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Original Research

Effect of lubricated polishing and repolishing on gloss, roughness and material loss of nanoparticle resin composite

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Aim: The study examined how different dry and lubricated polishing protocols impact the gloss, roughness, and material loss of nanoparticle resin composites, before and after simulated toothbrushing. **Methods:** One hundred cylindrical resin composite specimens were prepared and divided into an unpolished group and three test groups: Dimanto (DIM), Sof-Lex Pop-On (SOF), and Astrobrush (ASTRO). These groups underwent polishing dry, with water, or with or petroleum jelly. Surface parameters including gloss (Novo-Curve – Rhopoint TM, England), roughness, and material loss (MaxSurf XT 20, MahrGoettingen, Germany) were evaluated at four stages: baseline, polishing, simulated toothbrushing, and repolishing. Data were submitted to repeated measures ANOVA ($P<0.05$). **Results:** Lubrication did not affect the studied parameters after polishing with DIM. SOF showed improved performance without lubricants, whereas ASTRO achieved higher gloss and lower roughness when lubricated. In terms of surface material loss, DIM exhibited less material loss when used with petroleum jelly, SOF had reduced material loss when used with water, and ASTRO showed the most material loss when lubricated with petroleum jelly. **Conclusion:** The gloss, roughness, and surface material loss of the nanoparticle resin composite are influenced by the type of polisher used and the choice of lubricant. However, none of the differences observed surpassed the established thresholds for roughness or gloss perception, suggesting that these protocols are potentially viable for clinical application. Despite detectable differences among the polishing systems and lubricant combinations, all tested options are clinically acceptable. None of them exceeded the thresholds for biofilm accumulation or perceptible differences in surface gloss.

Keywords: Dental polishing. Composite resins. Optical phenomena. Dental restoration wear. Aging.

Introduction

Resin composites are extensively utilized for dental restorations due to their favorable physical and mechanical properties, satisfactory aesthetics, and effective adhesive characteristics[1]. Optimal resin composite restorations are often characterized by a high-gloss surface and minimal roughness, features that emulate the natural aesthetics of tooth enamel. These qualities not only impede the accumulation of biofilm at the restoration margins and surfaces, thereby enhancing patient comfort, but also correlate with increased resistance to material loss and staining, which contributes to the clinical longevity of the restoration[2].

While numerous factors influence the outcome of restorations, including polishing, the literature on the efficacy of different polishing systems and their impact on the surface quality of restorative materials is inconclusive[3]. There is a lack of consensus regarding the optimal finishing and polishing protocols for resin composites, particularly with respect to the use of lubricants during the process[4]. Furthermore, the contradictory findings reported in the literature add complexity to this subject.

Current polishing protocols are not standardized. Practitioners often rely on personal experience and peer recommendations rather than on evidence-based guidelines, which can lead to suboptimal clinical choices. Although finishing and polishing are crucial for the durability of restorations and patient comfort, their scientific significance seems to be underestimated. Digital media often promote various combinations of polishers and lubricants as standard protocols, yet these recommendations frequently lack scientific validation[5-7]. While such information can facilitate the dissemination of knowledge, it may also propagate clinical practices that are not the most effective.

Digital media have emerged as a powerful communication tool, used by various professionals, including those in the healthcare sector, to disseminate information and promote distance education, public health alerts, and more[6,7]. Nonetheless, it remains uncertain whether specific combinations of polishers and lubricants have a significant impact on the longevity of the polished surface of resin composite restorations.

There is a paucity of research evaluating methods to restore surface smoothness and gloss after clinical use. Addressing this gap, the present study investigates the effects of different polishing systems, with and without lubrication, on the gloss, roughness, and material loss of a nanofilled resin composite, including a repolishing step after simulated toothbrushing. The null hypotheses tested are that there will be no detectable difference in surface gloss, roughness, and material loss when considering: I: the type of polishing system; II: the lubrication protocol used; and III: the assessment stages (post-polishing and repolishing).

Materials and Methods

For this study, one hundred z350 XT resin composite discs (3M ESPE) were fabricated using a silicone mold. The specimens had dimensions of 2 mm in height and 6 mm in diameter. Each was formed from a single increment placed inside the mold, compressed with a glass slide, and light-cured for 40 seconds at an intensity of 850 mW/cm² (Radii-Cal CX, SDI, Victoria, Austrália). The specimens were then finished with #1,200 FEPA-P grit sandpaper (Extec, Enfield, CT, USA) affixed to a circular polisher (DP-10 - Panambra, São Paulo, Brazil) and subsequently underwent ultrasonic cleaning in water before being stored in an oven for 24 hours[8].

The samples were randomly allocated into 10 groups based on the different polishing protocols being tested, which included various polishing systems either used alone or lubricated with water or petroleum jelly, as well as a control group. Measurements of surface gloss in *GU* and roughness were taken in *Ra*. For both, increased values represent increased gloss or roughness.

Surface gloss was quantified using a Novo-Curve glossmeter (Rhopoint TM - East Sussex, England), with a metallic shield employed to obstruct environmental light and minimize extraneous interference. Three arbitrary measurements were recorded per specimen, and the mean value was used for statistical purposes.

Surface roughness was gauged using the MaxSurf XCR Profilometer (Mahr - Göttingen, Germany). Three scans were conducted per sample at intervals of 0.25 mm for each evaluation period, and the average of these readings was used. The values are reported as roughness parameters. The resin wear was calculated by comparing the initial profile to the post-procedures (polishing, abrasion, and re-polishing). After overlapping the profiles, the resulting height difference determined the material structure loss in *µm* (Mahr Surf XCR 20 4.50-07 SP3, 2011). Greater values represent increased material loss.

Subsequently, the samples underwent the assigned polishing protocols using a Beltec LB100 micromotor with an attached handpiece (KAVO INTRA 500, model 2068 FGBN), where only one calibrated operator was responsible for the polishing procedures. The groups were divided among three polishing systems (n=30 each): Sof-Lex Pop-On for fine and ultrafine steps (SOF - 3M ESPE), Dimanto (DIM – VOCO) single-step silicone cups impregnated with diamond abrasive particles, and Astrobrush (ASTRO - IVOCLAR VIVADENT) single-step carbide-impregnated bristles. The polishers were utilized as per the manufacturers' guidelines. Further division of the groups was based on the type of lubricant used (n=10 for each subgroup under each polishing system): none, water (applied with a syringe), or petroleum jelly. The control group (n=10) was not polished before or after simulated toothbrushing aging. The protocols for each polishing system are detailed in Table 1.

Table 1. Characteristics of the polishing systems used in the study (commercial brand, manufacturer, type of polish and mode of use).

Polishing material	Material (Manufacturer)	Type	
Sof-Lex Pop-ON	3M ESPE, Saint Paul, MN, USA	Abrasion discs: thin and superfice.	In two Steps: light Orange disc (3-9 µm) handled for 30 seconds, following yellow disc (1-7 µm) handled for 30 seconds using light pressure

Continue

Continuation

Diamanto	VOCO, Cuxhaven Germany	Silicone tips and bowls impregnated with Diamond particles	Single pitch: device handled for 60 seconds, applying slight pressure in Shuttle movements
Astrobrush	Ivoclar Vivadent, Schaan, Liechtenstein	Polishing brush with silicon carbide on bristling (used withour paste)	Single pitch: device handled for 60 seconds, applying slight pressure in Shuttle movements

After polishing, the samples were rinsed with distilled water in an ultrasonic cleaner (1440 D – Odontobrás, Ribeirão Preto, São Paulo, Brazil), and measurements of gloss, roughness, and surface profile were repeated. Material loss was determined by comparing the baseline and post-polishing profiles.

Simulated toothbrushing to mimic clinical use was conducted with a MEV-2T machine (Odeme Medical and Dental Equipment Ltda, Joaçaba, SC, Brazil). A slurry was prepared in a 1:3 weight ratio of Colgate Maximum Cavity Protection toothpaste (Colgate-Palmolive Ind. and Com. Ltda) to distilled water. The specimens were brushed using Bitufo toothbrushes (Cosmed Ind. de Cosmetics e Medicamentos S/A) in two 8-hour cycles (equivalent to 100,000 brushing strokes), with a consistent brushing force of 200g (2N), simulating 10 years of material loss[9]. Slurry was applied to the samples hourly. Toothbrushes were replaced after 50,000 cycles.

Gloss, roughness, and surface profile measurements were reevaluated following the simulated toothbrushing. Repolishing was performed under the same initial protocols for all groups except the control, and new assessments of surface gloss, roughness, and profile characteristics were conducted. The study's phases are illustrated in figure 1.

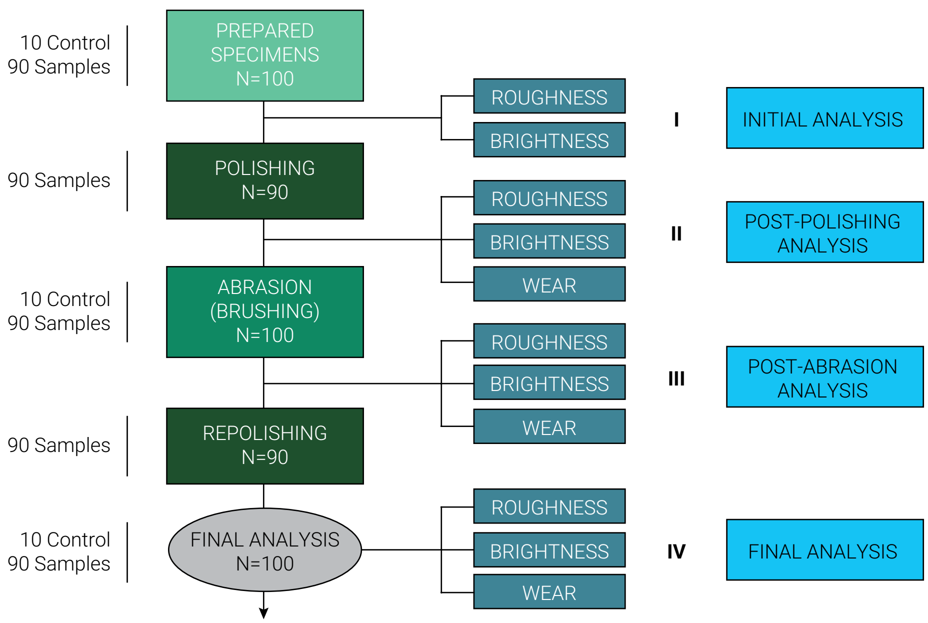

Figure 1. Diagram presenting the phases of the study. Preparation of samples, distribution according to polishing systems and lubrication used, periods evaluated at three levels (polishing, abrasion and repolishing) and the analysis of dependent variables (surface gloss, roughness and material loss), according to chronological sequence.

Statistical analysis involved three-way repeated measures ANOVA, adhering to established prerequisites and assumptions. Study factors, consisted in type of polishing system, lubricant used and evaluation time, the latter being the repetition factor. Multiple comparisons were conducted using Tukey's test. Comparisons between the control group and the other tested groups were made using one-way ANOVA and Tukey's test, with significance determined at $p<0.05$.

Results

Table 2 provides a descriptive analysis of surface gloss values across different polishers, lubricants, and evaluation times. The repeated measures ANOVA test found differences for the polish, the type of lubrication, the evaluation time, and the interaction between the three factors ($p < 0.001$ for all conditions). Initially, gloss values were consistent across all samples. When lubricated with water, DIM exhibited higher gloss values compared to the other polishers, aligning with the gloss levels of other DIM protocols tested. Lubricated SOF and non-lubricated ASTRO displayed gloss values comparable to the control group with no polishing. Upon repolishing, lubricated ASTRO and DIM in all tested conditions achieved the highest gloss values, whereas SOF, whether non-lubricated or with petroleum jelly, mirrored the control group's values.

Table 2. Distribution of mean gloss values (GU) and standard deviation at baseline, after polishing, simulated toothbrushing and repolishing steps.

Polisher	Lubrication	Baseline	Polishing	Aging	Repolishing
Sof-Lex	Dry	$54.62 + 5.94^{Aa,*}$	$73.24 + 3.76^{AC,b}$	$43.95 + 6.41^{AB,c,*}$	$48.49 + 7.90^{ABC,ac,*}$
Sof-Lex	Water	$55.72 + 7.62^{A,ab,*}$	$62.86 + 5.96^{AB,a,*}$	$46.32 + 5.31^{AB,b,*}$	$59.90 + 6.35^{AC,b}$
Sof-Lex	Petroleum jelly	$54.79 + 6.92^{A,a,*}$	$58.00 + 6.74^{B,a,*}$	$41.92 + 6.94^{AB,b,*}$	$41.79 + 7.05^{B,b,*}$
Dimanto	Dry	$52.76 + 7.71^{A,a,*}$	$79.33 + 5.13^{CD,b}$	$46.43 + 4.15^{AB,a,*}$	$68.85 + 8.14^{CD,c}$
Dimanto	Water	$49.95 + 6.76^{A,a,*}$	$85.08 + 3.60^{D,b}$	$47.23 + 7.32^{AB,a,*}$	$67.54 + 6.28^{CD,c}$
Dimanto	Petroleum jelly	$52.22 + 6.18^{A,a,*}$	$83.35 + 5.86^{CD,b}$	$53.96 + 13.16^{A,a}$	$75.59 + 8.26^{D,b}$
Astrobrush	Dry	$52.68 + 7.12^{A,a,*}$	$58.38 + 5.44^{B,a,*}$	$40.38 + 3.79^{B,b,*}$	$58.87 + 5.15^{A,a}$
Astrobrush	Water	$55.27 + 5.53^{A,a,*}$	$71.26 + 7.50^{C,b}$	$46.45 + 2.86^{AB,a,*}$	$71.40 + 8.24^{DE,b}$
Astrobrush	Petroleum jelly	$51.73 + 9.21^{A,a,*}$	$72.96 + 7.90^{C,b}$	$48.63 + 7.56^{AB,a,*}$	$65.34 + 8.48^{CD,b}$
Control	-	$54.08 + 7.49^{a,*}$	$54.32 + 4.30^{a,*}$	$41.23 + 10.59^{b,*}$	$42.87 + 5.63^{b,*}$

Footnote: Different lowercase letters represent differences in rows (comparions of different asessing stages within each polishing and lubrication condition tested) and different uppercase letters represent differences within each column (comparison of different polishing protocols within each evaluation time). Asterisk indicates group similar to the control within each evaluation period.

Table 3 details the roughness measurements. The repeated measures ANOVA test found differences for the polish ($p=0.0014$), the evaluation time, and the interaction between the three factors (p<0.001). All samples shared similar baseline roughness values. After polishing, SOF with water showed increased roughness, comparable to that of SOF with petroleum jelly. DIM with petroleum jelly was the only group to exhibit lower roughness than the control group at this stage. Examining the aging, non-lubricated SOF exhibited an increase in roughness following simulated tooth-brushing, which was sustained even after repolishing. DIM with water demonstrated reduced roughness post-polishing. ASTRO maintained consistent roughness across all evaluation times, irrespective of lubrication protocol.

Table 3. Mean roughness values (Ra) and standard at baseline, after polishing, simulated toothbrushing and repolishing steps

Polisher	Lubrication	Baseline	Polishing	Aging	Repolishing
Sof-Lex	Dry	$0.0747 + 0.0075^{A,ab*}$	$0.0488 + 0.0186^{AC.b*}$	$0.0856 + 0.0239^{A,a*}$	$0.0850 + 0.0257^{A,a*}$
Sof-Lex	Water	$0.0949 + 0.0696^{A,a*}$	$0.0937 + 0.0451^{B.a*}$	$0.0869 + 0.0309^{A,a*}$	$0.0865 + 0.0346^{A,a*}$
Sof-Lex	Petroleum jelly	$0.0742 + 0.0130^{A,a*}$	$0.0883 + 0.0161^{AB,a*}$	$0.0846 + 0.0159^{A,a*}$	$0.0735 + 0.0173^{A,a*}$
Dimanto	Dry	$0.0768 + 0.0123^{A,ab*}$	$0.0438 + 0.0072^{A,b*}$	$0.0844 + 0.0136^{A,a*}$	$0.0581 + 0.0338^{A,ab*}$
Dimanto	Water	$0.0850 + 0.0206^{A,a*}$	$0.0447 + 0.0049^{A,b*}$	$0.0818 + 0.0089^{A,a*}$	$0.0598 + 0.0102^{A,ab*}$
Dimanto	Petroleum jelly	$0.0756 + 0.0121^{A,ab*}$	$0.0413 + 0.0103^{A,b}$	$0.0851 + 0.0308^{A,a*}$	$0.0479 + 0.0131^{A,ab*}$
Astrobrush	Dry	$0.0778 + 0.0117^{A,a*}$	$0.0892 + 0.0587^{AC,a*}$	$0.0911 + 0.0199^{A,a*}$	$0.0660 + 0.0242^{A,a*}$
Astrobrush	Water	$0.0749 + 0.0087^{A,a*}$	$0.0578 + 0.0113^{AC,a*}$	$0.0893 + 0.0317^{A,a*}$	$0.0564 + 0.0347^{A,a*}$
Astrobrush	Petroleum jelly	$0.0843 + 0.0197^{A,ab*}$	$0.0581 + 0.0257^{AC,a*}$	$0.0934 + 0.0260^{A,b*}$	$0.0592 + 0.0173^{A,a*}$
Control	-	$0.0805 + 0.0134^{*}$	$0.0828 + 0.0095^{*}$	$0.0830 + 0.0181^{*}$	$0.0860 + 0.0166^{*}$

Footnote: Different lowercase letters represent differences in rows (comparison of different stages within each polishing and lubrication condition tested) and different uppercase letters represent differences in columns (comparison of different polishing protocols within each evaluation time). Asterisks indicate group similar to control within each evaluation period.

Table 4 outlines the material loss outcomes based on the different polishers and lubricants. The repeated measures ANOVA test found statistically significant differences for the type of polisher, lubrication, time, and the interaction of all factors (p<0.02). After the initial polishing, DIM with water showed more material loss than SOF with water, DIM with petroleum jelly, and non-lubricated or water-lubricated ASTRO. DIM with water was also the only group to significantly differ from the control at this evaluation point. Following repolishing, SOF with water, DIM with petroleum jelly, and non-lubricated or water-lubricated ASTRO exhibited the least material loss, aligning with control group levels. However, DIM with water and SOF with petroleum jelly showed the most material loss during this final evaluation phase.

Table 4. Mean material loss values (μm) and standard deviation at baseline, after polishing, simulated toothbrushing and repolishing steps

Polisher	Lubrication	Polishing	Aging	Repolishing
Sof-Lex	Dry	2.1858 + 2.2808$^{AB\ a}$*	2.9358 + 2.3510$^{AB\ a}$*	5.7572 + 2.1961$^{BC\ b}$
Sof-Lex	Water	0.9800 + 1.0442$^{A\ a}$*	1.6508 + 1.5818$^{A\ ab}$*	2.8653 + 1.4548$^{A\ b}$*
Sof-Lex	Petroleum jelly	3.4475 + 3.1391$^{AB\ a}$*	4.3183 + 3.2717$^{AB\ a}$	8.9875+ 3.0019$^{D\ b}$
Dimanto	Dry	1.1533 + 1.0267$^{AB\ a}$*	2.7625 + 2.0407$^{AB\ b}$*	4.4175 + 1.7144$^{AB\ c}$
Dimanto	Water	3.8817 + 1.1299$^{B\ a}$	4.8358 + 1.8885$^{B\ a}$	8.0250 + 1.6756$^{CD\ b}$
Dimanto	Petroleum jelly	0.8942 + 0.3989$^{A\ a}$*	1.9891 + 1.0990$^{AB\ ab}$*	2.6679 + 1.3052$^{A\ b}$*
Astrobrush	Dry	0.6250 + 0.2972$^{A\ a}$*	1.7311 + 1.4081$^{A\ a}$*	2.2681 + 1.4310$^{A\ b}$*
Astrobrush	Water	0.8372 + 1.0323$^{A\ a}$*	1.7033 + 1.3938$^{A\ a}$*	2.1831 + 1.4327$^{A\ b}$*
Astrobrush	Petroleum jelly	3.1496 + 2.6263$^{AB\ a}$*	4.0222 + 2.4721$^{AB\ ab}$*	5.0259 + 2.0046$^{ABC\ b}$
Control	-	0.4586 + 0.1266 *	0.9357 + 0.7081 *	1.1414 + 0.6847 *

Footnote: Different lowercase letters represent differences in rows (comparing each assessed stage within each polishing and lubrication condition tested) and different uppercase letters represent differences in columns (comparing different polishing protocols within each evaluation time). Asterisks indicate a group similar to the control within each evaluation period.

Discussion

This study demonstrates that surface gloss, roughness, and material loss are affected by the employed polishing protocols, showing significant differences based on the type of polishing as well as the interaction of factors such as polishing system, lubrication protocols, and evaluation periods ($p<0.001$). Consequently, the three null hypotheses positing no differences in surface gloss, roughness, and material loss among the tested polishing systems, lubrication protocols, and periods of evaluation were rejected.

SOF yielded higher surface gloss values compared to the control group after polishing without lubrication, aligning with findings from previous studies[10-12]. Davidson et al.[10] (1981) observed that non-lubricated polishing increases surface temperature, potentially causing a “resinous slurry” that could catalyze the conversion of unreacted monomers into polymers, enhancing surface hardness and reducing porosity, which may explain the results with non-lubricated SOF. As for roughness, SOF without lubrication exhibited lower values compared to its use with water or petroleum jelly. An inverse correlation between surface gloss and roughness is well-documented, as increased surface roughness leads to more diffuse light reflection and less specular reflection, resulting in less gloss[13]. This inverse relationship is evident when comparing the results of surface gloss and roughness in all stages of this study.

Post-polishing, DIM showed consistent performance in terms of surface gloss, irrespective of lubrication, a finding not yet supported by literature, suggesting that the intrinsic properties of the rubber point, having a relatively uniform surface, may not be significantly affected by the presence or absence of lubricant. However, this pattern did not hold for SOF with petroleum jelly, where the lubricant’s impregnation could reduce friction and potentially impair the abrasive action of the aluminum oxide discs. Jung et al.[14] (2007) noted that the efficiency of these discs is attributable to their capacity to remove both filler particles and the organic matrix, resulting in smoother surfaces.

ASTRO's performance remained consistent in roughness across all tested times and lubrication protocols, although this was not the case for surface gloss, where non-lubricated ASTRO resulted in lower gloss after both polishing and repolishing. This discrepancy might be due to the high variability and consequent large standard deviation in the results. Schmidlin et al.[15] (2002) reported that abrasive bristle brushes combined with water yielded the most effective cleaning, smoothness, and gloss in composite restorations and noted no cumulative effect when used with prophylactic paste.

All tested polishing systems produced surfaces with roughness below the clinically acceptable threshold of 0,2 µm[16], and the observed differences in surface gloss were within clinically acceptable limits (<35.7 gloss units), indicating that none of the combinations of polishers and lubricants reached levels that could promote bacterial accumulation or patient discomfort due to surface roughness[17].

Non-lubricated DIM was the only group to exhibit increased material loss after brushing compared to its post-polishing stage, possibly due to heat generation from dry polishing leading to organic matrix degradation. This increased material loss wasn't observed when lubrication was used. However, after repolishing, DIM with water showed the greatest material loss among the lubrication types. Even with this observation, the clinical relevance of material loss due to non-lubricated rubber use is uncertain, and further research is needed to elucidate this aspect.

After simulated aging, DIM with water and SOF with petroleum jelly showed greater material loss than the control group, which was not significantly different from their post-polishing levels, suggesting the initial material loss might have contributed to this result. Variability in findings might also be attributed to operator-dependent factors such as applied load and polishing speed, as suggested by Jones et al.[18] (2006). Stoddard and Johnson[19] (1991) also noted that the effectiveness of finishing and polishing systems is influenced by various parameters including time, motion, pressure, and instrument geometry. To mitigate these variables, a single trained operator conducted the polishing procedures in this study.

The findings of this study reveal varied effects on surface gloss, roughness, and material loss from the tested protocols. Understanding the underlying mechanisms of these phenomena is complex and extends beyond the scope of the current test results. Predicting average material loss, which is crucial for estimating restoration longevity, remains challenging, and the applicability of in vitro findings to clinical practice is limited. Polishing systems in this study were applied to smooth, fully accessible surfaces, conditions not always present clinically. Hence, further in vivo studies are necessary to determine the most effective polishing systems in the intraoral environment and on non-flat surfaces.

While the definition of a single polishing protocol could be important for clinicians, this study is unable to reach this definition, but concludes that several possibilities can be employed, with or without lubrication, answering the study question and contradicting the reports of specific protocols for success shown on social media. It would be important to be able to define all the consequences of the protocols used on the results obtained, however, the lack of detailed knowledge of the properties of the resins and polishes used, the influence of the operator, the accuracy limit of the tests used, and the variability of the information present in the literature do not allow this extrapolation to be made in an assertive/definitive way.

Literature lacks consensus on the optimal finishing and polishing protocols for resin composites. Some findings of this study are novel and are justified by clinical and experimental insights from the authors. The current clinical question remains open and merits additional investigation.

In conclusion, within the limitations of this study, it can be concluded that polishing system and lubrication protocol choices influence the behavior of surface gloss, roughness, and material loss. This complexity makes it challenging to establish a gold standard for polishing protocols, and clinicians should consider the type of polishing system and potential lubricant associations they employ.

However, none of the differences observed in this study reached the threshold for biofilm accumulation in roughness, nor were the gloss variations clinically perceptible, suggesting that all tested protocols may be suitable for clinical application.

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Conflict of Interest

The authors have no conflict of interest to disclose.

Data availability

Datasets related to this article will be available to the corresponding author upon request.

Author Contribution

Vanessa de Faria: conceptualization, formal analysis, data curation, writing. **Jefferson Pires da Silva Júnior:** investigation, software, writing. Taciana **Marco Ferraz Caneppele:** contribution, conceptualization, methodology. **Eduardo Bresciani:** review & editing, supervision. All the authors actively participated in the manuscript's findings and have revised and approved the final version of the manuscript.

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