

Surface roughness of composite resins submitted to three different finish and polish systems

Rugosidade superficial de resinas compostas submetidas à três diferentes sistemas de acabamento e polimento

Rugosidad superficial en resinas compuestas sometidas a tres diferentes sistemas de acabado y pulido

Received: 03/23/2021 | Reviewed: 03/29/2021 | Accept: 04/12/2021 | Published: 04/21/2021

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Abstract

Objective: This study aimed to evaluate the in vitro performance of three different finishing and polishing systems, concerning providing better surface smoothness. **Materials and methods:** 2x4 mm specimens were made with 6 composites: Filtek Z250, Classic Herculite, Opalis, Filtek Z350, Zirconfill and Estelite Omega, which were subsequently divided into four groups according to a different finishing system (Sof-Lex, OptiDisc, Praxis and Control). After polishing, twelve specimens were distributed to each of the six resins studied, making a total of 72 samples (n = 3), which had their roughness evaluated by a contact roughnessmeter. The Kruskal-Wallis test and Dunn's post-test with Bonferroni adjustment were used to search for significant differences. Values were considered significant when $p < 0.05$. **Results:** The roughness values for finishing systems showed statistical differences between OpiDisc x Praxis ($p = 1,000$), OpiDisc and Sof-lex ($p = 0.605$) and Control and all systems ($p < 0.0001$). There was no statistical difference when analyzing the combination of resin x system. The Mylar strip provided surface quality. **Conclusions:** The size, composition and shape of the filler influenced the surface. Sof-lex and Praxis showed similar results, thus being a good choice for polishing. **Clinical Relevance:** This study aimed to help the professional in the choice of a better material in the polishing step.

Keywords: Dental aesthetics; Composite resins; Dental polishing; Operative dentistry.

Resumo

Objetivo: O presente estudo teve como objetivo avaliar o desempenho in vitro de três diferentes sistemas de acabamento e polimento, considerando sua capacidade de proporcionar melhor lisura. **Materiais e Métodos:** Espécimes de 2x4 mm foram confeccionados com 6 compósitos: Filtek Z250, Classic Herculite, Opalis, Filtek Z350, Zirconfill e Estelite Omega, que foram posteriormente divididos em quatro grupos de acordo com um sistema de acabamento diferente (Sof-Lex, OptiDisc, Praxis e controle). Após o polimento, doze corpos de prova foram distribuídos para cada uma das seis resinas estudadas, perfazendo um total de 72 amostras (n = 3), as quais tiveram sua rugosidade avaliada por um rugosímetro de contato. O teste de Kruskal-Wallis e o pós-teste de Dunn com ajuste de Bonferroni foram usados para buscar diferenças significativas. Os valores foram considerados significativos quando $p < 0,05$. **Resultados:** Os valores de rugosidade dos sistemas de acabamento apresentaram diferenças estatísticas entre OpiDisc x Praxis ($p = 1,000$), OpiDisc e Sof-lex ($p = 0,605$) e Controle e todos os sistemas ($p < 0,0001$). Não houve diferença estatística ao analisar a

combinação resina x sistema. A tira de Mylar forneceu qualidade de superfície. **Conclusões:** O tamanho, composição e forma do filler influenciaram a superfície. Sof-lex e Praxis apresentaram resultados semelhantes, sendo, portanto, uma boa escolha para polimento. *Relevância Clínica:* Este estudo teve como objetivo auxiliar o profissional na escolha do melhor material na etapa de polimento.

Palavras-chave: Estética dentária; Resinas compostas; Polimento dentário; Dentística operatória.

Resumen

Objetivo: El presente estudio tuvo como objetivo evaluar el desempeño in vitro de tres sistemas diferentes de acabado y pulido, considerando su capacidad para proveer una mejor suavidad. *Materiales y Métodos:* Se realizaron muestras de 2x4 mm con 6 composites: Filtek Z250, Classic Herculite, Opalis, Filtek Z350, Zirconfill y Estelite Omega, que posteriormente se dividieron en cuatro grupos según un sistema de acabado diferente (Sof-Lex, OptiDisc, Praxis y control). Después del pulido, se distribuyeron doce muestras a cada una de las seis resinas estudiadas, haciendo un total de 72 muestras ($n = 3$), a las que se les evaluó la rugosidad mediante un rugosímetro de contacto. Se utilizaron la prueba de Kruskal-Wallis y la posprueba de Dunn con ajuste de Bonferroni para buscar diferencias significativas. Los valores se consideraron significativos cuando $p < 0,05$. *Resultados:* Los valores de rugosidad de los sistemas de acabado mostraron diferencias estadísticas entre OpiDisc x Praxis ($p = 1,000$), OpiDisc y Sof-lex ($p = 0,605$) y Control y todos los sistemas ($p < 0,0001$). No hubo diferencia estadística al analizar la combinación resina x sistema. La tira de Mylar proporcionó calidad de superficie. *Conclusiones:* El tamaño, la composición y la forma del relleno influyeron en la superficie. Sof-lex y Praxis mostraron resultados similares, siendo, por tanto, una buena opción para el pulido. *Relevancia clínica:* Este estudio tuvo como objetivo ayudar al profesional a elegir el mejor material en el paso de pulido. **Palabras clave:** Estética dental; Resinas compuestas; Pulido dental; Operatoria dental.

1. Introduction

Composite resin restorations require the performance of sensitive steps to obtain an ideal result (Lowe, 2015). For this reason, the evolution of composites was accompanied by the evolution of the materials that are part of these steps (Avsar, *et al.*, 2015). Among these, the finishing and polishing stand out for its impact on the surface quality of restorations (Kocaağaoğlu, *et al.*, 2016; St-Pierre, *et al.*, 2019).

Similarly, the structural composition of the resin itself, the finishing and polishing step has an influence on the surface quality of the restorations (Rodrigues-Júnior, *et al.*, 2015) through the reduction of surface roughness and irregularities, thus minimizing the accumulation of biofilm and stains caused by the penetration of solutions and pigments of dietary origin (Itanto, *et al.*, 2017; Lassila, *et al.*, 2020; Morais, *et al.*, 2015; Ruivo, *et al.*, 2019). The finishing and polishing are considered critical during the restoration stage, as it influences essential factors for the restoration, such as aesthetics, strength and durability (Kocaağaoğlu, *et al.*, 2016; Morais, *et al.*, 2015; Schmitt, *et al.*, 2016).

Superficial irregularities can provide an unpleasant tactile perception to the patient. The clinically acceptable roughness value of restoration is $0.2 \mu\text{m}$, which is similar to the degree of smoothness of the enamel (Itanto, *et al.*, 2017). However, patients can perceive the roughness of restoration with the tip of the tongue. Due to tactile sensitivity, surfaces with roughness between $0.25 \mu\text{m}$ and $0.5 \mu\text{m}$ can be easily perceived (Alves, *et al.*, 2015).

Some factors affect the quality of the surface of restorations, such as the quantity and size of inorganic particles, where smaller particles result in better surface smoothness (Rodrigues-Júnior, *et al.*, 2015). Another important point is that the size difference between the matrix and the particles prevents an ideal polishing because the difference in the hardness between both causes the wear to occur in different degrees, forming craters (Schmitt, *et al.*, 2016).

Considering that the surface roughness of a resin can be reduced from 26% to 74% through finish and polishing, a failure in this step can lead to a series of clinical problems, such as accumulation of biofilm caused by surface irregularities and superficial staining, a factor that may lead to the need to early change of restoration (Llena *et al.*, 2016; Morais, *et al.*, 2015). Likewise, the quality of polishing depends on factors such as the materials used, the different techniques and the operator (Itanto *et al.*, 2017).

There is currently a wide variety of finishing and polishing systems available on the market, such as abrasive discs, diamond burs and different polishing pastes (Avsar, *et al.*, 2015; Schmitt, *et al.*, 2016). For the professional, the choice of which

system to use in his practice contemplates the clinical time, the dental element involved and the composite resin of choice, since it has been proven that the finishing and polishing systems behave different way according to the resin submitted to them (Rodrigues-Júnior, *et al.*, 2015).

Likewise, cost-benefit can influence the choice of material, between national and international brands, there is a wide variation in prices of these materials (Avsar, *et al.*, 2015) and one must consider which of these are the best choice between price, clinical time and results (Ardur, *et al.*, 2018). Given the importance of this step for the quality and longevity of the restoration, this choice presents itself as a crucial measure both for adequate treatment and for the cost-benefit of the professional.

Therefore, this work aims to test through an experimental study the effectiveness of some of the systems currently available on the market, with similarities in their techniques and structures, but with different manufacturers and costs, aiming to facilitate this clinical choice, considering the quality of the polishing as the surface smoothness provided.

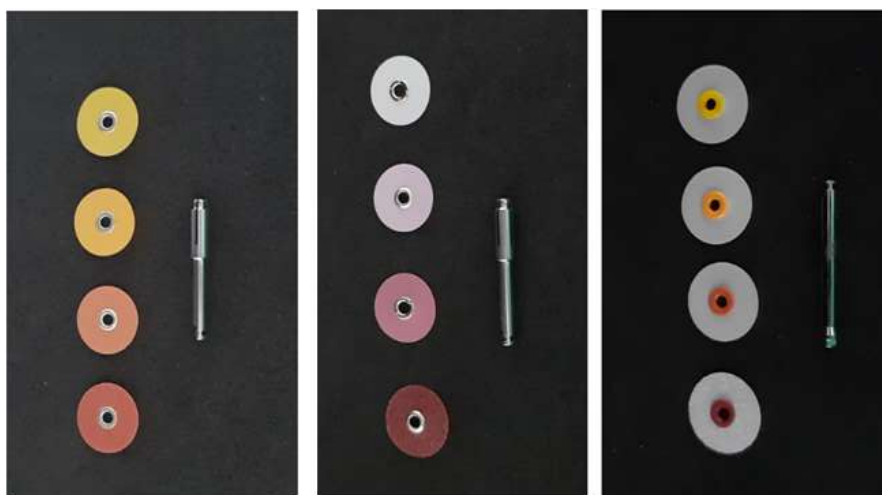
2. Materials and Methods

The systems selected for the study were discs impregnated with aluminium oxide from three different manufacturers (Figure 1), for they are responsible for producing more homogeneous surfaces when compared to other systems (Avsar, *et al.*, 2015). Also, the choice of discs with the same polishing substance helps to reduce confounding variables.

The resins chosen were three micro-hybrids and three nano-hybrids composites currently on the market and used in anterior teeth (Figure 2), areas where polishing discs are more suitable. Both have good mechanical properties combined with good aesthetics and, therefore, are materials widely used (Enone, *et al.*, 2017), making it important to study their performance. The systems and resin composites information provided by the manufacturers are summarized in the Tables 1 and 2, respectively.

For the manufacture of the control group, the use of Mylar® strips was chosen, the material usually indicated as responsible to produce smoother surfaces (Avsar, *et al.*, 2015; Kocaağaoğlu, *et al.*, 2016; Schmitt, *et al.*, 2016).

Figure 1. Finishing and polishing systems used, in order: Sof-lex Pop on (Orange series), OptiDisc® and Praxis.



Source: Authors.

Figure 2. Composite resins used, in order: Filtek Z250, Classic Herculite, Opalis, Filtek Z350, Zirconfill and Estelite Omega.



Source: Authors.

Table 1. Information on the finishing and polishing systems selected.

System	Sof-lex Pop on®	OptiDisc®	Praxis®
Classification	Polyester discs	Polyester discs	Polyester discs
Diameter	12,77 mm	12,6 mm	12 mm
Abrasive particles	Aluminum Oxide	Aluminum Oxide	Aluminum Oxide
Granulation (µm)	Coarse - 55 µm Medium- 40 µm Fine - 24 µm Superfine - 8 µm	Extra Coarse - 80 µm Coarse/Medium - 40 µm Fine - 20 µm Superfine – 10 µm	Coarse – 103 µm Medium – 53 µm Fine – 24 µm Ultrafine – 18 µm
Batch number	1825700622	199204	1083753101
Manufacturer	3M ESPE™	Kerr Dental™	TDV Dental Ltda.

Source: Authors.

Table 2. Informations about the composites selected.

Composite	Filtek® Z250 XT	Herculite clássico	Opalis	Filtek® Z350 XT	Zirconfill®	Estelite Omega
Classification	Microhybrid	Microhybrid	Microhybrid	Nanohybrid	Nanohybrid	Nanohybrid
Inorganic filler particle size	0.01 µm at 3.5 µm with average size of 0.6 µm	Average of 0.6 µm	Average size of 0.5 µm	4-11 nm 20 nm 0.6 – 10 µm 0.6 – 20 µm	20 nm 15.8 µm	100 a 300 nm Average size 200 nm
Polymeric matrix	BIS- GMA ¹ BIS – EMA ² UDMA	BIS-GMA TEGDMA ³	BIS-GMA BIS-EMA TEGDMA UDMA ⁴	BIS-GMA UDMA TEGDMA BIS-EMA	BIS-GMA UDMA TEGDMA BIS-EMA	BIS-GMA TEGDMA MEQUINOL
Colour	A2E	A2E	A2E	A2E	A2E	A2E
Batch number	1818700420	6212002	270213	1818600624	18038	101EY7
Manufacturer	3M ESPE ®	Kerr ®	FGM®	3M ESPE ®	BM4®	Tokuyama®

Abbreviations: ¹ Bis-GMA: bisphenol A diglycidyl methacrylate; ² Bis-EMA: bisphenol A diglycidyl methacrylate ethoxylated; ³ TEGDMA: triethylene glycol dimethacrylate, ⁴ UDMA: urethane dimethacrylate. Source: Authors.

To make the specimens, it was manufactured square transparent acrylic plates 2 mm thick, 7 cm high and 7 cm wide. The design of this plat was created by the author for use in this study, aiming a matrix that should stabilize the samples during the creation and the tests that would be realized along the study. Each plate carried 4 holes of 4 mm in diameter with 4 cm of distance between them and 1 cm of distance between the holes and the edge of the plate (Figure 3). Eighteen structures were used in this study, making a total of 72 cylindrical specimens with 4 mm in diameter and 2 mm in thickness.

For the creation of the specimens, the structure was positioned on a glass plate with a polished surface (FAVA) and the resin was inserted in a single increment inside each hole (Figure 4) with the help of a titanium-coated spatula (Thompson®). Then, a polyester strip (Mylar™) was placed on top of the resin, and on top of it, a glass slide was placed with light pressure, aiming at the removal of excess resin, and also serving as a standardization of the distance from the tip of the light-curing device (Figure 5). This protocol as chosen as provided by literature (Avsar, *et al.*, 2015; Kocaağaoğlu, *et al.*, 2016; Schmitt, *et al.*, 2016). The photoactivation was carried out according to the time indicated by the manufacturer of each resin, using light-curing (Optilight Max, Saevo, GNATUS) with a power intensity of 1200 mW / cm².

After, the plates were fixed to a flat surface parallel to the ground. A contra-angle and a micro-motor (Kavo Kerr) were used to perform the polishing procedure. Except for the control group, the specimens were polished (Figure 6), according to the manufacturers' instructions, in a single direction, with intermittent movements and performed by the same operator. Water spray was used for five seconds after each polishing to remove debris.

After the procedure, the samples were catalogued and immersed in distilled water and kept in an incubator with a temperature of 37°C for a period of 24 hours. After that period, the groups were distributed.

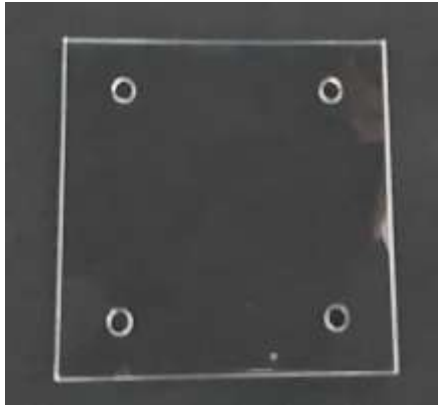
Twelve specimens were distributed to each of the six studied resins (n = 3), three specimens of each resin were subjected to each of the polishing systems and the remaining three became the control group, which remained unpolished.

After the distribution of the samples in their groups, the evaluation of the surface roughness was performed. A Mitutoyo SJ-411 contact rugosimeter was used for this procedure.

The readings were taken at three different points on the surface in a vertical pen movement, with a cutoff value of 0.2 mm per second and speed of 0.25 mm per second. Three successive measurements were made on each sample, obtaining an average value.

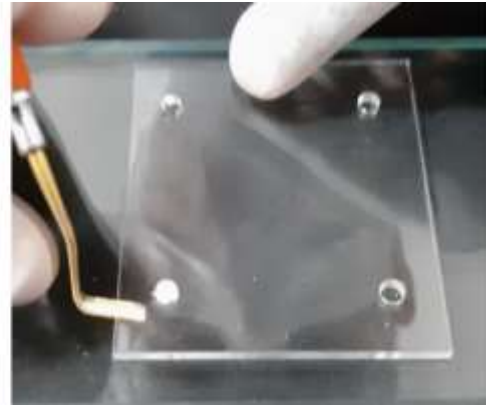
Data analysis was performed using SPSS version 22, with descriptive data analysis based on frequencies, media, medians and quartiles. Assuming the non-normality and the independence of the sample, the Kruskal-Wallis test and Dunn's post-test with Bonferroni adjustment were used, to search for significant differences. Values were considered significant when $p < 0.05$.

Figure 3. Plate used for manufacturing the samples.



Source: Authors.

Figure 4. Increment inserted.



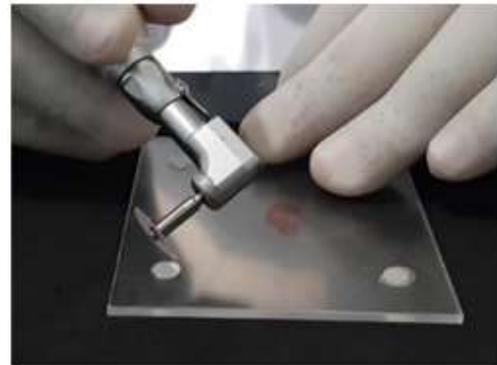
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Figure 5. Set of polyester strip and glass slide.



Source: Authors.

Figure 6. Polishing.



Source: Authors.

3. Results

The Ra mean was 0.427 (SD / Standard Deviation = 0.248). Comparing the resins according to the Ra no significance was observed, however when comparing the roughness according to the system, as is showed in Table 3, OptiDisc presented the highest roughness and this difference was significant.

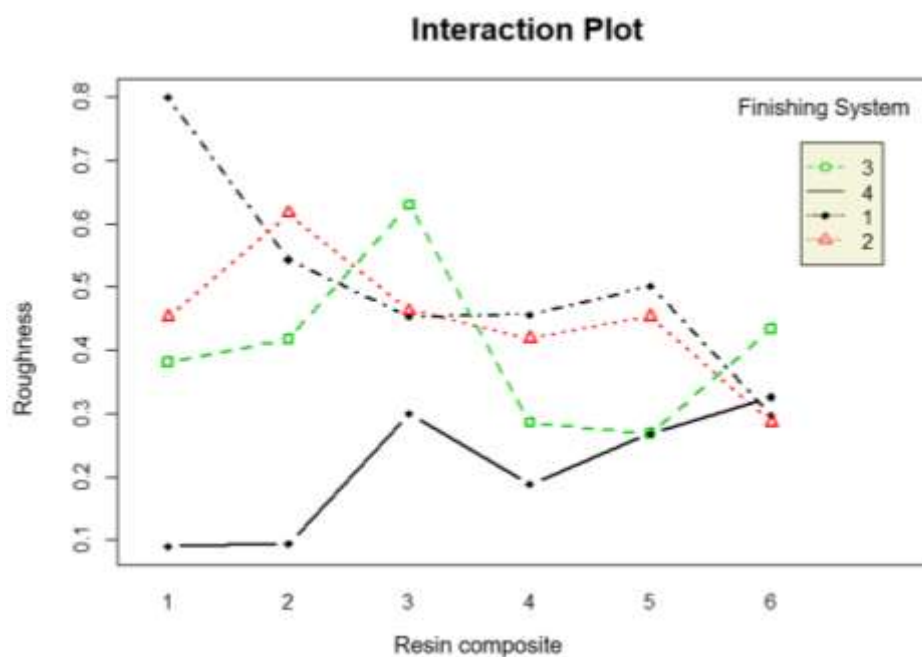
The systems were assessed separately in search of which composite presented the smoothest surface for which system. For OptiDisk ($p = 0.083$), Praxis ($p = 0.232$) and Sof-lex ($p = 0.055$) there was no significant difference between resins when Ra was evaluated, as is showed in Figure 7.

Table 3. Date for Ra results for the composites and systems, presented as median and minimum – maximum range.

Resin	Finishing and Polishing Systems			
	OptiDisc	Praxis	Sof-lex	Control
Composites				
Z350 XT	0.86 (0.66-0.87) b	0.41 (0.36-0.57)	0.38 (0.37-0.38)	0.09 (0.03-0.13)
Herculite Classic	0.59 (0.32-0.70)	0.59 (0.32-0.72)	0.41 (0.29-0.53)	0.04 (0.03-0.2)
Opalis	0.52 (0.18-0.65)	0.5 (0.36-0.52)	0.59 (0.43-0.86)	0.09 (0.08-0.72)
Zirconfill	0.49 (0.36-0.50)	0.43 (0.33-0.48)	0.28 (0.28-0.28)	0.14 (0.13-0.28)
Z250	0.47 (0.33-0.69)	0.54 (0.15-0.66)	0.23 (0.19 - 0.37)	0.27 (0.23-0.30)
Estelite Omega	0.29 (0.16-0.43)	0.26 (0.14-0.45)	0.41 (0.24-0.64)	0.35 (0.26-0.36)

a = difference in relation to finishing systems; b = difference in relation to resin; c = difference in relation to resin x system combination / OpiDisc x Praxis = 1,000; OpiDisk x Sof-lex = 0,605; Control x all p<0,0001. Source: Authors.

Figure 7. Graph 1. Interaction plot graph for the results of the surface roughness of each system related to the different resins. Resins composite: 1- Z350; 2- Herculite; 3-Opallis; 4- Zirconfill; 5- Z250; 6- Estelite Omega. Finishing Systems: 1- OptiDisc; 2- Praxis; 3- Sof-lex; 4-Control.



Source: Authors.

4. Discussion

The replacement of deficient composite restorations represents a negative impact on the remaining dental structure and financial loss to the patient and /or professional (Avsar, *et al.*, 2015). The surface quality influences the longevity of resin restorations (Tavangar, *et al.*, 2018), by affecting its resistance to wear and discolouration, one of the most pointed factors as the cause of replacement for aesthetic dissatisfaction (Ardur, *et al.*, 2018; Morais, *et al.*, 2015).

The use of Mylar strips under a restoration before photopolymerization was indicated as responsible to produce the smoothest surfaces (Avsar, *et al.*, 2015; Bansal, *et al.*, 2019; Schimitt, *et al.*, 2016), a result also found in the present study.

However, the clinical use of this technique is not effective, mainly due to the need to remove the resin-rich surface layer (Mathias, *et al.*, 2015) which makes polishing indispensable.

Regarding roughness, between the systems, there were statistical differences between the OptiDisc x Praxis and OptiDisc x Sof-lex system, with the OptiDisc system providing a rougher surface than the others, while the Sof-lex showed the best results.

The success of Sof-lex discs was attributed mainly to the malleability of the discs, which, because they do not cause load displacement, promote a more homogeneous abrasion (Alves, *et al.*, 2015). Also, the size of its abrasive particles causes the removal of the residual matrix without displacing the glass (Avsar, *et al.*, 2015). Praxis discs, like Sof-lex, have more malleable structures than those of OptiDisc, which can also be associated with their results.

The systems depend on the resins submitted to them (Rodrigues-Júnior, *et al.*, 2015), this means that the systems will behave differently depending on the composition of the studied resins, a fact that was also observed in this study. Particularly, resins showed better results in systems from the same manufacturer, a fact previously observed in other studies (Abzal, *et al.*, 2016; Patel, *et al.*, 2016).

Concerning the evaluated resins, no statistical differences were observed between them, however, a better surface quality was observed in the nanohybrid resins when compared to microhybrids. This can be associated with differences in the size of the filler particles, as nanoparticles reduce the interstitial space between the filler particles, leading to a smoother surface (Schmitt, *et al.*, 2016).

The shape and type of the fillers can also be associated with polishing, since the resins that showed the best surface smoothness have differentiation in them. Estelite Omega has spherical and monodispersed supra-nano particles, which due to its geometry allows a more uniform polishing. The same can be said about the Z250 resin, which also has the same spherical filler particle, and it was among the microhybrid resins that presented the best surface smoothness. The Zirconfill composite also has the addition of diatomite in its composition, which among other mechanical improvements (Feitosa, 2018) has also been observed to provide better polishing capacity (Lima, 2005).

The Estelite Omega + OptiDisc provided the smoothest surface between the combinations (0.196) while Z350XT + OptiDisc (0.878) presented the roughest surface, however, these results did not show statistical significance.

The main limitation of the study was that the specimen surfaces were flat, whereas restorations presented an irregular shape. Also, the polishing procedure as was performed may be difficult to repeat clinically. Protocols of how to reduce this variable may be considered in further studies.

5. Conclusions

It was observed that polishing is involved with the size, shape and compositions of the filler particles. Composites with spherical particles showed better surface smoothness.

Among the systems, it is important to note that although the Sof-lex system presents the best results, Praxis showed similar results, thus when considering the cost-benefit for the clinician this system presents as a good alternative of choice.

Considering the variables of this study on the use of flat surfaces, that differ of the irregular shape of restorations, it is important to consider further similar studies of those systems with protocols that can reduce this variable.

Compliance with ethical standard

Conflict of Interest: The authors declares that has no conflict of interest.

Funding

The work was supported by the authors personal fundings.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

For this type of study, formal consent is not required.

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