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Surface roughness of indirect composites using different polishing systems

Rugosidade superficial de resinas compostas indiretas utilizando diferentes sistemas de polimento

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ABSTRACT

Objective: The aim of this study was to evaluate the surface roughness of indirect composites after polishing with aluminum oxide (Al_2O_3) discs. **Material and Methods**: One-hundred and eighty specimens were confectioned with 6 indirect composites using a prefabricated matrix, resulting in six groups (n-30): Group SO - Solidex, Group SI - Signum, Group SF - Sinfony, Group OP - Opallis; Group RE - Resilab, Group EP - Epricord, Group AD - Adoro. Each group was divided into three subgroups according to the polishing (n-10): Subgroup C (Control) - without polishing (polyester strip); Subgroup S - polishing with Sof-Lex discs; Subgroup T - polishing with TDV discs. The surface roughness was measured with a profilometer. **Results:** The results were analyzed by ANOVA and Tukey tests (5%), resulting in p = 0.00. The mean values (±standard-deviation) measured in Ra (μm) for each Group/Subgroup were: RE/C - 0.14 (± 0.14) a; EP/C - 0.18 (± 0.46) ab; SO/C - 0.24 (± 0.22) abc; SF/S - 0.24 (± 0.17) abc; SF/C - 0.26 (± 2.54)abc; SI/C - 0.30 (± 0.34)abcd; SO/T - 0.33(± 0.42) abcd; AD/S - 0.34(± 0.88)abcd; AD/C - 0.37(± 0.60)ab; SI/S - 0.37(± 1.39)bcd; SO/S - 0.43(± 0.26) cd; EP/S – 0.44 (± 1.02) cd; RE/S - 0.54(±2.02) de; SI/T - 0.65(± 0.88)ef; RE/T - 0.83 (± 0.54) fg; SF/T - 0.85 (± 0.21) fg; AD/T - 0.88 (± 1.74) fg; EP/T - 0.91(± 0.89) g. **Conclusion:** It is concluded that polyester strip resulted in significantly lowest surface roughness; polishing with TDV discs resulted in significantly higher surface roughness compared to Sof-Lex discs and that the surface roughness results depend on the composite tested.

KEYWORDS

Composite resins; Dental polishing; Biofilms.

RESUMO

Objetivo: O objetivo este estudo foi avaliar a rugosidade superficial de resinas compostas indiretas após polimento com discos de óxido de alumínio (Al_2O_3). **Material e Métodos:** Foram confeccionados 180 espécimes de 6 resinas compostas indiretas utilizando uma matriz pré-fabricada, resultando em 6 grupos (n - 30): Grupo SO - Solidex, Grupo SI - Signum, Grupo SF - Sinfony, Grupo OP - Opallis; Grupo RE - Resilab, Grupo EP - Epricord, Grupo AD - Adoro. Cada grupo foi dividido em três subgrupos, de acordo com a técnica de polimento: Subgrupo C - não foi realizado polimento (tira de poliéster); Subgrupo S: polimento com discos Sof-Lex; Subgrupo T: polimento com discos TDV. A rugosidade superficial foi mensurada com um rugosímetro. **Resultados:** Os resultados foram analisados pelos testes estatísticos de ANOVA e Tukey (5%), obtendo-se p = 0,00. Os valores de média (± desvio-padrão) medidos em Ra (μm) para cada Grupo/ Subgrupo foram: RE/C – 0,14 (± 0,14) a; EP/C – 0,18(± 0,46) ab; SO/C – 0,24 (± 0,22)abc; SF/S – 0,24 (± 0,17) abc; SF/C – 0,26 (± 2,54) abc; SI/C – 0,30 (± 0,34) abcd; SO/T – 0,33 (± 0,42) abcd; AD/S – 0,34 (± 0,88) abcd; AD/C – 0,37 (± 0,60) ab; SI/S – 0,37(± 1,39) bcd; SO/S – 0,43 (± 0,26) cd; EP/S – 0,44 (± 1,02) cd; RE/S – 0,54 (±2,02)de; SI/T – 0,65 (± 0,88) ef; RE/T – 0,83 (± 0,54) fg; SF/T – 0,85 (± 0,21) fg; AD/T - 0,88 (± 1,74) fg; EP/T - 0,91(± 0,89) g. **Conclusão:** Pode-se concluir que a tira de poliéster resultou na menor rugosidade superficial; o polimento com discos TDV apresentou média significantemente maior de rugosidade em relação ao polimento com discos Sof-Lex e que o resultado de lisura superficial depende da resina composta testada.

PALAVRAS-CHAVE

Resinas compostas; Polimento; Biofilme.

INTRODUCTION

The indirect composites were developed in order to solve some difficulties that direct composites presented, such as: polymerization shrinkage, material degradation, colour instability [1], low wear resistance, limitations of shape and anatomical contours [2] and technique sensitivity. The indirect composites are used mainly for widespread tooth destruction and small tooth absence. However, these composites have some limitations during surface finishing and polishing procedures, such as: biofilm accumulation, irritation of gingival tissues, marginal discoloration, changes in its dental aesthetics and properties [3].

The finishing and polishing procedures aim to improve clinical performance of composites. The finishing removes excess of material and models the anatomical contour of the restorative material. The polishing provides a slightly rough surface with smoothness and brightness surface on composites similar to dental enamel [4]. Furthermore, the polishing promotes aesthetic improvements, increases durability, reduces porosity and surface staining and improves mechanical properties of the restorations [3,5].

Well polished restoration facilitates hygiene, reduces biofilm accumulation, gingival irritation, pigmentation in composite, surface wear and secondary caries, increasing its longevity [6,8]. However, several factors can interfere in the roughness of the composites, such as: filler particles, size of filler particles and percentage of filler loading in the organic matrix of the composites [9].

For a finishing and polishing system to be effective, the cutting particles of abrasive material have to be harder than the filler component of the restorative material. The aluminum oxide (Al_2O_3) are the best tools to provide less roughness on surfaces of composites. This ability to produce smooth surface, is due to its ability to also cut the filler particles and organic matrix [10].

Therefore, due the variety of composites available for indirect restorations, this study aimed to evaluate the surface roughness of different indirect composites after two different polishing procedures with Al_2O_3 discs. The first null hypothesis is that the indirect composites do not differ on the test surface roughness. The second null hypothesis is that the two different polishing procedures do not differ on the surface roughness.

MATERIAL AND METHODS

One-hundred and eighty specimens were made using a two-piece metallic device with a diameter of 3.0 mm and a height of 2.0 mm. The specimens were divided into 6 groups (n = 30) in accordance to the indirect composite. The trade name, chemical composition and manufacturer of the materials used are presented in Table 1. The indirect composites were adapted in a single increment within the matrix. A polyester strip (FAVA, Sao Paulo, SP, Brazil) was placed on the composites that were pressed with a glass plate to obtain a flat surface. Each indirect composite was polymerized according to the manufacturer's recommendations.

After complete polymerization, the specimens were stored in a dark container at 37 ºC for 24 h. The specimens were bonded on glass slides using a cyanoacrylate-based adhesive, and the flat surface of the specimens was positioned upward.

Each group was divided into three subgroups according to the polishing system used (n-10):

• Subgroup C (control): without polishing. The surface roughness was standardized by polyester strip used during the preparation of specimens;

• Subgroup S: polishing with Sof-Lex Discs (3M ESPE, St. Paul, Mn, USA) – gross, medium, fine and ultra-fine granulations;

• Subgroup T: polishing with TDV Discs (TDV Dental Ltda., Pomerode, SC, Brazil) -gross, medium, fine and ultra-fine granulations.

Table 1 – Composition and manufacturer of materials used

Trade name	Manufacturer	Size of particules	% filler	Type of filler	Classification	Lot #
Signum	Heraeus Kulzer, GmbH, Hanau, German	0.6 µm	75%	Silica	Microhybrid	010040
Sinfony	3M/ESPE, St. Paul, MN, USA	0.5 – 0.7 µm	45%	Silica, Quartz	Microhybrid	160415
Resilab	Wilcos, Petrópolis, RJ, Brazil	50 µm	53%	Silica	Hybrid	310/06
Adoro	Ivoclar/Vivadent, Schaan, Liechtenstein	10 – 100 nm	65%	Silica	Microparticle	0208/09
Solidex	Shofu, GmbH, Ratingen, German	43 - 56 µm	53%	ceramic microfillers (quartz)	Hybrid	010727
Epricord	Kuraray CO., Tokyo,Japan	0.04 - 100 µm	77%	Silica	Microhybrid	00010G

Table 2 – Functions and technical features of the polishing systems used

Trade name	Manufacturer	Technical features	Function
Sof-Lex Discs	3M ESPE, St. Paul, Mn, USA	Al_2O_3 - based flexible sanding discs. ½ inch. Gross, medium, fine and ultrafine granulations.	Finishing and polishing of composite restorations.
TDV Discs	TDV Dental Ltda., Pomerode, SC, Brazil	Al_2O_3 - based sanding discs with 12 mm diameter. Gross, medium, fine and ultrafine granulations.	Finishing and polishing of composite restorations.

Polishing procedures were made by one calibrated operator according to the manufacturer's recommendations and polishing instruments were used only once. Each granulation was used for 20 s. The functions and technical features of polishing systems are listed in Table 2.

Assessment of the surface roughness was carried out with a profilometer (Surftest SV 2000 - Mitutoyo Corp., Kawasaki, Japan). Three measurements (μm) were recorded for each specimen, the roughness parameter (cut-off - 0.25 mm) recorded was roughness (Ra) and the mean Ra was determined for each specimen.

Data were subjected to statistical tests for parametric data analysis of variance - two-way ANOVA (Type of composite X Type of polishing) and Tukey at a level of significance of 5%.

RESULTS

When analyzing the factors Type of composite ($p = 0.000$, 5 degree of freedom, $F = 6.36$) and Type of polishing ($p = 0.000$, 2 degree of freedom, $F = 161.54$), significant differences were found. The ANOVA results for the interaction between factors (Type of composite X Type of polishing) showed a p-value = 0.0000 ($F = 10.65$), with 10 degrees of freedom, which resulted significant differences among groups.

Table 3 shows the results of the Tukey's test for Type of composite factor. The surface roughness of Solidex was statistically lower than the surface roughness of all indirect composites tested, except for the Signum.

Table 3 – Results (Ra) of Tukey's test for Type of composite factor

Type of Composite	Mean (standard-deviation)	Homogeneuos sets*	
Solidex	0.34 (± 0.32)	A	
Signum	0.45 (± 0.92)	A	B
Sinfony	0.45 (± 2.21)		B
Resilab	0.50 (± 1.41)		B
Epricord	0.51 (± 0.90)		B
Adoro	0.53 (± 1.18)		B

* The groups accompanied by the same letters presented no significant differences

Table 4 shows the results of the Tukey's test for Type of polishing factor. The surface roughness of Subgroup C (Control) was statistically lower than the surface roughness of Subgroup S (Sof-Lex discs) and Subgroup T (TDV discs). The surface roughness of Subgroup S (Sof-Lex discs) was statistically lower than the surface roughness of Subgroup T (TDV discs).

Table 4 – Results (Ra) of Tukey's test for Type of polishing factor

Type of Composite	Mean (standard-deviation)	Homogeneuos sets*		
Polyster Strip (control)	0.25 (± 0.19)	A		
Sof-Lex Discs	0.41 (± 1.65)		B	
TDV Discs	0.74 (± 0.84)			C

* The groups accompanied by the same letters presented no significant differences.

Table 5 shows the results of Tukey's test for all group/subgroups. The surface roughness of all composites/Subgroup C was statistically lower than the surface roughness of all composites/ Subgroup T, except for the Solidex composite. The surface roughness of Sinfony/ and Adoro/ Subgroup S was statistically lower than the surface roughness of all composites/Subgroup T, except for the Solidex composite. The surface roughness of Signum/, Solidex/, Epricord/ and Resilab/Subgroup S was statistically lower than the surface roughness of Resilab/, Sinfony/, Adoro/ and Epricor/Subgroup T.

Table 3 – Results (Ra) of Tukey's Test for all group/subgroups

Type of Composite	Type of polishing	Mean (standard-deviation)	Homogeneuos sets*
Resilab	Control	0.14 (± 0.14)	A
Epricord	Control	0.18 (± 0.46)	A B
Solidex	Control	0.24 (± 0.22)	A B C
Sinfony	Sof-Lex	0.24 (± 0.17)	A B C
Sinfony	Control	0.26 (±2.54)	A B C
Signum	Control	0.30 (± 0.34)	A B C D
Solidex	TDV	0.33 (± 0.42)	A B C D
Adoro	Sof-Lex	0.34 (± 0.88)	A B C D
Adoro	Control	0.37 (± 0.60)	A B C D
Signum	Sof-Lex	0.39 (± 1.39)	B C D
Solidex	Sof-Lex	0.43 (± 0.26)	C D E
Epricord	Sof-Lex	0.44 (± 1.02)	C D E
Resilab	Sof-Lex	0.54 (±2.02)	D E
Signum	TDV	0.65 (± 0.88)	E F
Resilab	TDV	0.83 (± 0.54)	F G
Sinfony	TDV	0.85 (± 0.21)	F G
Adoro	TDV	0.88 (± 1.74)	F G
Epricord	TDV	0.91 (± 0.89)	G

* The groups accompanied by the same letters presented no significant differences.

DISCUSSION

The finishing and polishing systems of composites are Al_2O_3 abrasive-based, from the mineral bauxite. The Al_2O_3 can also present in its composition some abrasive minerals, such as zirconia. These systems have particles in the micrometer (μm) size, which satisfies the surface roughness of composites.

According to Chen et al. [11], Al_2O_3 abrasive-based sanding discs are capable of providing composites with a pattern of smooth polished surface. The Sof-Lex and TDV Al_2O_3 abrasive-based sanding discs have gross, medium, fine and superfine granulations, and they are easy to use, due the presence of a center with metal that provides flexibility and easy access to the tooth from any side (proximal, facial or lingual areas).

The indirect composites tested have a great diversity in terms of composition. According to Yap et al. [12], the surface roughness and hardness of the composites after the polishing procedure are directly associated with filler particles, size of filler particles, percentage of filler loading in the organic matrix and ability of polishing system to wear the surface of restoration [4].

The first null hypothesis of this study was rejected because the composites showed significant differences of the surface roughness. The surface roughness of the Solidex was statistically lower than the surface roughness of Sinfony, Resilab, Epricord and Adoro. Unexpected results for the Solidex, because this composite has particle size on a micron scale of 43 to 56 μm. It was expected a surface roughness increasing for it, due to the larger particle size compared to the composites Sinfony, Resilab, Epricord and Adoro, which have smaller particle size. Contradicting the findings of this study, several authors stated that the smaller the particle size in organic matrix the greater the smoothness and brightness surface of composites [7, 13,14].

Maybe this results might be due the lower percentage of filler loading in the organic matrix of Solidex (53%) compared to Epricord (77%) and Adoro (65%) and similar to Resilab (53%). The higher the percentage of filler loading incorporated in the organic matrix, the greater the wear resistance [13,14]. The low percentage of filler loading presented by Solidex may indicate a lower abrasion resistance to the polishing procedures, increasing the performance of polishing compared to other composites, which may require a polishing procedure more efective for better results of surface roughness.

The second null hypothesis was rejected, because the surface roughness of the Subgroup C, that used only the polyester strip for the preparation of the specimens, was statistically lower than the surface roughness of Subgroups S and T, polishing procedures with Sof-Lex and TDV discs, respectively, confirming the findings of Borges et al. [15], Roeger et al. [16], Hoelcher et al. [17] and Stanford et al.[18]. Borges et al. [14] explained that the lower surface roughness of the composite is obtained in contact with the polyester strip, because the use of polishing systems increases de surface irregularities of the composites. Also, Wilson et al. [19], studying the best method for polishing procedures of composites, concluded that the polyester strip produces a smoother surface than any polishing system.

According to Leinfelder [20], during the polishing procedures, microstructural deformations occur in surface topography of composites that can decrease the abrasion resistance of the restorations. These deformations can be deeper about 20 μm below the surface of composites. However, although the surface of the composite polymerized from a polyester strip is generally smoother, generally finishing and polishing procedures are indispensable for achieve an adequate restoration [21]. In addition, the surface layer of composite pressed against the polyester strip is rich of organic matrix, being this surface lower abrasion resistance [22].

Although both polishing systems tested in this study have the same granulations series, the smoothest surface were obtained from a Sof-Lex discs, probably due its inherent characteristics. The flexibility, hardness and different granulations of the polishing system can influence the surface roughness of restorative materials. According Anusavice [23], the discrepancy between the size of abrasive particules present in the abrasive discs and abraded material should be minimal to reduce the creation of scratches or roughs on the surface polished. In addition, the abrasive particles present in the polishing system must have the cut performamce relatively higher than the resistance of filler particles of restorative material to obtain an effective polishment [23].

For interaction between factors (Table 5), it was observed that surface roughness of the all composites of Subgroup C (control), without polishing procedures, was statistically lower than the surface roughness of all composites that received polishing with TDV discs (Subgroup T), except for the composite Solidex/Subgroup T. As previously mentioned, it was expected that the polyester strip produces smoother surface of composite than any polishing procedure [15-19], confirming the results of this study.

The composites Sinfony and Adoro polished with Sof-Lex discs showed significant reduction in surface roughness compared to the other composites polished with TDV discs, except for composite Solidex/Subgroup T. Additionally, composites Signum, Solidex, Epricord and Resilab polished with Sof-Lex discs showed a significant reduction in surface roughness compared to composites Resilab, Sinfony, Adoro and Epricord polished with TDV discs.

The composite Solidex has in its formulation a combination of ceramic microfillers (quartz) (53%) and multifunctional copolymers (25%). Multifunctional copolymers increase the chain-growth polymerization and the degree of polymerization, which improve the mechanical performance of composites. Contradicting the findings of this study, Wendt Junior & Leinfelder [24] states that the higher the mechanical properties of the composite, the greater its resistance to abrasion, consequently, composite Solidex should have lower polishing, due it higher abrasion resistance to the polishing procedures, decreasing the performance of polishing compared to other composites. Also, Anusavice [23] states that composites that have silica particles are polished more easily than those with quartz particles, because silica particles are softer when compared to quartz particles. However, the composite Solidex showed better polishment than the other tested composites.

The composite Epricord polished with TDV discs showed significantly higher surface roughness compared to the other composites, regardless of polishing sytem used. The composite Epricord contain a higher percentage of filler loading incorporated in the organic matrix (77%) compared to the other tested composites. As explained previously, the higher the percentage of filler loading incorporated in the organic matrix, the greater the mechanical properties of the composites [13,14], such as abrasion resistance mechanical property, reducing the effectiveness of polishing.

The end result of the polishing depends on the composite resin and the polishing system. Composite restorations must provide adequate polishing and contour to promote oral health, color stability, wear resistance and reduced biofilm accumulation to increase its longevity. The primary importance of finishing and polishing procedures is to make a biocompatible restoration to tooth structure and to the surrounding tissues. Thus, the higher the brightness and surface smoothness the greater the biocompatibility of the dental restorations. Restorations with maximum polish and brightness favored teeth cleaning, which increases longevity, function and esthetics of the restoration, preserving oral health.

CONCLUSION

It is concluded that It is concluded that polyester strip resulted in significantly lowest surface roughness; polishing with TDV discs resulted in significantly higher surface roughness compared to Sof-Lex discs and that the surface roughness results depend on the composite tested.

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