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Effects of different polishing systems on the surface roughness of two ceromers

Efeito de diferentes sistemas de polimento na rugosidade superficial de dois cerômeros

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ABSTRACT

Objective: This in vitro study evaluated the effects of three polishing systems on the surface roughness of two ceromers. **Material and Methods:** 96 specimens (8 mm in diameter and 2 mm thick) were prepared in a metal mold using two restorative materials: CERAMAGE (Shofu, Japan) and VMLC VITA (VITA Zahnfabrik, Germany). The specimens were divided into 4 groups (n=12): G1: positive control, Mylar strip; G2: abrasive tips, Edenta system; G3: silicon tips, Enhance system; and G4: abrasive tips, Shofu system. The parameter evaluated was the average surface roughness (Ra) determined by using a profilometer SJ 301 (Mitutoyo, Japan), followed by photographic evaluation images through Scanning Electron Microscopy (SEM), with a 1000x magnification range. The data was subjected to statistical analysis for comparison between the groups (ANOVA, Tukey and Student T-tests), with a significance level of 5%. **Results:** there was a statistically significant difference between the silicone tip Enhance and the other groups for both ceromers with higher values of surface roughness. There was no statistically significant difference between the ceromers, except for the Shofu system, which showed lower values of surface roughness for Vita VMLC. **Conclusion:** Within the limitations of this study, it was concluded that the Edenta and Shofu abrasive tips are more effective in reducing the surface roughness of ceromers compared with the Enhance silicone tip.

KEYWORDS

Resins; Dental polishing.

RESUMO

Objetivo: Avaliar o efeito de três sistemas de polimento na rugosidade superficial de 2 cerômeros. **Material e Métodos:** Foram confeccionados 96 corpos de prova divididos em 8 grupos: G1 e G5, controle positivo (matriz de poliéster), G2 e G6 (pontas abrasivas Edenta); G3 e G7 (pontas siliconadas Enhance); G4 e G8 (sistema Shofu). O parâmetro avaliado foi a média aritmética da rugosidade superficial (Ra) determinada em rugosimetro SJ 301 (Mitutoyo, Japão), seguida de avaliação fotográfica através da microscopia eletrônica de varredura (MEV), com o aumento de 1000 vezes. Os dados obtidos foram submetidos à análise estatística para comparação entre os grupos (ANOVA, Tukey e t-student pareado), nível de significância de 5%. **Resultados:** Houve diferença estatística significativa entre a ponta siliconada Enhance e os demais grupos, em ambos cerômeros, apresentando maiores valores de rugosidade superficial. Entre os polimentos avaliados, o único que diferiu entre os cerômeros foi o sistema Shofu que apresentou menores valores de rugosidade superficial para a Vita VMLC. **Conclusão:** Dentro das limitações do presente estudo, concluiu-se que as pontas abrasivas EDENTA e Shofu são mais eficazes na redução da rugosidade da superficial de cerômeros comparação com a ponta de silicone Enhance.

PALAVRAS-CHAVE

Resinas; Polimento Dental.

INTRODUCTION

An important current requirement in dentistry is to provide aesthetics through metal-free restorations that restore the teeth's natural appearance. The aesthetic requirement and the worry with appearance are imperative factors for a better social life. Moreover, these aesthetics significantly improve self-esteem, thus explaining the reason for the increase on the demand for restorations that provide a natural appearance, biocompatibility, durability, and affordability[1].

Research studies have been conducted in an attempt to combine all these positive characteristics. This may attract more elaborate scientific attention to certain materials. Among these materials are indirect resins or laboratory-made compound resins[2]. These resins emerged on the second half of the 1990s as a second-generation of laboratory-made compound resin systems, or microhybrids, with the inclusion of ceramic particles, as described by Touati[3].

These compounds, also known as ceromers, are classified as a new generation of easily made materials for indirect restorations, with a better durability against attrition, as well as excellence in superficial quality[4].

In addition, most ceromers use a post-polymerization system, resulting in a higher flexural strength, minimal polymerization contraction, attrition proportion similar to tooth enamel [5,6] and color stability [7,8].

After cementation an indirect restoration into the mouth, adjustments with diamond tips are unavoidable. Such wear are made to remove eventual premature contacts[9] finish the cemented restoration margins; improve the aesthetic appearance; or correct the shape, texture, or contour imperfections [10-12].

The occlusal adjustment of an indirect restoration is usually performed after cementation. The dentist needs to know the best way to make the restoration in order to avoid micropores or microfractures, which may lead to the failure of the restoration [9].

After performing these adjustments, additional polishing is required to restore the appearance and superficial flatness [13]. Therefore, the knowledge of finishing and polishing procedures becomes essential for the adequacy of the restored material and for the maintenance of its ideal characteristics in the oral environment.

The increase in the roughness of the restoring material, caused by the intra-oral adjustment, has a large impact on the initial adhesion and the retention of oral microorganisms. In other words, it accelerates the maturation of the biofilm and may result in secondary cavities, soreness of gingival tissue, and periodontal disease, thus causing a restoration failure [12-15]. In addition, a flat and well-polished surface provides better control over the restoration's texture, brightness, and aesthetic preservation through the maintenance of the color [16-17].

Several materials and techniques are available for the intra-oral finishing and polishing of ceromers, and their effectiveness in reducing superficial roughness is considered satisfactory by many authors [9,18-21]. However, the best method to obtain a perfectly flat and polished surface remains controversial.

The finishing may be accomplished with mounted stones, abrasive rubbers, or aluminum oxide discs, along with polishing with felt discs and siliconized rubber[4] using cobalt-chromium-based pastes, or commonly, diamond paste [11].

Regarding the effectiveness of these different polishing systems, the data in the literature is diverse, thus making new studies necessary that use qualitative and/or quantitative methods in order to promote a better analysis of the behavior of these materials.

The objective of this paper is to evaluate the effects of different polishing systems (abrasive rubbers, Edenta; silicon tips, Enhance; and abrasive rubbers, Shofu) on the surface roughness of two ceromers: Ceramage (Shofu Inc., Japan) and Vita VMLC (Vita Zahnfabrik, Germany).

MATERIAL AND METHODS

The finishing and polishing systems evaluated were abrasive tips (Edenta system), silicon tips (Enhance), and abrasive tips (Shofu system). Table 1 shows the compositions of the polishing systems tested and their manufacturers.

Table 1 - Characteristics of materials tested

Restorative Materials	Filler Volume (%)	Shade	Manufacturer
CERAMAGE	73	A3B	Shofu inc., Japan
Vita VMLC	45-48	3M2	Vita Zahnfabrik, Germany

A total of 96 specimens (48 of both restorative materials) were made using a metal mold (8.0 mm in diameter and 2.0 mm thick) covered by a Mylar strip (SS White Co., Philadelphia, PA, USA) and pressed flat with a microscopic glass slide using two different composite materials. All the restorative materials were cured according to the manufacturers' instructions with a specific apparatus (XenosGlows, Protécnica Equipment, Minas Gerais, Brazil). To reduce variability, the procedures for the preparation, finishing, and polishing of all specimens were performed by the same operator.

The specimens were examined for obvious voids and then labeled on the bottom and randomly separated in four treatment groups (n=12). The mylar strip groups were selected and the others were wet grounded with 240, 320, and 360 grit silicon on a politriz AROPOL AV (AROTEC, Cotia, Brazil), for 20 s to provide a baseline before using the polishing systems.

Posteriorly, wear were made using a diamond tip 2135F (KG Sorensen, Brazil) adapted for high-speed hand piece (Kavo do Brasil Ind. Com. LTDA, Brazil), with the objective of simulating the occlusal adjustment. This abrasion was made by the same operator, through soft movements, without taking the dental drill off the specimens' surface and using air/water refrigeration for 20 s.

Three polishing systems were used (Table 2) and the groups were divided as follows:

1. Group I (control): Mylar strip (no application).

2. Group II (Edenta abrasive points): Each specimen was polished with three differently granulated rubbers, starting with the more abrasive one, white-colored ExaCerapol, followed by a pink-colored ExaCerapol, and finally a less abrasive gray-colored CerapolSuper.

3. Group III (Enhance silicone points): Each specimen was polished with a tip.

4. Group IV (Shofu system): Both the Dura-Green stone and the CompoMaster Coarse (Shofu, Japan) were used.

All the tips were adapted to an LB-100 desk engine (Beltec Ind. e Com. de EquipamentosOdontológicos, Brazil), using a calibrated speed of 20,000 rpm.

Each rubber was used with soft and intermittent 30-second movements within the specimen's abrasive region. Then a cotton wheel (Bech, Germany) was used with diamond paste (KG Sorensen, Brail), with the same 20,000 rpm, low-rotation method (counter-angle) for 30 s.

Table 2 - The composition and manufacturer of the polishing systems investigated

Polishing Systems	Composition	Manufacturer
Exa Cerapol	Abrasive points – Silicon with aluminium oxide	Edenta, Switzerland
Enhance	Silicon points	Dentsply, USA
Dura Green / CompoMaster Coarse	Abrasive points – silicon carbides / Diamonds particles	Shofu inc., Japan

For the quantitative evaluation of the roughness, the digital profilometer (Mitutoyo SJ 301, Japan) was calibrated in accordance with its manufacturer's instructions. The equipment has a specific 0.5 mm radius diamond tip moving at a speed of 0.25 mm/s. Its point was programmed to travel 4 mm, with a wave length of 0.8 mm and with the average surface roughness adjustment measured in micrometers (μm). The considered value was the arithmetic average between the peaks and valleys travelled by the active point of the equipment. Three different readings were made in different places on each specimen.

For the qualitative evaluation, two specimens from each group were randomly selected and submitted to gold metallization. These specimens were fixed in stubs and subsequently analyzed at Oswaldo Cruz Foundation-FIOCRUZ (Salvador, Bahia, Brazil) through the Scanning Electron Microscopy (SEM, Jeol JSM 6390LV) photographic method performed by a single operator with a 1000x magnification range to identify their morphologic characteristics.

Statistical analysis

The results were analyzed using the one-way ANOVA test, with a significance level of 0.05 for the surface roughness tests. A multiple comparison was performed with the Tukey test and paired Student T-test.

RESULTS

In Table 3, it is possible to verify that, except for the Shofu system, which presented lower values of Ra on the VITA VMLC ceromer, there was no statistically significant difference between the ceromers. Evaluating the polishing systems used in this paper, we noticed a significant statistical difference between the Enhance system and other systems, as the Enhance system presented higher values of superficial roughness. There was no difference between the Edenta system and Shofu system for any of the evaluated ceromers.

A qualitative analysis was made using the SEM method with a magnification range of 1000x (Figure 1 and Figure 2). It is possible to notice the post-polishing surface quality in the control group materials (Mylar strip) and in the other groups.

All the surfaces have shown smoothness for all the composites and polishing techniques, except group III (Enhance silicon points), which presented visible voids. The magnified images reveal that groups I and IV presented the smoothest surfaces. Groups II and III show multiple filler dislodgements of the greatest sizes.

Table 3 - Composition of composite resins evaluated in the study

Variables	Ceramage		Vita VMLC		p-Valor
	Average	Standard Deviation	Average	Standard Deviation	
Mylar Strip	0.506^{aA}	0.183	0.522^{aA}	0.143	0.7819
Exa-Cerapol tips (Edenta)	0.690^{bA}	0.175	0.770^{bA}	0.201	0.0861
Silicon Tips (Enhance)	1.233^{cA}	0.169	1.247^{cA}	0.239	0.8946
Abrasive Tips (Shofu)	0.694^{bA}	0.112	0.563^{abB}	0.112	0.0171
p-Valor	<0.001		<0.001		

Distinguished capital letters were attributed when a statistically significant difference in the comparison of the ceromers was observed. Distinguished lowercases were attributed when a statistically significant difference in the comparison of each column, among the different polishing systems, was observed. (P<0.05, ANOVA, TukeyComparison Test, t-student test).

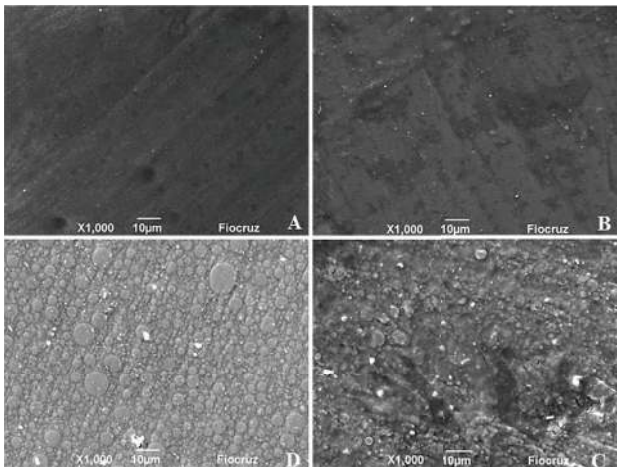

Figure 1 - CERAMAGE ceromer (A) control group, Mylar strip; (B) Edenta polishing system; (C) Enhance polishing system; and (D) Shofu polishing system.

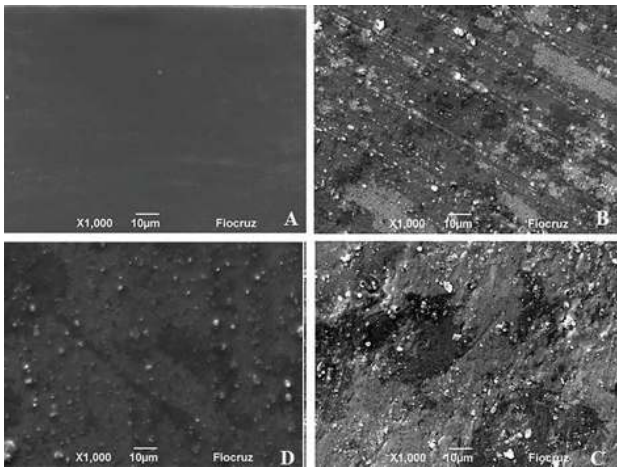

Figure 2 - VITA VMLC ceromer (A) control group, Mylar strip; (B) Edenta polishing system; (C) Enhance polishing system; and (D) Shofu polishing system.

DISCUSSION

The quality of the materials' surfaces affects the accumulation of biofilm and the physical properties of this restoration. It is associated with the patient's discomfort in terms of tactile perception, aesthetic appearance, and restorative materials' resistance to corrosion [27]. Hence, the importance of the evaluation of the superficial roughness of the restorative materials, as it may favor the formation of secondary cavities and periodontal disease through the accumulation of biofilm, which is the main reason for the restorations' substitution [12,14-17,22-25].

In this paper, after the attrition with a diamond tip 2135F (simulating occlusal adjustment in the mouth), 12 specimens were randomly selected, with the accompanying superficial roughness (Ra) mensuration. The obtained values varied from 2.11 to 3.12 μm, resulting in an average of 2.50 μm. Therefore, this emphasizes the importance of the polishing, considering that the occlusal adjustment can promote the growth of the surface's roughness.

In 1997, Bollen et al.[25] described that, ideally, the surface of a restoration should be as smooth as possible in order to make the retention of the dental biofilm more difficult, considering the value 0.2 μm as a limit, beyond which there were higher possibilities of bacterial build-up.

The ceromer is a resin that had its physical and mechanical properties improved with the incorporation of inorganic ceramic particles [3]. There is no standardization in the literature about the indicated polishing of this material. In the studies of Montemezzo et al. [1], Nishioka et al. [9] and Oliveira et al. [13], different finishing and polishing systems with ceramics or compound resins were used. Three systems were selected for this paper: one of them indicated for a compound resin (Enhance) and the other two for ceramics (Shofu and Edenta).

In the present study, a mylar strip was used to produce standardized specimens. After polymerization, the specimens that were not polished served as the control group and were compared with groups treated with different polishing systems. Not only in this study, but also in other studies,[26,28] mylar strips formed the smoothest surface among all the composite groups tested.

The results presented in this paper have shown that the systems with abrasive rubbers (Edenta and Shofu) obtained better results

on the ceromers' surface compared with the Enhance system silicon tips, which is a different result than that observed in the study by Nishioka et al.[9] in 2000, where the silicon tips system showed lower superficial roughness. However, in this study, the authors used the silicon tips in a compound resin and the abrasive tips in ceromers, which does not allow a trustworthy evaluation of the polishing systems.

The silicon tips are better indicated for the polishing of compound resins [16]. Nevertheless, in spite of the ceromers' resinous matrix, such tips may not have the desired polishing effect, probably due to the inorganic particles that compose the ceromer.

The roughness of a composite surface is dictated basically by the size, hardness, and amount of filler (all of which influence the mechanical properties of the resin composites), by the flexibility of the finishing material, and by the hardness of the abrasive and grit size [26].

Verifying the study results, the Shofu system was the one that presented the lower values of average superficial roughness (Ra) compared with the other systems. Just like in this study, Berh et al. [19] and Cho et al. [17], while evaluating polishing systems on ceromers, also found lower surface roughness on the abrasive tip systems. The Shofu syst em has shown lower values of surface roughness compared with silicon tips and/or aluminum oxide discs [13,15,19,21], and like most systems, it must be combined with a polishing diamond paste when used, thus producing a smoother surface that is biocompatible with the dental and gingival tissue.

Furthermore, the Shofu system was more effective when applied on the surface of the Vita VMLC ceromer, a fact that may be justified by the difference of the material's composition. The Ceramage has more than 73% of inorganic charge, while the Vita VMLC has between 45% and 48%. According to Bowen [27] the inclusion of charge particles decreases the contraction of the polymerization and provides better mechanical properties. However, on the other hand, an excessive quantity of this charge may harm the material's aesthetics and make the final polishing of this restoration more difficult.

Among the other forms of roughness quantitative evaluation, one may consider the profilometer as the gold standard. Although the profilometer allows the evaluation of only a portion of the material at a time, Agra and Vieira [22], still considers it as the most practical and convenient method to evaluate the roughness of a surface.

It is noteworthy that the analysis results made by a profilometer may be influenced by the position of the surface in which the equipment's reading, calibration, and parameter selection will be done. In this study, the evaluated parameter was the roughness arithmetic average (Ra), which is the most commonly used.

According to Erdemir et al. [28] the results of an analysis made with equipment such as a profilometer provide limited bidimensional information and may be influenced by some factors like the position in which the reading of the surface was made, the selection of the parameters, and the equipment's calibration. Hence, analysis in an anatomic strength microscope, evaluation of other properties such as free surface energy, and the usage of a scanning electron microscopy must be done to allow a more accurate evaluation of the behavior of these materials.

Surface analysis through a SEM photomicrograph was used in the present study, and from its results, one can consider that both materials presented the same form in all polishing systems.

Due to the diversity and the shortage of data within the specialized literature that refers to methods of finishing and polishing ceromers, it is necessary to perform longitudinal studies that follow the clinical behavior of such materials and their surfaces when submitted to intra-oral environments.

CONCLUSION

The additional polishing after the occlusal adjustment is indispensable for reducing the surface roughness of an indirect restoration. Within the limitations of this study, it was concluded that the abrasive tips (Edenta and Shofu) are more effective in reducing the surface roughness of ceromers compared with the silicone tip (Enhance).

LIMITATION OF THE IN VITRO STUDY

By virtue of being an in vitro study, there is a difficulty in simulating the real conditions of the oral cavity, and can not standardize the weight of a Diamond tip during wear simulated occlusal adjustment.

CLINICAL RELEVANCE

Regarding indirect restorations, one of the problems that need more attention is the quality of the surface of the composites that need be adjusted with diamond tips during their adaptation to the tooth remaining to improve the shape, contour and surface texture. These adjustments remove the surface layer of polish and make the surface rough and extremely abrasive material, favoring the accumulation of biofilm and therefore irritation of the adjacent soft tissues, abrasion of the teeth and restorative materials antagonists, staining and even loss of aesthetic quality of the restoration. Thus, it is essential that the material receives any type of finishing and polishing intraoral, in order to recover the surface smoothness, ensuring the biocompatibility of the restorative material with the oral tissues.

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