA	.467	.035	.034	.899

Table III - Statistical comparison of height loss

Antagonist	Comparison	Mean difference	p value	Confidence interval	
				Lower limit	Upper limit
Ni-Cr	Z250 x CHA	39.250	.110	-9.397	87.897
Co-Cr	Z250 x CHA	-77.417	.003	-126.064	-28.769
cp Ti	Z250 x CHA	23.820	«.05	53.186	150.481

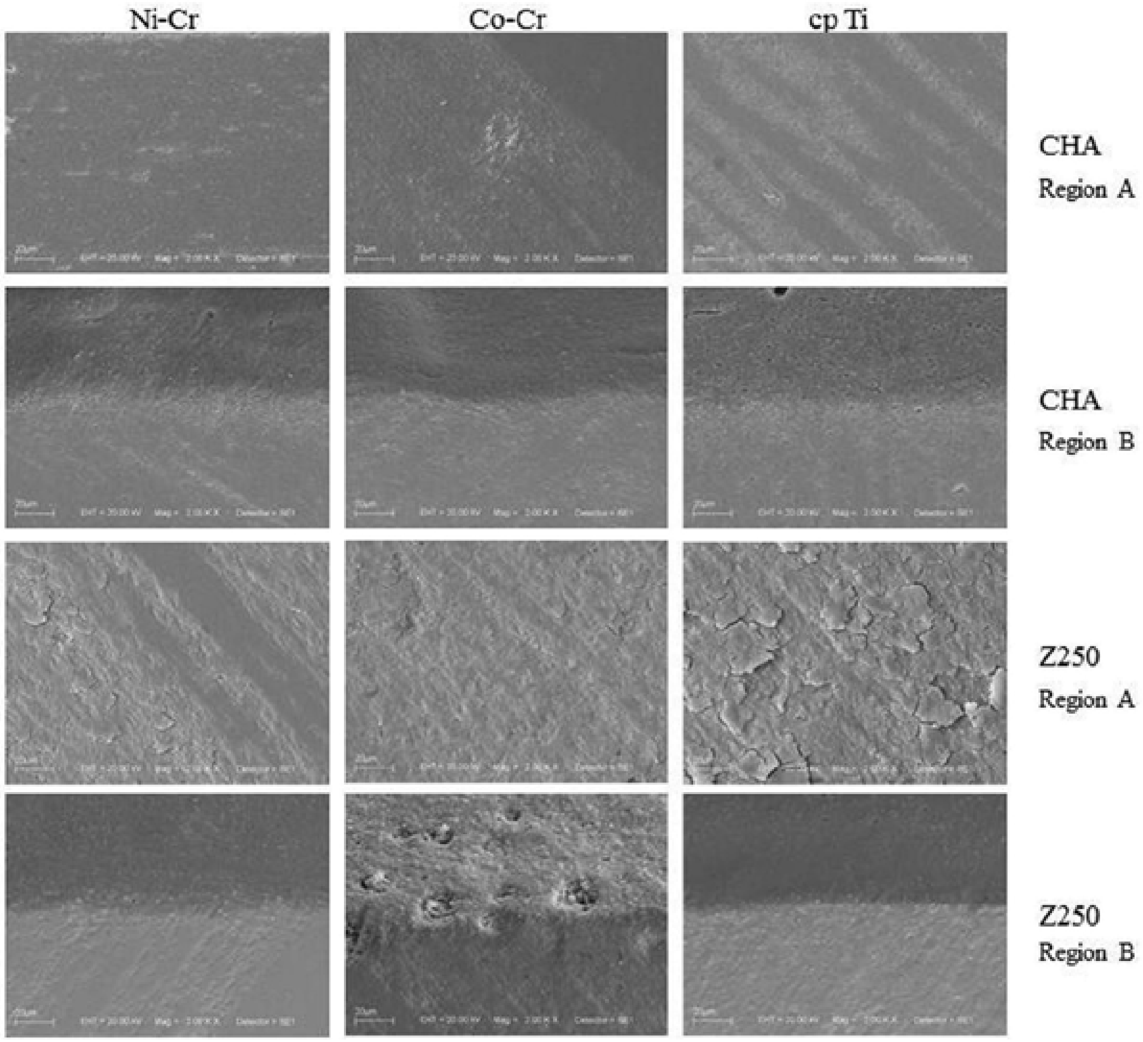


Figure 6 - SEM images. Region A) Central region of worn surface at composite resin sample; Region B) Peripheral region of worn surface at composite resin sample.

DISCUSSION

The clinical significance of wear of composite resins is mainly attributed to functional restrictions and aesthetic compromise. Wear in the oral cavity is complex because involves several factors such as pH and saliva, temperature, sex, age, ethnicity, nutritional and parafunctional habits, type of occlusion, neuromuscular pattern, thickness and hardness of the enamel, material and shape of the antagonists and the location of the restoration [17-19]. Although in vitro studies are limited to predict clinical behavior of materials, they are useful to predict material comparison before clinical use [8,20].

The null hypothesis of this study was partially rejected because resins worn differently against Co-Cr and cp Ti alloy, but no difference were noted between them against Ni-Cr alloy.

Inorganic filler content and its interaction with organic matrix can affect wear resistance of composite resin. High inorganic filler content and its strong adhesion to organic matrix improve load transfer and increase wear resistance [3,21,22]. In the present study, CHA, whose filler content is 64%, worn less than Z250, whose filler content is 60%, against cp Ti.

Thus, considering filler content, Z250 should present lower wear resistance than CHA against any antagonist of the present study. However, Co-Cr alloy inverted result and Z250, whose filler content is lower and hardness is higher, worn less than CHA. Particles composition possibly leads to greater wear rates of CHA against Co-Cr, once CHA is composed by barium glass particles slightly smaller than harder zirconia particles of Z250.

Hard particles accelerate abrasion because forces generated at particle surface are readily transmitted to the lower layer resulting in high stress concentration that raises small fractures. These fractures propagate until the surface and break matrix, exposing particles and favoring their displacement [23]. Therefore, high hardness of zirconia particles on Z250 resin is probably responsible for wear feature as show at Figure 6.

Cracks were almost absent at worn surface of Z250 against Co-Cr while cp Ti leads to many cracks. Alloy microstructure and hardness probably interfered with this behavior because Co-Cr presents greater hardness and grains than cp Ti and Ni-Cr [24].

Wear results from abrasion, corrosion and fatigue that act simultaneously on dental restorations [4]. Abrasion and corrosion dominate contact free areas while fatigue, occlusal contact ones [25]. Considering that samples are subject to fatigue at wear tests, and wear is favored by particles delamination raised from cracks, the absence of cracks at Z250 tested against Co-Cr justifies its greater wear resistance.

Then, the presence of previous prostheses will determine the choice of restorative material that will occlude against it. Based on this study, CHA should be chosen when cp Ti is present in the antagonistic arch while Z250 should be chosen for Class V restorations in contact with Co-Cr frameworks of removable partial denture.

CONCLUSION

Within the limitations of the present study, it was concluded that CHA is suitable against cp Ti, and Z250 for association with Co-Cr alloy while any composite resin can be used against Ni-Cr.

REFERENCES

1. van Dijken JW. Direct resin composite inlays/onlays: an 11 year follow-up. J Dent. 2000 Jul;28(5):299-306.
2. Hickel R, Manhart J. Longevity of restorations in posterior teeth and reasons for failure. J Adhes Dent. 2001 Spring;3(1):45-64.
3. Lazaridou D, Belli R, Petschelt A, Lohbauer U. Are resin composites suitable replacements for amalgam? A study of two-body wear. Clin Oral Investig. 2015 Jul;19(6):1485-92.
4. Mair LH, Stolarski TA, Vowles RW, Lloyd CH. Wear: mechanisms, manifestations and measurement. Report of a workshop. J Dent. 1996 Jan-Mar;24(1-2):141-8.

5. Turssi CP, Purquerio BM, Serra MC. Wear of dental resin composites: insights into underlying processes and assessment methods--a review. J Biomed Mater Res B Appl Biomater. 2003 May;65(2):280-5.

6. Al Khuraif, AA. An in vitro evaluation of wear and surface roughness of particulate filler composite resin after tooth brushing. Acta Odontol Scand. 2014 Nov;72(8):977-83.

7. Lambrechts P, Braem M, Vuylsteke-Wauters M, Vanherle G. Quantitative in vivo wear of human enamel. J Dent Res. 1989 Dec;68(12):1752-4.

8. Barkmeier WW, Takamizawa T, Erickson RL, Tsujimoto A, Latta M, Miyazaki M. Localized and generalized simulated wear of resin composites. Oper Dent. 2015 May-Jun; 40(3):322-35.

9. Condon JR, Ferracane J L. In vitro wear of composite with varied cure, filler level, and filler treatment. J Dent Res. 1997 Jul;76(7):1405-11.

10. Torii Y, Itou K, Itota T, Hama K, Konishi N, Nagamine M, et al. Influence of filler content and gap dimension on wear resistance of resin composite luting cements around a CAD/CAM ceramic inlay restoration. Dent Mater. 1999 Dec;18(4):453-61.

11. Musanje L, Ferracane JL, Ferracane LL. Effects of resin formulation and nanofiller surface treatment on in vitro wear of experimental hybrid resin composite. J Biomed Mater Res B Appl Biomater. 2006 Apr;77(1):120-5.

12. Osiewicz MA, Werner A, Pytko-Polonczyk J, Roeters FJM, Kleverlaan CJ. Contact- and contact-free wear between various resin composites. Dent Mater. 2015 Feb;31(2):134-40.

13. Wataha JC. Alloys for prosthodontic restorations. J Prosthet Dent. 2002 Apr;87(4):351-63.

14. Rodrigues RC, Ribeiro RF, de Mattos Mda G, Bezzon OL. Comparative study of circumferential clasp retention force for titanium and cobalt-chromium removable partial dentures. J Prosthet Dent. 2002 Sep;88(3):290-6.

15. Mello PC, Coppedê AR, Macedo AP, Mattos MGC, Rodrigues RCS, Ribeiro RF. Abrasion wear resistance of different artificial teeth opposed to metal and composite antagonists. J Appl Oral Sci. 2009 Sep-Oct;17(5):451-6.

16. Faria AC, Rodrigues RC, Claro AP, de Mattos Mda G, Ribeiro RF. Wear resistance of experimental titanium alloys for dental applications. J Mech Behav Biomed Mater. 2011Nov;4(8):1873-9.

17. Suzuki S, Nagai E, Taira Y, Minesaki Y. In vitro wear of indirect compiste restoratives. J Prosthet Dent. 2002 Oct;88(4):431-6.

18. Wataha JC, Messer RL. Casting alloys. Dent Clin N Am. 2004 Apr; 48(2):499-512.

19. Elmaria A, Goldstein G, Vijayaraghavan T, Legeros RZ, Hittelman EL. An evaluation of wear when enamel is opposed by various ceramic materials and gold. J Prosthet Dent. 2006 Nov;96(5):345-53.

20. Theodoro GT, Fiorin L, Moris ICM, Rodrigues RCS, Ribeiro RF, Faria ACL. Wear resistance and compression strength of ceramics tested in fluoride environments. J Mech Behav Biomed Mater. 2017 Jan;65:609-15.

21. Manhart J, Kunzelmann KH, Chen HY, Hickel R. Mechanical properties and wear behavior of light-cured packable composite resins. Dent Mater. 2000 Jan;16(1):33-40.

22. Lim BS, Ferracane JL, Condon JR, Adey JD. Effect of filler fraction and filler surface treatment on wear of microfilled composites. Dent Mater. 2002 Jan;18(1):1-11.

23. Leinfelder KF, Lemons JE. Clínica restauradora: materiais e técnicas. 1st ed: Santos, 1989.

24. Vallittu PK, Miettinen T. Duration of induction melting of cobalt-chromium alloy and its effect on resistance to deflection fatigue of cast denture clasps. J Prosthet Dent. 1996 Mar;75(3):332-6.

25. Heintze SD, Zimmerli B. Relevance of in-vitro tests of adhesive and composite dental materials. A review in 3 parts. Part 2: non-standardized tests of composite materials. Schweiz Monatsschr Zahnmed. 2011;121(10):916-30.

Prof[a]. Dra. Renata Cristina Silveira Rodrigues (Corresponding address)
Department of Dental Materials and Prosthodontics, Dental School of Ribeirão Preto, University of São Paulo, Avenida do Café, s/n, Monte Alegre, Ribeirão Preto – SP, Brazil.
CEP 14040-904
Phone Number: +55 (16) 3315-4005;
Fax: +55 (16) 3633-0999
e-mail: renata@forp.usp.br

Date submitted: 2016 Oct 26

Accept submission: 2017 Mar 17