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ORIGINAL ARTICLE

The effect of different finishing and polishing techniques on surface roughness and gloss of two nanocomposites

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Gloss meter

Abstract *Objectives:* The aim of this in vitro study was to evaluate the effect of four finishing and polishing protocols in Surface Roughness (Ra) and Surface Gloss (Ga) of two different nanocomposites.

Materials and Methods: In total, 50 disc samples of a nanofilled resin and a nanohybrid resin were prepared. The samples were assigned randomly to one of the five groups to which different polishing protocols were applied. Analysis of surface roughness was performed using an Atomic Force Microscope (AFM), with the gloss evaluated using a gloss meter.

Statistical evaluation of the results were analyzed using SPSS software, based on one-way ANOVA parametric tests along with the Welch correction and the Dunnett test for multiple comparisons of the tested protocols.

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Results: The results evidence the significant influence of the applied Protocol Types and Resin Types on Surface Roughness (Ra) and Surface Gloss (Ga). The multiple comparisons between polishing systems highlight the contrast between the most complex protocol, evidencing the lowest average Ra and the highest value Ga, and control protocol, evidencing the highest average Ra and the lowest percentage Ga. Filtek™ Supreme XT provided the best results in both Ra and Ga, in Protocol 4, while Brilliant Everglow™ performed better in Protocols 2 and 3.

Conclusions: Both Ra and Ga are dependent on the type of protocol used, as protocol 4 evidence a higher performance, depending also on the type of resins tested in the research, as nanofilled resin provided the best results. Furthermore, the gloss is influenced significantly by the surface roughness of the composite resin.

Clinical Relevance: In order to achieve excellent aesthetic appearance and high durability of the direct restoration, it is important to select initially the appropriate biomaterial for use and then to base preference for a polishing technique on achieving perfect results in the surface texture.

1. Introduction

In aesthetic dentistry, resin composites are the most frequently used materials in direct rehabilitation of the anterior region of the oral cavity, as they meet all the requirements of preservation of the tooth, aesthetic characteristics, and durability in the medium- and in the long-term (Demarco et al., 2015; Villalta et al., 2006).

In order to preserve the aesthetic features of the tooth to be restored, it is critical to take into account the surface characteristics of restorative materials such as surface roughness, gloss, and colour stability (Kumari et al., 2015; Lainovic et al., 2014; Rocha et al., 2017).

Research has reported that a material should be capable of attaining and maintaining an average roughness value below 0.2 μm *in vitro* (Bollen et al., 1997) since in anything above this value, plaque retention occurs. For this reason, it is broadly assumed that irregularities in restorations affects the accumulation of plaque itself as it does also the durability, discolouration, and aesthetic appearance of the biomaterial used.

In order to maintain or improve the aesthetic appearance of a restorative material, it is essential that the surface roughness is equal to or less than the roughness of tooth enamel in occlusal contact areas (Ferreira et al., 2015; Lainovic et al., 2014). Thus, the surface treatment with a suitable finishing and polishing technique is considered a critical procedure in order to achieve a favourable aesthetic result and to increase the longevity of the tooth restoration (Janus et al., 2010; Jefferies, 2007; Yildiz et al., 2015).

It is known that filler particles provide better physical and mechanical properties to the biomaterial and protect the organic matrix against the force applied to the direct restoration, having a direct influence on the surface properties of the composite such as the roughness and surface gloss (Hilton et al., 2013; Kaizer et al., 2014; Manhart et al., 2000; Rawls et al., 2013).

Theoretically, the resins containing nanoparticles are less susceptible to the loose particles caused by contact with the abrasive material of polishing systems, which will decrease the surface roughness of the resin type mentioned (Ferreira et al., 2015).

On the other hand, nanohybrid resins are hybrid resin composites with nanofiller in a prepolimerized filler (PPF) form, such that they are easily handled and polished, showing a higher retention of polishing and long-term gloss than other types of resin (Aytac et al., 2016).

According to research the appearance of an anterior restoration is also influenced by the degree of gloss on the surface after polishing. This is associated with the amount of light that is reflected by the biomaterial itself. The higher the surface roughness, the greater the light scattering effect, and the lower the gloss of the observed sample (Antonson et al., 2011; Ergücü and Türkün, 2007). Therefore, a smoother surface has a higher gloss, indicating superior clinical durability and better aesthetic appearance, thus inducing better optical compatibility between resin composite and the natural tooth enamel (Antonson et al., 2011; Jung et al., 2007; Lainovic et al., 2014).

Several *in vitro* investigations were carried out as part of the current research, in order (a) to evaluate the effect of different finishing and polishing procedures, (b) to identify the technique that produces the smoothest surface possible, and (c) to identify which increases stain resistance (Türkün and Leblebicioğlu, 2006). This research adds value both to the current literature and clinical practice by creating an additional and more integrated protocol, which incorporates multiple polishing techniques that minimize surface roughness and provide higher surface gloss on two nanocomposites, one nanofilled and one nanohybrid resin.

The tested null hypothesis reinforces the findings that there is a lack of significant difference between the various protocols tested, both for surface roughness and surface gloss of the nanocomposites under scrutiny.

2. Materials and methods

Two resin composites, one nanofilled and one nanohybrid, were used in the current research (Table 1).

Twenty-five cylindrical specimens of each composite resin were prepared in a cylindrical stainless-steel mould: Smile Line USA Inc. (Colorado, USA) of 12 mm in diameter and 2 mm depth.

Each composite resin was covered with a mylar strip, pressed flat with a glass slide, (Aytac et al., 2016) and light-cured using an Elipar™ DeepCure-S LED curing light (3M™ ESPE™, St. Paul, MN, USA) with a light intensity of 900

Table 1 Characterization of biomaterials tested.

Resin Composite		Type	Shade	Resin Matrix	Filler Particles			Manufacturer	Batch No.
					Type	Avg size	Dist		
A	Brilliant Everglow™	Nanohybrid	A2B2	Bis-GMA Bis-EMA TEGDMA	Silica Glass Zinc oxide	0,02–1 μm	56	Coltene/Whaledent® AG Altstatten, Switzerland	H16234
B	Filtek™ Supreme XT	Nanofilled	A2E (*Enamel*)	Bis-GMA Bis-EMA TEGDMA UDMA	Zirconia Silica *Nanoclusters*	0,6–1,4 μm	63,3	3 M™ ESPE™ (St Paul, Minnesota, USA)	N710202
					Nanoparticules (SiO_2)	20 nm			

mW/cm^2 for 40 s, according to the recommendations of the manufacturers. The intensity of radiation was monitored quantitatively using a Radiometer Curing Radiometer P/N 10,503 Model 100 (Danbury, USA).

The cured samples were assigned randomly to one of the five groups to which different finishing and polishing protocol techniques were applied (Table 2).

The specimen preparation, finishing, and polishing procedures were carried out by the same operator. All instruments were used in a circular and continuous path over the sample for a period of 30 s. The finishing and dry-polishing procedures were carried out with the assumption that a water-free technique has greater effect than the wet procedure, especially when aluminium oxide discs are used (Dodge et al., 1991). It should be noted that only tools with a spiral format were used with water, in order to prevent overheating of the resin surface, and to prevent particles from the polishing instrument impregnating the restoration.

New discs, spirals, and polishing cups were used to polish each specimen.

Before being observed and analysed, the cured samples were stored in distilled water at 37 °C for 24 h (Antonson et al., 2011).

The surface roughness (R_a) values were measured by an Atomic Force Microscope (AFM) – AFM TT Workshop (Signal Hill, California, USA). Deflection and height-mode images were obtained simultaneously at a fixed-scan rate of 0.4 Hz with a resolution of 512 × 512 pixels, in vibrating mode (Giacomelli et al., 2010; Janus et al., 2010). The central region of the sample was chosen and images were acquired, each of 40 μm × 40 μm in size.

The images were analysed with specific software – the Gwyddion 2.45 Program (Brno, Czech Republic). This software allows the image to be divided into sixteen different sections (each 10 μm × 10 μm in size) in order to obtain the mean value of the surface roughness of each section. In total,

Table 2 Defining the finishing and polishing protocols applied.

Steps	Protocol 1	Protocol 2	Protocol 3	Protocol 4	Protocol 5 (Control)
1st	Sof-Lex™ XT Dic Medium grain (dark orange)	Sof-Lex™ Pre-Polishing Spiral (yellow)	SwissFlex™ Finishing Disc (Blue)	Sof-Lex™ XT Disc Medium grain (Dark orange)	Finishing Diamond Bur TDF 135 Serie 014
2nd	Sof-Lex™ XT Disc fine grain (light orange)	Sof-Lex™ Diamond Polishing Spiral (rose)	SwissFlex™ Polishing Disc (Red)	Sof-Lex™ XT Disc fine grain (light orange)	
3th	Sof-Lex™ Pre-Polishing Spiral (yellow)		Spiral pre-polishing silicon bur DIATECH® *ShapeGuard* (rose)	*Enhance® Multi-Polishing* resin finishing cups	
4th	Sof-Lex™ Diamond Polishing Spiral (rose)		Spiral polishing silicon bur DIATECH® *ShapeGuard* (blue)	Sof-Lex™ Diamond polishing Spiral (Rose)	
5th				*Diashine®* ® Intra Oral *Polishing Compound* 2g applied with *SHP soft-bristle Brush*	
6th				Suede Disc	

80 sections were obtained for each polishing protocol; a total of 800 observations of the nanocomposites were tested ($n = 800$).

The evaluation of surface gloss was performed with a gloss meter Micro-Tri-Gloss No. 4520 (BYK Additives & Instruments, Geretsried, Germany). After calibration of the equipment, all samples were measured with a square measurement area of 2 mm × 4 mm area, at a 60-degree incidence angle, according to ISO 2813/2014 (2813 ISO, 2014).

2.1. Statistical analysis

Statistical analysis of both surface roughness (R_a) and surface gloss (G_a) values were performed using the SPSS IBM Program 24 Statistics (New York, USA). Comparison of R_a by Protocol Type (PRO) and Resin Type (RES) was made according to the one-way ANOVA parametric test, proceeding to the mean comparison approach, and sequencing these factors through the Dunnett test, for a 5% significance level ($\alpha = 0.05$). The same procedure was performed to evaluate the variable Surface Gloss (G_a), when compared by Protocol Type and Resin Type.

The interaction between those factors and dependent variables was performed using the two-way ANOVA ($\alpha = 0.05$). In contrast, the correlation between surface roughness and gloss was obtained using the Pearson correlation coefficient, complementary to the simple linear regression model.

In order to identify the interaction of the combined effect of both factors (Protocol and Resin) on R_a and G_a, and once the correlation between the two dependent variables was identified, a two-way MANOVA analysis ($\alpha = 0.05$) was conducted.

3. Results

3.1. Surface roughness

The Spearman association coefficient provides evidence of the existence of a statistically significant association between the variables R_a and PRO ($p < 0.001$).

According to the statistical approach and procedures described in the previous section, statistically significant differences between all of the polishing protocols tested over the current research ($p < 0.001$) were extracted. Comparing the five types of protocol, it is clear and unquestionable that the Protocol 4 (PRO4) evidences the lowest average roughness (18.69 nm) as opposed to the control protocol (PRO5-C) which evidences the highest average roughness (329.32 nm), and consequently the worst result in terms of performance. Thus, according to the aims and objectives of the current research, it is relevant to emphasize at this stage the sequence of the protocols, based on the surface roughness by polishing type, as follows: PRO4, PRO1, PRO2, PRO3, and PRO5-C.

In relation to the segmentation of the protocols by the type of resin used (nanofilled or nanohybrid), the sequence mentioned above is maintained (PRO4; PRO1, PRO2, PRO3; PRO5-C), confirming the aforementioned opposition between Protocol 4 (PRO4) and the Control Protocol (PRO5-C). This result is illustrated in Table 3. Furthermore, the statistical approach also confirms that, for a 5% significance level, the variable R_a depends on the type of protocol (PRO) performed, on the type of resin (RES) tested, and on the combined effect of both factors, in Protocol 2 (PRO2), Protocol 3 (PRO3), and Protocol 4 (PRO4).

3.2. Surface gloss

Analysis of correlations between the gloss and the type of protocol, and between the gloss and the type of resin, allows identification as to the existence of a strong interaction between these variables, for a significance level of 5% and 10%, respectively.

The one-way ANOVA test with the Welch correction ($\text{Welch} = 2945.49$; $gl1 = 4$; $gl2 = 322.70$, $p < 0.001$) evidences that there are statistically significant differences between the gloss of at least two different protocols tested. In relation to the R_a variable, and assuming that the polarity of those two dependent variables are antagonistic, Protocol 4 (PRO4) evidences the best performance in terms of gloss (with a mean value of 39.31%), as opposed to the Control Protocol (PRO5-C), which achieved the worst performance with a global result of 3.27%.

The sequence of the protocols obtained, based on the surface gloss, is in accordance with the sequence of protocols already observed for surface roughness values, except for nanofilled resin, the Protocol 3 of which evidenced a higher gloss value than theoretically expected (18.08%).

It was also possible to confirm that, according to the performance evidenced by statistical approach and procedures, both variables, the surface roughness (R_a) and the gloss (G_a), are dependent on the Protocol Type (PRO) followed and the Resin Type (RES) used.

As to analysis of the simple linear regression model, confirmed by bilateral association measures, it is possible to conclude that a globally adherent model ($F = 578.319$, $p < 0.001$) was achieved, with an explained variance of 41.9% (adjusted R^2) of the dependent variable by the independent variable R_a. As theoretically expected, these two variables observe a statistically significant negative correlation ($p < 0.001$), confirmed by the Pearson correlation coefficient ($r = -0.648$). Thus, as expected and confirmed by the literature review (Heintze et al., 2006; Kaizer et al., 2014; Kakaboura et al., 2007), the lower the surface roughness the higher the surface gloss.

4. Discussion

The research insights discussed in this section are obtained through extensive analysis of the distribution of variables (Surface Roughness and Surface Gloss by Protocol Type, and Resin Type) and the application of the Kolmogorov-Smirnov test. This allows to conclude that there is non-normal distribution of those variables. The same evidence was achieved for the homogeneity of variances of the variables as verified through the Levene test (Marôco, 2014). In the scope of distribution analysis, and based on the evidence, the simultaneous violation of both assumptions associated with the application of statistical parametric tests induce us to apply the Welch F^W test as an alternative to the ANOVA F test, and the Dunnett test as an alternative to the Tukey HSD (Grissom, 2000) test, a procedure already applied in the research carried out by Ergücü and Türkün (2007).

Table 3 Sequencing the average values of surface roughness and gloss by protocol type (Dunnett test).

	Nanohybrid Resin		Nanofilled Resin	
	Ra (Avg values)	Gloss (Avg values)	Ra (Avg values)	Gloss (Avg values)
PROTOCOL 4	22.47	36.52	14.90	42.10
PROTOCOL 1	57.03	25.08	62.16	14.60[a]
PROTOCOL 2	60.70	17.00	95.75	15.40[a]
PROTOCOL 3	94.92	13.54	111.47	18.08[a]
PROTOCOL 5-C	332.76	3.38	325.88	3.16

[a] Sorts of changed protocols.

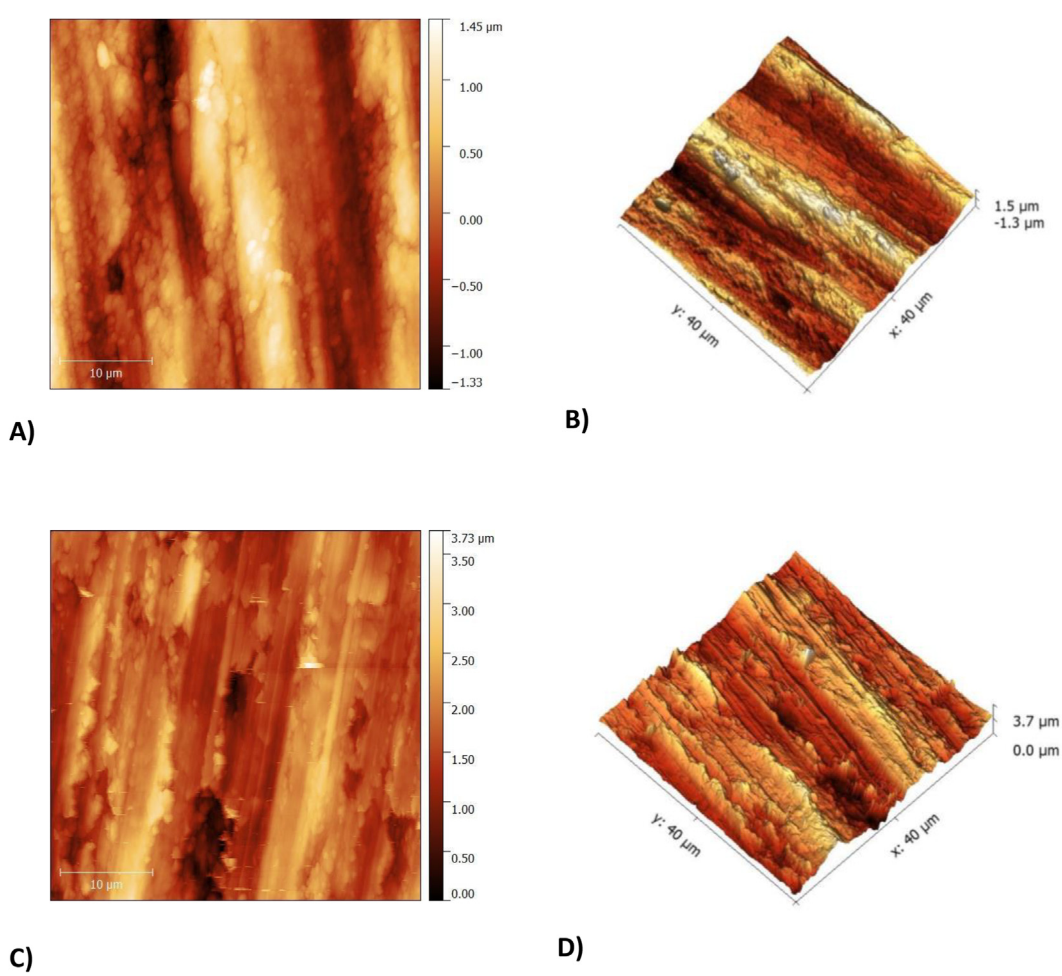

Fig. 1 AFM images of tested surfaces using the Protocol 5 (A) 2D image (Nanohybrid Resin); (B) 3D image (Nanohybrid Resin); (C) 2D image (Nanofilled Resin); (D) 3D Image (Nanofilled Resin).

Clinical research shows that the surface roughness (R_a) of a direct restoration directly affects the gingival health of the tooth undergoing restoration. This is due both to the reduced effectiveness of oral-hygiene procedures and to the possible increase in plaque accumulation (Aytac et al., 2016).

According to the overall results, the absence of surface roughness values above 200 nm (the minimum estimated value for the adhesion of plaque to the tooth surface), can be highlighted, with the exception of the control protocol. For this reason, the importance of the implementation phase of finishing and polishing direct restorations of composite resins in order to avoid irregularities in the retention of unfeasible plaque, is underlined. Consequently, it affects both the aesthetic appearance and durability of the executed restoration (Aytac et al., 2016; Sarac et al., 2006).

As evidenced by Aytac et al. (2016), surface roughness (R_a) is a characteristic of the biomaterials which is influenced by the type of finishing and polishing technique applied in any of the

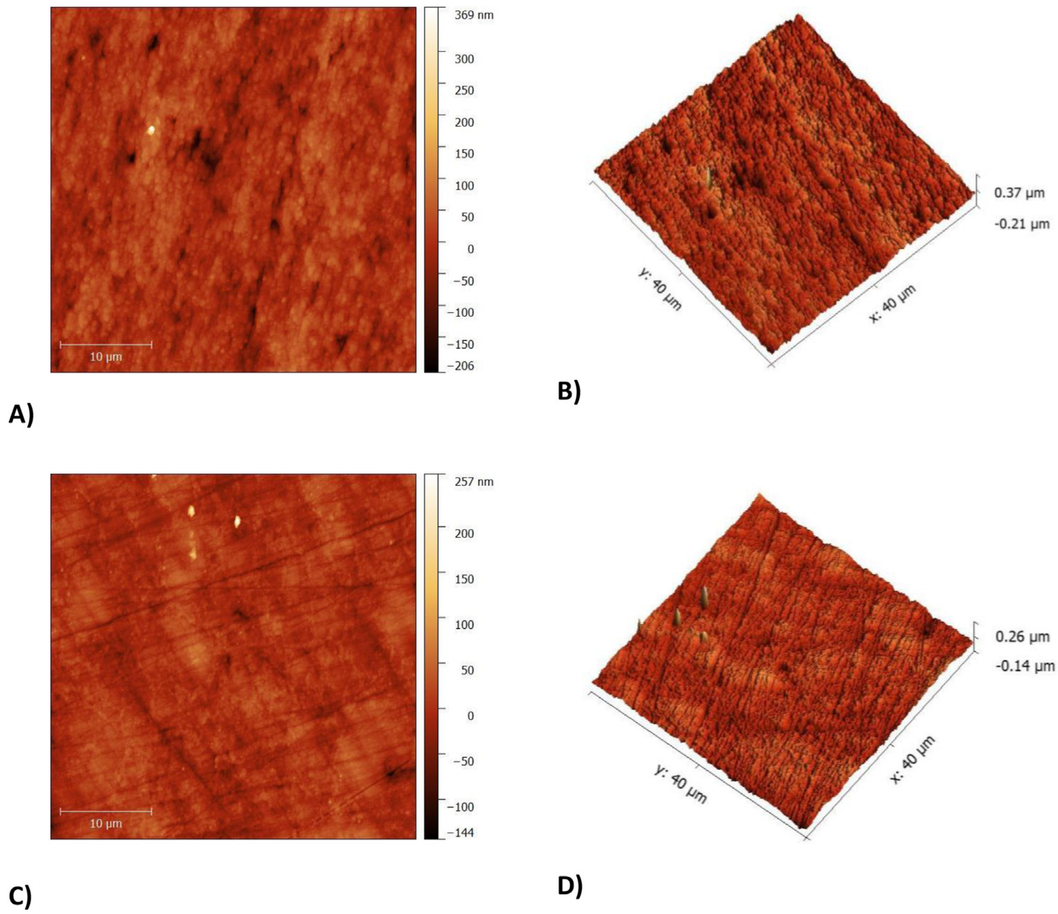

Fig. 2 AFM images of tested surfaces using the Protocol 4 (A) 2D Image (Nanohybrid Resin); (B) 3D Image (Nanohybrid Resin); (C) 2D Image (Nanofilled Resin); (D) 3D Image (Nanofilled Resin).

composite resin types tested. Thus, the outcomes of the current research corroborate the insights provided by Aytac et al. (2016). Thus, the null hypothesis is rejected, confirming that the variables are independent and, therefore, that the level of surface roughness depends on the type of protocol.

The R_a also depends on the microstructure of the resin composites used. Based on these results, and evaluating the differences between the various protocols in the resin – Brilliant Everglow™ and Filtek™ Supreme XT resin – alternative hypotheses of the current research cannot be rejected, which assume the existence of statistically significant differences between protocols, for the surface roughness finishing and polishing procedures and for the gloss of the composite nanohybrid and nanofilled resins.

Based on the overall evaluation and ranking of the different polishing systems, Protocol 5 (PRO5-C) is underlined as the one that induces a higher surface roughness (average value of 329.32 nm) in both resins (Fig. 1) and, therefore, this protocol is associated with the worst performance at the clinical level. This fact arises since the finishing phase (applied exclusively in PRO5-C) allows only a rough outline of the edges of direct restoration, in order to remove deeper irregularities and achieve the desired anatomy, without creating a further smooth surface, and high lustre. For this reason, the need and effectiveness of the application of a polishing method in the final stage when performing a direct composite resin restoration is emphasized, as also evidenced by Türkün and Leblebicioğlu (2006).

In this scope, Berastegui et al. (1992), Janus et al. (2010) and Gönülol & Yilmaz (2012) have all demonstrated that flexible discs of aluminium oxide (Sof-Lex™ XT discs and Cups Enhance® System, both used in the Protocol 4) were considered the best polishing tools for removing particulate inorganic filler at the very surface of the organic matrix of the biomaterial (Aytac et al., 2016).

Disc composition in medium- and fine-grain (29 µm and 14 µm, respectively) allows the creation of a smooth surface and the removal of irregularity on the surface of the resin (Kumari et al., 2015), which explains the excellent results of techniques that use aluminium oxide discs. For this reason, this type of instrument acts as a key driver for the best results, also demonstrated by PRO4 and by the topographic images obtained for this polishing technique (Fig. 2).

The excellent results obtained in Protocol 4 emerged as a result of the higher use of diamond elements such as the Sof-Lex™ Diamond polishing spiral. Successive research has also evidenced that clinical polishing procedures, which have achieved better performance in terms of less roughness, are those containing diamond abrasive particles as already corroborated by Jung (2002). This evidence is more relevant when a polishing vehicle that allows for greater dispersion of the diamond particles is introduced: this is the case of the polishing

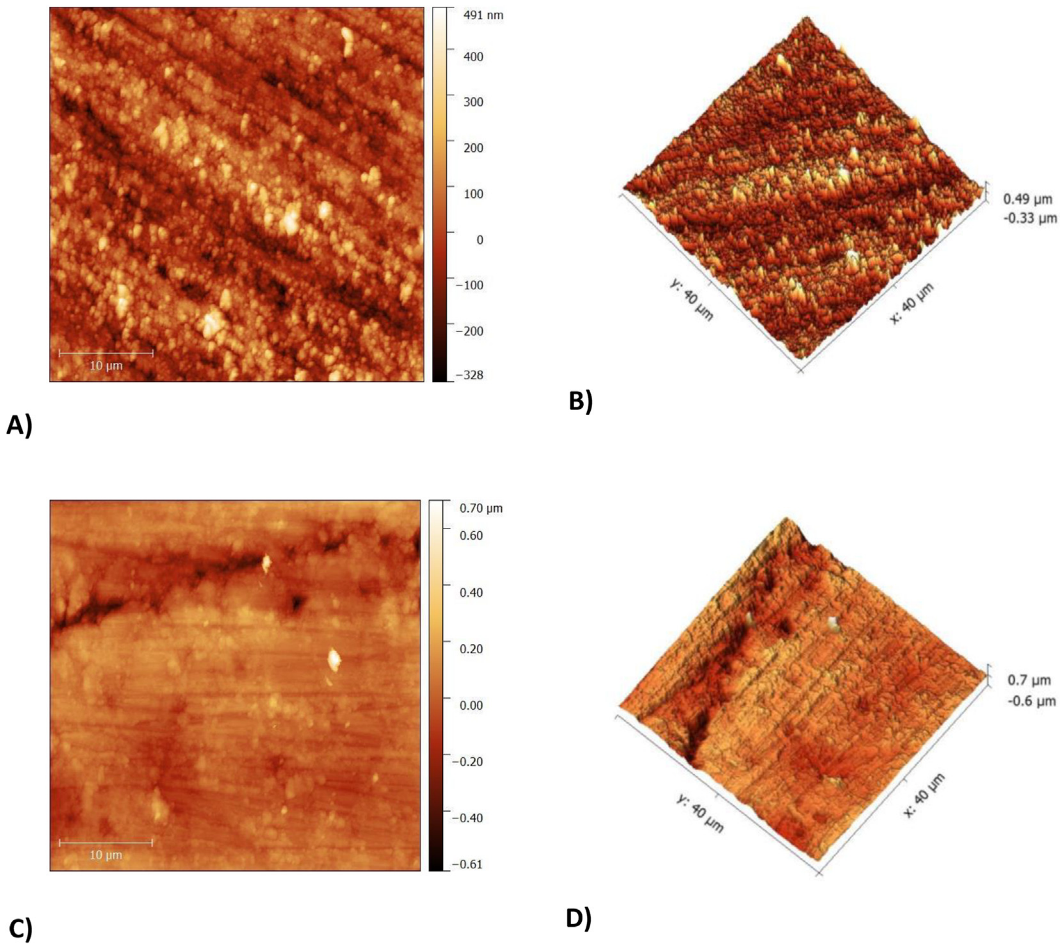

Fig. 3 AFM images of tested surfaces using the Protocol 1 (A) 2D Image (Nanohybrid Resin); (B) 3D Image (Nanohybrid Resin); (C) 2D Image (Nanofilled Resin); (D) 3D Image (Nanofilled Resin).

slurry Diashine® Polishing Compound, applied in conjunction with a soft-bristle brush (Soft-bristle brush SHP). All the factors mentioned above, when applied sequentially, in order to decrease the particle size, induce a much lower surface roughness among the tested resins. These assumptions thus explain and confirm the excellent results achieved in PRO4.

The use of the Sof-Lex™ XT disc is complemented by applying the Sof-Lex™ aluminium oxide and diamond spirals, respectively, in order to induce a more uniform surface texture and a much higher gloss of both nanocomposites, as observed by comparing PRO1 and PRO2. The results obtained for the latter of these protocols (Fig. 4) evidences that the sole use of the Sof-Lex™ spiral is not sufficient to reduce the surface roughness of the composite. This demonstrates the importance of the sequential use of instruments with a higher level of abrasivity (the case of aluminium oxide discs Sof-Lex™ XT), and the benefits of finishing the technique with a diamond tool of ultrafine grain.

The low performance observed in PRO3 is associated with the high abrasiveness of Alpen® Swiss-Flex™ discs, medium- and fine-grain (50 µm and 30 µm, respectively). The use of two DIATECH® ShapeGuard rubbers is insufficient to overcome the high surface roughness produced by the aforementioned disc, despite its low abrasion and formation of diamond particles (Fig. 5).

By observing the interaction of surface roughness and other factors, it is possible to verify that the R_a variable is influenced significantly by the resin-type factor, at a significance level of 10%. Among the research, several studies corroborate that the roughness depends on the type, form, concentration, and quantity of existing inorganic particles in the composite tested (Aytac et al., 2016).

Based on the general characteristics of both resins, the expectation is that the Filtek™ Supreme XT resin will evidence a higher performance in terms of surface roughness. It is important to note that this resin is constituted of agglomerates of particles of zirconia-silica (nanoclusters), which also have a higher percentage of particulate inorganic filler. Thus, the removal of material on the surface of the composite induces smaller irregularities, which can be transposed into lower results in terms of surface roughness. It is also notable that Brilliant Everglow™ resin consists of silica glass particles, which increase the porosity of the biomaterial and, therefore, produce a higher level of surface roughness.

Overall, the results seem increasingly to confirm the existence of statistically significant differences between the two types of resins as seen in PRO2, PRO3, and PRO4.

The improved performance of nanofilled resin observed in PRO4 aligns with the results expected in preliminaries, which are mainly supported by the breakdown of the organic matrix

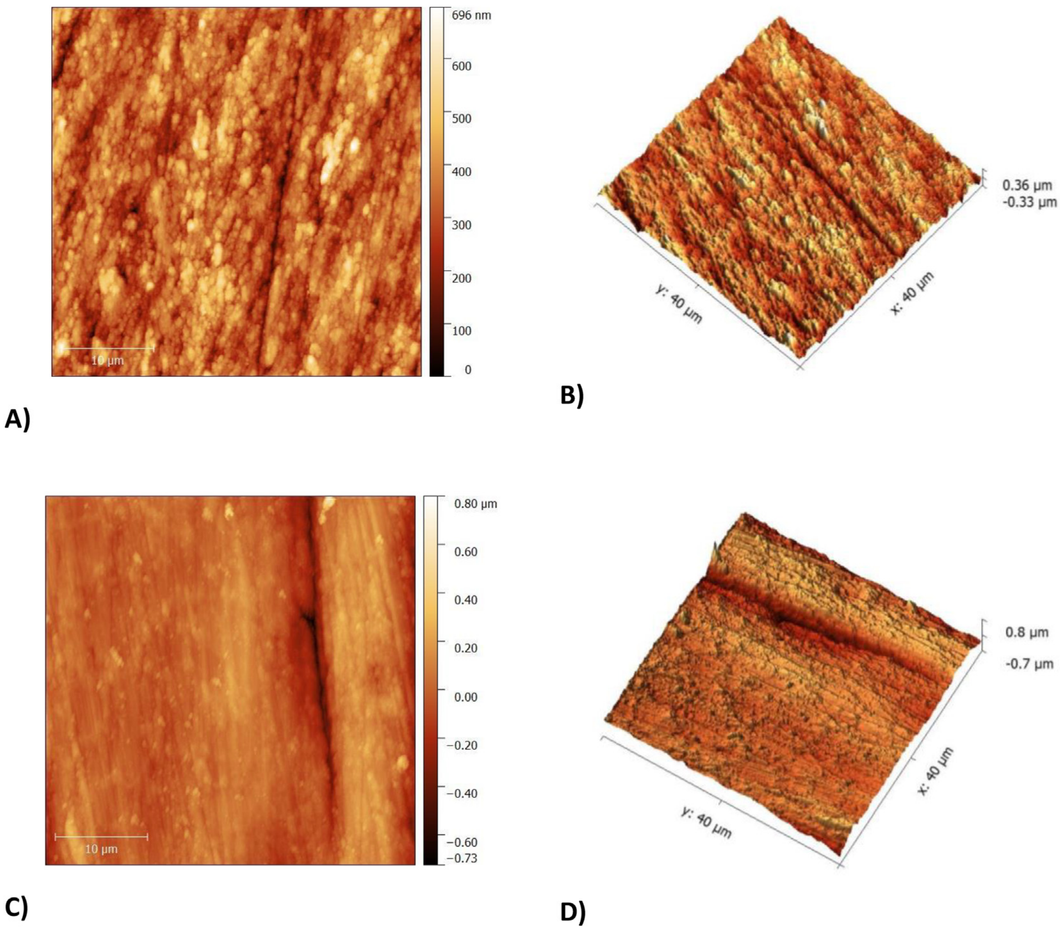

Fig. 4 AFM images of tested surfaces using the Protocol 2 (A) 2D Image (Nanohybrid Resin); (B) 3D Image (Nanohybrid Resin); (C) 2D Image (Nanofilled Resin); (D) 3D image (Nanofilled Resin).

embodied by the resin, with loss of particulate pre-cured resin, as previously evidenced by Senawongse and Pongprueksa (2007). This loss of substance on the surface of the resin, associated with the increased concentration of charged particles per unit volume (63.3%) and the presence of silica-zirconia nanoclusters that make up the nanofilled resin, have confirmed the best performance with regard to surface roughness when compared with the nanohybrid resin. This fact is also demonstrated and corroborated by other research that has studied the performance of Filtek Supreme™ XT resin, namely Antonson et al. (2011) and Gönülol and Yilmaz (2012).

Furthermore, and complimentary to the observed variation of the composition of both resins, the type of polishing protocol is also important to the final results and has a greater influence on nanofilled resin than it does on nanohybrid resin.

Contradicting the preliminary and theoretical expectations, PRO2 and PRO3 provided the best results in both surface roughness and gloss of nanohybrid resin. Both are associated with the incorporation of particles of less than average size (between 0.02 μm and 1 μm), which causes the removal of material from the surface, caused by abrasive particles of the polishing system, subsequently inducing irregularities and shallower grooves.

The results obtained for both R_a biomaterials can be confirmed by the research carried out by Demarco et al. (2015) and by Kaizer et al. (2014) both of which observed that there are no significant differences between the two composite resins of PRO1 and PRO5. Thus, it is assumed that the coarse nature of both protocols, marked by the excessive removal of surface material, induced through procedures of the research, settle on the finding that the resin composition has no significant influence on the final level of roughness.

The procedures applied in nanohybrid resin evidenced no statistically significant differences of R_a in PRO1 or PRO2. Based on these results, it is understood that the use of aluminium oxide discs in PRO1 evidenced no significant improvements on the outcome of the level of roughness, only demonstrating a higher performance with regard to the gloss intensity of the biomaterial surface (Fig. 3).

Using the analysis of linear regression between the gloss and the surface roughness, this research demonstrated, as theoretically expected and as illustrated and corroborated by Kakaboura et al. (2007), that both variables are negatively correlated. This means that the intensity of gloss increases as the level of surface roughness decreases. However, in the current laboratory research gloss variance is explained at 41.9% by the level of surface roughness, which also brings about the significant impact of other multiple factors on the variation of surface gloss of both composites. This evidence corroborates

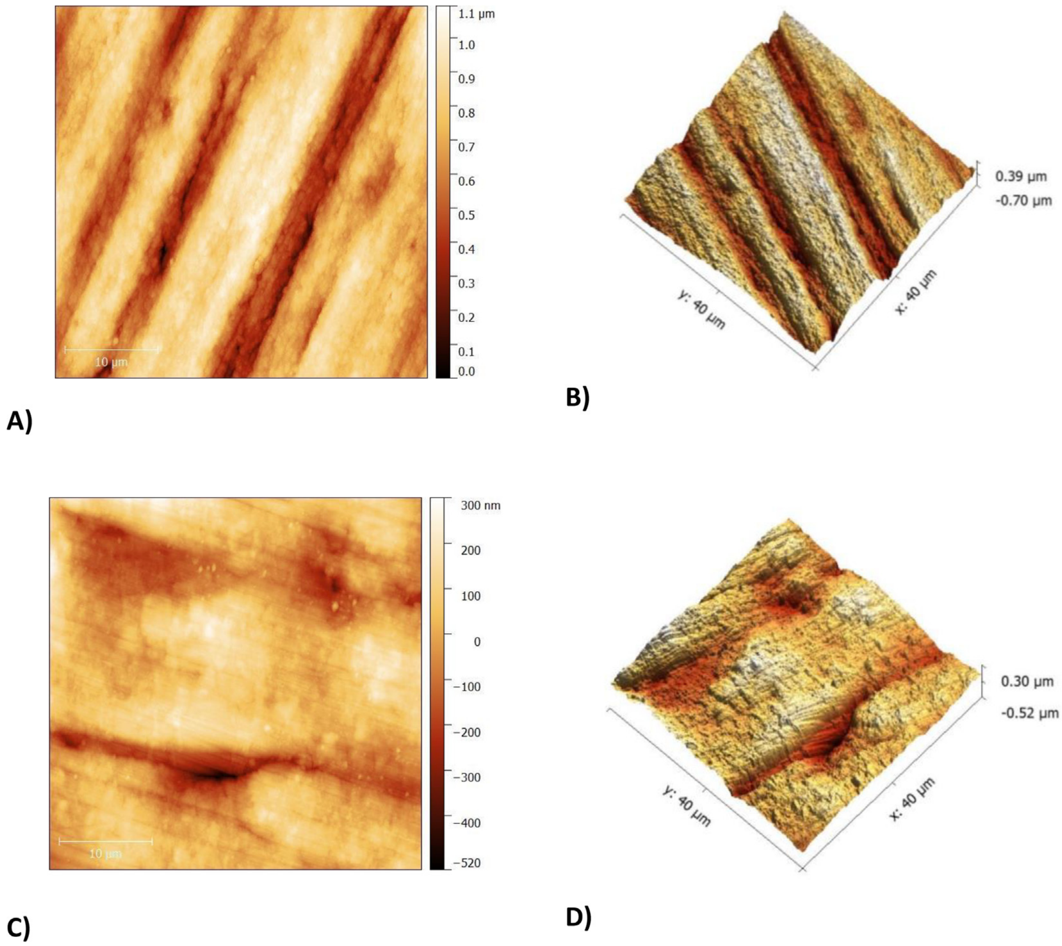

Fig. 5 AFM images of tested surfaces using the Protocol 3 (A) 2D Image (Nanohybrid Resin); (B) 3D image (Nanohybrid Resin); (C) 2D image (Nanofilled Resin); (D) 3D Image (Nanofilled Resin).

assumptions previously stated in the literature by Kaizer et al. (2014)

According to the results, which align with the outcomes provided by Heintze et al. (2006), it is understood that gloss and surface roughness are both variables that are negatively associated although with a different quantitative impact. Even though required for gloss improvement, the roughness is not sufficient for the same extent of variation. Thus, the gloss increases alongside the polishing procedure in a linear manner more than the surface roughness does. In order to enhance the relevance of this correlation between both variables, it is important to note that the sequence of polishing protocols tested for the percentage of gloss in the samples of nanohybrid resin is equal to the sequence evidenced by surface roughness (PRO4, PRO1, PRO2, PRO3, and PRO5-C). PRO4, which achieved the lowest surface roughness values also had the highest gloss values. This is explained by the use of instruments that achieve high lustre, which is the case of suede discs and tools with diamond particles.

In relation to the nanofilled resin, the same sequence of protocols was not observed for the gloss average values. However, it should be noted that these differences are not significant in the overall context and in the relationship between the two variables under analysis: roughness and surface gloss.

Protocols that evidenced lower R_a values evidenced higher values in the surface gloss observations. Consequently, the sequence of protocols mentioned above describe the sequence of performance observed in the protocols put forward. Complimentarily, and for a 10% significance level, the gloss intensity also depends on the type of resin tested.

According to the research of Kaizer et al. (2014) it was confirmed that the diffuse reflection is lower in biomaterials with smaller particles (which is the case of nanohybrid resin), creating a higher gloss in such areas. Accordingly, this explains why the nanohybrid resin evidenced superior gloss values in most of the protocols tested.

The use of two-step polishing systems, in comparison with more complex systems, is not advantageous for the characterization and surface morphology of either material of the systems tested. The multistep protocols (PRO1 and PRO4) evidenced the best results for both variables tested, as corroborated by Jung et al. (2007).

The results achieved for the level of roughness and gloss variables highlights that a better experimental performance was achieved by PRO4 and that this sample would be most likely to demonstrate a better clinical performance. Thus, in order to maximize the clinical success of direct restoration, the preference is for a nanoparticulate resin (such as Filtek

™ Supreme XT) when utilizing the above-mentioned PRO4 in a clinical setting. Otherwise, the clinician should choose a nanohybrid resin (such as Brilliant Everglow ™) with the other protocols tested by us, in light of the influence the structure of the resin matrix and the characteristics of the charge particles have on the composition of the biomaterial.

Broadly, it is understood that – in order to achieve a suitable aesthetic restorative material and good durability of aesthetic appearance – it is necessary to ensure not only the use of an appropriate choice of the biomaterial, but also the preference for a polishing procedure that results in the most perfect surface texture.

The results of the present research provide some flexibility of choice in terms of the clinical polishing protocol to be used, applying the same technique to the type of composite resin that best fits.

Nevertheless, it is important to highlight the importance of progressive and continuous scientific research in order to explain the results associated with the appearance of new finishing systems and polishing.

5. Conclusion

Both the Surface Roughness (R_a) and Gloss (G_a) of resin composites used in the current research is influenced by the Type of Protocol used and by the Type of Resin (nanofilled resin or nanohybrid resin) tested. The gloss intensity depends on the surface roughness of the aesthetic restorative material, but it is certainly influenced by other factors not captured by this research, and globally included in the statistical residuals, which, through its conjoint effects, explain the variations in the gloss values measured among the five protocols followed in the current research.

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Conflicts of interest

None declared.

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