

Evaluation of different types of polishing of composite resin surfaces after the removal of metal and ceramic brackets

Avaliação de diferentes tipos de polimento de superfície de resina composta após a remoção de bráquetes metálicos e cerâmicos

Mariana de Oliveira VIANA¹, Adriana Aparecida Faziolli Almeida DIAS¹, Sílvia Amélia Scudeler VEDOVELLO¹, Rogério Heládio Lopes MOTTA², Jose Augusto RODRIGUES³, Flávia Martão FLÓRIO⁴

1 – Department of Orthodontics – São Leopoldo Mandic School of Dentistry and Research Center – Campinas – SP – Brazil.

2 – Department of Pharmacology – São Leopoldo Mandic School of Dentistry and Research Center – Campinas – SP – Brazil.

3 – Department of Dentistry – Guarulhos University – UnG – Guarulhos – SP – Brazil.

4 – Department of Public Health – São Leopoldo Mandic School of Dentistry and Research Center – Campinas – SP – Brazil.

ABSTRACT

Objective: To evaluate the effectiveness of different methods of composite resin polishing after the removal of orthodontic brackets. **Material and Methods:** 160 resin discs made from a matrix of acrylic resin were divided into 4 groups, according to the type of composite resin used: G1 - microfilled (n = 40), G2 - microhybrid (n = 40), G3 - nanohybrid (n = 40) and G4 - nanofilled (n = 40). One half of the samples was subjected to thermocycling, at 2000 cycles from 5 ± 2 °C to 55 ± 2 °C, for 1 min each. Half of each group of resins was bonded with Gemini™ metallic brackets (3M Unitek) and the other half with Transcend™ ceramic brackets (3M Unitek). The brackets were transferred to a universal testing machine (EMIC DL model 2000). Half of the specimens from each subgroup were polished with diamond burs and the other half with Sof-Lex discs. The average surface roughness of composite resin discs was measured, using a profilometer, before the bonding of brackets, after the removal of brackets, after removing the excess resin and after polishing. **Results:** After removal of brackets and after polishing, the surface roughness was greater in the microhybrid group (ANOVA, p < 0.05). After removal of ceramic brackets, the groups showed higher surface roughness (ANOVA, p < 0.05). There was no significant difference in roughness related to thermocycling and the type of polishing. **Conclusion:** The quality of the polish is subjected to the type of resin used. Ceramic brackets provided rougher surfaces after removal. Both types of polishing used are effective.

KEYWORDS

Composite resins; Polishing; Surface roughness.

RESUMO

Objetivo: Avaliar a efetividade de diferentes métodos de polimento de superfície de resina composta após a remoção de bráquetes ortodônticos. **Material e Métodos:** 160 discos de resina composta foram confeccionados a partir de uma matriz de resina acrílica e divididos em 4 grupos, de acordo com o tipo de resina composta usada: G1- microparticulada (n = 40), G2- microhíbrida (n = 40), G3 nanohíbrida (n = 40), G4- nanoparticulada (n = 40). Metade das amostras foi submetida à termociclagem, com 2000 ciclos entre 5 ± 2 °C to 55 ± 2 °C, por um min cada. Metade de cada grupo o bráquete metálico Gemini™ (3MUnitek) e a outra metade o bráquete cerâmico Transcend™ (3M Unitek). A remoção dos bráquetes foi realizada em máquina de teste Universal (EMIC DL model 2000). Metade dos espécimes de cada subgrupo foi polido com pontas diamantadas e a outra metade com discos Sof-Lex. A média da rugosidade superficial dos discos de resina composta foi calculada usando-se um perfilômetro, antes da colagem dos bráquetes, após a remoção dos bráquetes, após a remoção dos excessos de resina e após o polimento. **Resultados:** O teste ANOVA mostrou que após a remoção dos bráquetes e após o polimento, a rugosidade superficial foi maior no grupo G2 (p < 0,05). Após a remoção dos bráquetes cerâmicos os grupos mostraram maior rugosidade superficial (p < 0,05). Não houve diferença estatisticamente significativa na rugosidade entre os grupos termociclados e os tipos de polimento. **Conclusão:** A qualidade do polimento está sujeita ao tipo de resina utilizada. Os bráquetes cerâmicos induzem a uma maior rugosidade superficial após a remoção. Ambos tipos de polimentos usados foram efetivos.

PALAVRAS-CHAVE

Resinas compostas; Polimento; Rugosidade da superfície.

INTRODUCTION

There is constant demand for esthetic restorative procedures in the daily practices of dental clinics and, among the esthetic dental materials developed over recent years, composite resins have played a prominent role [1].

With the evolution of composite resins, it has become possible to make dental restorations while preserving the dental structure and with excellent esthetic results [2]. Polishing ability is one of the main properties required [3] as it minimizes biofilm stagnation, gum inflammation and it prevents changes in color. If performed properly, polishing guarantees a reduction in surface roughness of composite resins by 26% to 74% [4].

The effectiveness of these procedures varies depending on the type of composite used, the polishing sequence employed and the characteristics of instruments, considered isolated or in combination [5].

Adult patients usually have esthetic restorations made of composite resins, which currently represents a considerable proportion of orthodontic patients [6]. The debonding of the brackets at the end of the treatment is achieved in two stages: the removal of bracket and the removal of residual composite adhering to the surface of enamel or dental restoration [7]. During this procedure, the professional should avoid damaging the surface receiving the bracket and restore its smoothness [8].

There is a vast amount of literature available on surface roughness of composite resins after polishing [9-11], and also the condition of the dental enamel after removing orthodontic brackets [12-15]. However there have been very few studies that aim to make an association between these variables [16] and which propose an analysis on quality of polishing in composite resins after the removal

of orthodontic brackets, a situation which occurs very often in daily clinical practice.

This study aimed to evaluate the effect of two types of polishing on the surface roughness of different types of composite resins after removal of metallic and ceramic orthodontic brackets.

MATERIAL AND METHODS

The experimental units consisted of 160 composite resin discs divided according to the type of resin used, namely:

- Group MF: Microfilled – Renamel Microfill – Shade A2 (Cosmedent Inc., Chicago, IL, USA) – Batch: 121006 AA

- Group MH: Microhybrid – Filtek Z250 – Shade A2

- (3M/ESPE, St. Paul, MN, USA) – Batches: N396503BR e N405166BR

- Group NH: Nanohybrid – Tetric N-Ceram – Shade A2

- (Ivoclar, Schaan, Liechtenstein) – Batches: R60303 e R60302.

- Group NF: Nanofilled – Filtek Z350 – Shade A2

- (3M/ESPE, St. Paul, MN, USA) – Batch: N400816.

The response variable “surface roughness” was evaluated quantitatively using the parameter Ra (μm) at four points in time. The experimental design was fully randomized. The three principles of experimental design were observed, namely: replication, randomization and local control.

A) Preparation of specimens:

For each group, a total of 40 resin discs were made from a standardized acrylic matrix with a diameter of 7 mm and thickness of 4 mm [17].

Using the incremental technique, the resin was inserted and photopolymerized (UL

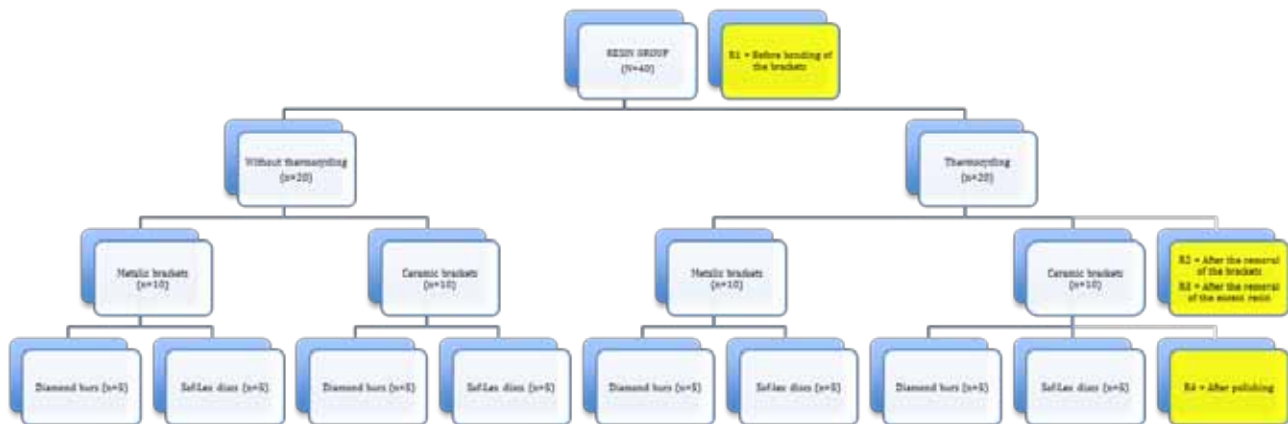


Figure 1 - Flow Chart: Division of specimens into groups and subgroups, and timing of roughness evaluations.

Ultralux EL photopolymerizer from Dabi Atlante, Indústria Médico e Odontológica – 500 mw/cm² - Ribeirão Preto, São Paulo, Brazil), following the manufacturer's instructions [18].

The 160 resin discs were inserted into PVC cylinders (Tigre® - Joinville, Santa Catarina, Brazil) and affixed with acrylic resin Jet® (Clássico, Brazil) in such a way that they would remain as centralized as possible.

After cleaning, the specimens were stored in distilled water for 30 days, in a 37 °C oven, simulating oral conditions [19].

Specimens were further polished using sanding discs (3M/ESPE, St. Paul, MN, USA) with grits of 400, 600 and 1200, mounted on a PL02 sander (TECLAGO Indústria e Comércio



Figure 2 - Specimen.

Ltda - Vargem Grande Paulista, São Paulo, Brazil) under refrigeration, in order to standardize the initial roughness of the resins [20].

B) Aging of the composite resin:

The thermocycling procedure was carried out on half of the specimens (n = 80), in an Thermal Cycle Simulation Machine (Elquip - São Carlos, São Paulo, Brazil), at 2,000 cycles and at temperatures dwell of 5 °C and 55 °C, for 1 min [21].

C) Bonding and debonding the brackets:

Two types of bracket were used: Gemini™ metallic brackets (n = 80) (3M/ESPE, St. Paul, MN, USA) and Transcend™ ceramic brackets (n = 80) (3M/ESPE, St. Paul, MN, USA), joined using Transbond™ XT resin (3M/ESPE, St. Paul, MN, USA), as recommended by the manufacturer [22].

After bonding, they were stored in distilled water in a 37 °C oven for 24 hours to prevent dehydration and then transferred to an EMIC DL-200N universal testing machine (EMIC – São José dos Pinhais, Paraná, Brazil). The shear bond strength test was performed at a speed of 0.5 mm per minute and using a 200 kgf load cell, which was the force required to promote the removal of ceramic brackets, as a standard method of bracket removal.

After the removal of the brackets, the specimens were polished. Firstly, the excess resin that remained stuck to the composite resin restoration was removed using multi-



Figure 3 - Removal of bracket.

blade burs (Orthometric® - Marília, São Paulo, Brazil) with 12 blades connected to a low-speed motor; these were replaced after every 10 applications [8].

One half of the specimens in each group was subjected to polishing with diamond burs, by a single operator, while the other half was polished using Sof-Lex discs, as described below:

POLISHING WITH DIAMOND BURS (n = 20): Polishing was carried out using no. 2135FF extra-fine diamond burs (KG Sorensen Ind. e Com. Ltda - Barueri, São Paulo, Brazil) connected to a high-speed handpiece, under refrigeration, with gentle pressure in one direction, for 20 s; they were replaced after every five applications [2,23].

POLISHING WITH SOF-LEX DISCS (n = 20): Polishing was carried out using a system of Sof-Lex discs (3M/ESPE, St. Paul, MN, USA) with a diameter of 19.5 mm, in the following order: back side coatings in dark blue, medium blue and light blue. Eight horizontal and unidirectional movements were performed using a low-speed handpiece; the discs were moistened with water and replaced after every two applications [4].

All procedures were performed by the same operator, which was calibrated previous, to standardize the pressure made on the specimens.

D) Roughness assay:

The profilometer used a microneedle (TR200, Time Group Inc - Beijing, China) to scan the surface roughness, employing the

parameter average surface roughness (Ra). Surface roughness was evaluated by a single blind evaluator prior to the bonding of the bracket (R1), after bracket removal, after excess resin removal and after polishing. Three points were initially marked in order to ensure repeatable measurements of the profiles. From these points, two perpendicular and one transverse profile were obtained on the surface of each specimen, with a cut of 0.80 mm (λ_c) and a speed of 0.1 mm/s. The surface roughness was recorded and the average roughness value (Ra expressed in μm) was determined for each specimen for each time.

E) Statistical analysis:

The surface roughness of the specimens was measured prior to the bonding of the brackets (R1), and again after the thermocycling; after the removal of the brackets (R2); after the removal of the excess resin (R3) and after polishing (R4), using a roughness meter.

After the descriptive and exploratory analysis of the data, the mixed model methodology was applied for repeated measurements using the PROC MIXED procedure in the SAS statistical program.

RESULTS

As can be seen from Table 1, there was no significant difference in the average roughness between the groups, either with or without thermocycling ($p = 0.2062$), regardless of the other factors studied.

As for the groups (microfilled, microhybrid, nanofilled and nanohybrid) there was no significant difference in average roughness between them prior to the bonding of the brackets (R1) ($p > 0.05$). After the removal of the brackets (R2), the roughness was significantly higher in the microhybrid group ($p \leq 0.05$), while there was no difference amongst the other groups ($p > 0.05$). After the removal of the excess resin (R3), the nanofilled group exhibited lower average roughness ($p \leq 0.05$) while there was no difference amongst the others ($p > 0.05$). After polishing (R4), both with Sof-Lex discs

and with diamond burs, the microhybrid group demonstrated a higher average roughness than the other groups ($p \leq 0.05$).

After the removal of the brackets (R2) and the removal of the excess resin (R3),

the difference between types of brackets was significant for all the groups studied ($p \leq 0.05$), with the ceramic brackets showing a higher level of roughness. After the final polishing (R4), both with the Sof-Lex discs and with the diamond

Table 1 - Average roughness (standard deviation) as a result of the treatments.

¹ Therm	² Brack	⁴ Poli	Groups	Time			
				⁹ R1	¹⁰ R2	¹¹ R3	¹² R4
With	Ceramic	Burs	⁵ MH	0.073 (0.011) Da	¹ 1.818 (0.042) Aa	⁹ 0.786 (0.103) Ba	0.321 (0.023) Ca
			⁶ MF	0.079 (0.022) Ca	¹ 1.631 (0.311) Ab	⁹ 0.777 (0.070) Ba	0.110 (0.017) Ca
			⁷ NH	0.082 (0.006) Ca	¹ 1.698 (0.123) Ab	⁹ 0.768 (0.051) Ba	0.174 (0.045) Ca
			⁸ NF	0.072 (0.007) Ca	¹ 1.664 (0.056) Ab	⁹ 0.754 (0.045) Bb	0.160 (0.074) Cb
With	Ceramic	Disc	MH	0.072 (0.006) Ca	¹ 1.833 (0.025) Aa	⁹ 0.752 (0.120) Ba	0.296 (0.008) Ca
			MF	0.065 (0.006) Ca	¹ 1.681 (0.141) Ab	⁹ 0.847 (0.098) Ba	0.100 (0.008) Ca
			NH	0.078 (0.013) Ca	¹ 1.639 (0.157) Ab	⁹ 0.730 (0.038) Ba	0.134 (0.050) Ca
			NF	0.070 (0.007) Ca	¹ 1.723 (0.080) Ab	⁹ 0.739 (0.042) Bb	0.158 (0.045) Cb
With	³ Metalic	Burs	MH	0.077 (0.014) Ca	1.797 (0.061) Aa	0.630 (0.037) Ba	0.201 (0.017) Ca
			MF	0.068 (0.017) Ca	1.469 (0.232) Ab	0.636 (0.161) Ba	0.079 (0.011) Ca
			NH	0.067 (0.014) Ca	1.480 (0.098) Ab	0.636 (0.053) Ba	0.135 (0.022) Ca
			NF	0.064 (0.022) Ca	1.600 (0.062) Ab	0.500 (0.079) Bb	0.109 (0.011) Cb
With	Metalic	Disc	MH	0.074 (0.018) Ca	1.668 (0.128) Aa	0.717 (0.084) Ba	0.227 (0.046) Ca
			MF	0.078 (0.016) Ca	1.573 (0.181) Ab	0.735 (0.155) Ba	0.091 (0.015) Ca
			NH	0.067 (0.017) Ca	1.452 (0.060) Ab	0.620 (0.074) Ba	0.250 (0.326) Ca
			NF	0.066 (0.017) Ca	1.595 (0.095) Ab	0.470 (0.084) Bb	0.090 (0.018) Cb
Without	Ceramic	Burs	MH	0.069 (0.009) Da	¹ 1.791 (0.095) Aa	⁹ 0.780 (0.070) Ba	⁹ 0.388 (0.039) Ca
			MF	0.059 (0.007) Ca	¹ 1.711 (0.077) Ab	⁹ 0.831 (0.053) Ba	⁹ 0.255 (0.055) Ca
			NH	0.073 (0.012) Ca	¹ 1.704 (0.191) Ab	⁹ 0.757 (0.063) Ba	⁹ 0.248 (0.070) Ca
			NF	0.066 (0.009) Da	¹ 1.701 (0.040) Ab	⁹ 0.767 (0.043) Bb	⁹ 0.303 (0.027) Cb
Without	Ceramic	Disc	MH	0.066 (0.012) Da	¹ 1.774 (0.096) Aa	⁹ 0.853 (0.055) Ba	⁹ 0.315 (0.051) Ca
			MF	0.064 (0.010) Ca	¹ 1.797 (0.068) Ab	⁹ 0.758 (0.097) Ba	⁹ 0.157 (0.040) Ca
			NH	0.074 (0.014) Ca	¹ 1.577 (0.072) Ab	⁹ 0.768 (0.044) Ba	⁹ 0.205 (0.078) Ca
			NF	0.068 (0.007) Da	¹ 1.665 (0.086) Ab	⁹ 0.765 (0.037) Bb	⁹ 0.297 (0.017) Cb
Without	Metalic	Burs	MH	0.069 (0.016) Ca	1.659 (0.070) Aa	0.656 (0.062) Ba	0.229 (0.033) Ca
			MF	0.067 (0.019) Ca	1.615 (0.088) Ab	0.573 (0.145) Ba	0.090 (0.022) Ca
			NH	0.113 (0.088) Ca	1.613 (0.027) Ab	0.597 (0.043) Ba	0.127 (0.023) Ca
			NF	0.062 (0.011) Ca	1.545 (0.085) Ab	0.456 (0.055) Bb	0.109 (0.022) Cb
Without	Metalic	Disc	MH	0.074 (0.006) Ca	1.726 (0.042) Aa	0.657 (0.061) Ba	0.190 (0.026) Ca
			MF	0.076 (0.020) Ca	1.654 (0.138) Ab	0.472 (0.148) Ba	0.095 (0.025) Ca
			NH	0.076 (0.007) Ca	1.504 (0.209) Ab	0.616 (0.063) Ba	0.103 (0.027) Ca
			NF	0.107 (0.093) Ca	1.590 (0.088) Ab	0.496 (0.034) Bb	0.097 (0.015) Cb

Caption: ¹Thermocycling; ²Brackets; ³Metal; ⁴Polishing; ⁵microhybrid; ⁶microfilled; ⁷nanohybrid; ⁸nanofilled; ⁹prior to shearing test; ¹⁰after shearing test; ¹¹after the removal of the excess resin; ¹²after polishing. Mean value followed by the same letters (upper case horizontally and lower case vertically) denotes no significance ($p > 0.05$)

burs, a significant difference was only found in groups not undergoing thermocycling ($p \leq 0.05$), and was also higher for ceramic brackets.

The highest average roughness was found after the removal of brackets (R2) for all groups in the study ($p \leq 0.05$), and the second highest was after removal of excess resin (R3). There was no difference in average roughness prior to bonding of brackets (R1) or after the final polishing (R4) ($p > 0.05$). There was also no significant difference in roughness between groups polished with Sof-Lex discs or with diamond burs.

DISCUSSION

Finishing and polishing are critical steps towards esthetic perfection and the durability of composite resins [18]. Restorations subjected to inadequate polishing are more susceptible to staining and to a buildup of biofilm bacteria, increasing the chance of gum inflammation and recurring caries [4,24].

Several authors [2,4,23,25-28] have been categorical in stating that the smoothest surfaces are obtained with the assistance of polyester abrasive strips, having used them in their studies when preparing the specimens. In the present study, the standardization of the specimens was conducted by metallographic polishing with sanding discs, under refrigeration [20,29,30], ensuring that the initial roughness of the specimens was similar. Surfaces conditioned using polyester strips are rich in organic matrix and should therefore be removed to avoid premature aging and staining of the resin, thereby requiring subsequent finishing and polishing procedures [23,26,27].

The polishing of composite resin restorations should afford a degree of smoothness similar to the enamel, leading to a clinically acceptable maximum value of up to $0.2 \mu\text{m}$ [24,31]. The results found show that the form of standardization used in this study

was effective, as it enabled all the specimens to present similar levels of roughness prior to the bonding of the brackets, levels which fall within clinically acceptable values.

The roughness analysis of the enamel surface or restoration consists of a safe, quantitative method for evaluating surface smoothness due to the ease of handling and accuracy of results [26]. There is standardization in the use of the parameter Ra in the literature, which facilitates comparison of results [4,17,25].

Thermocycling simulates thermal changes occurring in the oral cavity as a result of food intake and breathing, inducing repeated contraction and expansion, generating stress at the interface between the teeth and bonding material [32]. The presented results did not highlight any alteration in surface roughness due to aging via thermocycling, which was expected, since the intrinsic properties of the resins had not been evaluated, merely the surface roughness, considered to be a measurement for surfaces [33]. Moreover, due to the variety of components that could influence their performance (temperature, quantity and duration of each cycle), thermocycling is deemed to be a valid method for simulating the aging process, though making comparison difficult [34].

The presented results considered the influence of load particle size on the surface smoothness of the composite resin, both before and after final polishing. The microhybrid type resin exhibited high, sometimes clinically unacceptable, rates of surface roughness, after the removal of the brackets (R2) and after the final polishing (R4), when compared to other types of resin. Despite the fact that the other studied types did not show a statistical difference in the roughness value, an influence can be seen in the size of the inorganic load of each resin, since the characteristics of the microhybrid resins, i.e. higher quantity of inorganic load and smaller quantity of organic matrix, are prejudicial to the quality of the polishing [1,35,36].

Other authors [4,18,20,25] disagree, stating that composites containing smaller particles do not necessarily have lower rates of surface roughness as these are not the only characteristics that define the quality of the final polishing. This is partly consistent with what was found in the results of this study as, despite the microhybrid resin having stood out as having the roughest surface, the other resins (microfilled, nanohybrid and nanofilled) demonstrated similar results with regard to surface roughness. This may be explained by the percentage by weight of inorganic load contained in these resins. According to the manufacturers, the Renamel Microfill (microfilled) resin contains a percentage of 75% by weight, Filtek Z350 (nanofilled) 72.5%, Tetric N-Ceram (nanohybrid) between 80% and 81%, while Filtek Z250 (microhybrid) contains 82%. The percentage by weight of microfilled and nanofilled resins is lower than that found with the other resins. Despite this percentage being similar for the two hybrid resins, as was expected, the load composition is different; the resin Tetric N-Ceram being mainly composed of Barium while the Filtek Z250 is composed of Silica, which probably explains the difference.

According to the results, the surfaces that received ceramic brackets were found to be rougher after the removal of the brackets (R2) and after the removal of the excess resin (R3) in comparison with those that received metallic brackets. This behavior was also observed after the final polishing (R4) with Sof-Lex discs and diamond burs in samples that had not been subjected to thermocycling. It is assumed that the increase in surface roughness is directly related to the difficulty in removing the ceramic brackets [16], it not being uncommon to see a loss of minerals in the dental enamel, or even small fractures [37]. Due to the ceramic brackets having greater adhesion capacity, a greater force is required to completely remove them, which increases the chances of fracture [16]. These fractures appear as microscopic craters that make polishing difficult and adversely affect surface smoothness [38].

For a finishing and polishing system to be effective, the cutting particles of the abrasive material must be harder than the load component of the restorative material [25]. According to the results, the polishing carried out using Sof-Lex discs and diamond burs provided a similar surface smoothness, regardless of the type of resin used. This theory was supported by studies found in the literature according to which the aluminum oxide abrasive discs are superior to the diamond burs since the smaller particles on the disk and their characteristic malleability promote a uniform abrasion of the load particles and the organic matrix [2,4,23-25,28]. Moreover these studies emphasized that the diamond burs are more recommended for finishing due to their high abrasive power.

The same polishing technique was not followed by all authors studied. In this study, the diamond burs were connected to a high-speed handpiece, with continuous refrigeration while the Sof-Lex discs were connected to a low-speed handpiece, and moistened prior to use. This form of use is probably related to the diverging results presented as, even with the care taken to always use an air/water spray to rinse the surface that was being polished with the discs prior to the next stage, the absence of abundant refrigeration during the procedure could cause a buildup of particles from the abrasion, causing three-body wear, this type of wear being more aggressive to the surface that is being polished [39].

The nanofilled composite resins are at the end of the evolutionary scale of composite resins, as they are fabricated with the aim of improving the characteristics of esthetic restorations [36]. The polishing material selected for this type of resin must possess particles of lower grit size in order to abrade just the load particles of the composite, preventing them from being removed from their organic matrix and forming surface irregularities [35].

The two types of final polishing were effective in providing adequate surface smoothness as they exhibited similar levels of

roughness to those found prior to the bonding of the brackets; these are below the clinically acceptable thresholds with the exception of the microhybrid group. The high rates of roughness observed after the removal of the orthodontic brackets and after the removal of the excess resin, which are so prejudicial to the esthetics of restoration, may be remedied after the final polishing.

It is clear that, even with the constant evolution in composite resins, it is essential that the clinic does not neglect the performance of the polishing phase after removal of the orthodontic brackets, no matter whether they are metallic or ceramic. Gentle, targeted pressure, preferably accompanied by continuous refrigeration, produces smoother surfaces and, therefore, similar to the initial condition. Based on this study, if these recommendations are followed, this could be achieved with diamond burs or Sof-Lex discs for all four types of composite resins tested, as no statistically significant differences were found between them in relation to the levels of surface roughness.

CONCLUSION

Given the proposed aims and the data obtained in this study, it may be concluded that the quality of polishing is subject to the type of resin employed and that the ceramic brackets give rise to rougher surfaces after the removal. The microhybrid resin demonstrated the highest levels of surface roughness for the two types of polishing, when compared to the microfilled, nanohybrid and nanofilled resins. The diamond burs and Sof-lex discs are effective for the polishing of composite resins.

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**Prof. Flávia Martão Flório
(Corresponding address)**

Rua José Rocha Junqueira, 13
Ponte Preta – Campinas – SP - Brasil
Zip code: 13045-755
Email: flaviaflorio@yahoo.com

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