Superficial roughness on composite surface, composite-enamel and composite-dentin junctions after different finishing and polishing procedures. Part II: roughness with polishers treatment after carbide and diamond finishing and differences between enamel composite vs body composite

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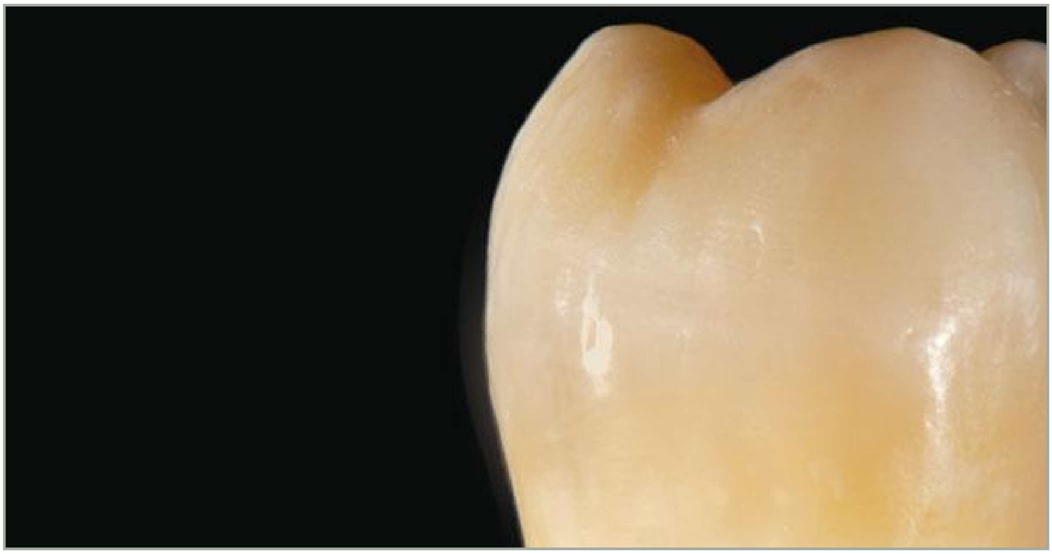

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Abstract

The following study asks three principle questions relative to composite finishing and composite polishing: *1)* Will the superficial roughness of different restoration surfaces have different values, utilizing the same polishing system (multistep), after finishing with the tungsten carbide or diamond bur? *2)* Under the same conditions of finishing and polishing sequences, will the composite surfaces (C), the composite-enamel (CE) and composite-dentin (CD) interfaces show different roughness values? *3)* Will the surface roughness of composites of different translucency in the various phases of finishing and polishing, and on different interfaces, have different results?

The null hypothesis is represented by the fact that there are no significant differences on roughness of composite restorations when polishing, after finishing with tungsten carbide or diamond burs. Furthermore, the null hypothesis is that there are no significant differences on roughness between polishing on composite surface, composite-enamel and composite-dentin interfaces, and finally there are no differences on roughness after finishing and polishing of two composite with different translucency. For the study, 56 class V cavities were prepared on extracted teeth.

Restorations were done in nanofilled composite Filtek XTE (3M Espe) in a standard fashion, and then finished and polished. The 28 buccal cavities were restored on the surface with composite enamel and the 28 palatals with composite body. Finishing was done with fine toothing burs in tungsten carbide (16 blades) or fine grit diamond burs (46 μm), and made by the same manufacturer (Komet). The second phase of finishing was done with burs (with the same form as already mentioned) ultrafine toothing tungsten carbide (30 blades) or with extra and ultrafine grit diamond (25 and 8 μm). The polishing phase for both of the earlier sequences was done with the application of three rubber tips with decreasing abrasiveness and an application with a self-polishing brush. All measurements were taken from surfaces C, and interfaces CE and CD. Statistical analyses were carried out with c2 test (a = 0.05).

Conclusions: *1)* There were no relevant differences of surface roughness on the different surfaces if the polishing was done after finishing with tungsten carbide or diamond burs. *2)* Keeping the same sequence of finishing and polishing, a difference was noticed between C, CE and CD, where the latter showed greater roughness. *3)* Analyzing the data in all the phases of finishing and polishing on every interface, it can be concluded that the composite enamel and the composite body did not show different levels of superficial roughness. The clinical relevance could be resumed as follows: no difference after polishing, which is preceded by tungsten carbide or diamond finishing burs. The less favorable interface to be polished is CD, compared to CE and C. Considering two composites with different translucency, no difference on roughness after finishing and polishing were detected.

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Introduction

The final polishing of composite restorations is an important factor with regards to esthetics and prevention of the accumulation of surface bacteria. In fact, it is difficult to obtain restorations that have a correct morphology and profile[1,2] and therefore maneuvers that optimize these two aspects become necessary. Two factors, among others, that can influence these are the characteristics of the composite material used, and the polishing protocol used.

Generally, different materials are compared, with different types of chemical composition and technology, to understand which are the best for surface polishing, given that not all materials offer the same surface characteristics.

From studies, it has been demonstrated that dentists dedicate a great amount of time to replacing old restorations.[3] These procedures are correlated to the development of secondary decay.[4,5] The principle areas are those where there is a greater stagnation of bacterial biofilm, for example the cervical margins of the restoration.[6]

The association between microfissures and the development of secondary decay has not been demonstrated by some studies,[3-5,7] while on the contrary, other data present in literature demonstrates the presence of this association,[8] underlining a conclusion of common sense: that it is correct to create a well polished surface with an absence of marginal microleakage on the restoration.

The final degree of polishing depends on the finishing procedures but also on the material used to restore. Some studies have shown how various nanofilled materials have an excellent surface quality.[9,10]

Polishing procedures can be carried out with different materials and systems. In fact, the rubber or silicone polishing inserts can have different compositions and different abrasive grades, but these may be substituted or associated with aluminum oxide discs or brushes that can give excellent surface polish.[11] For the final glossing pre-soaked brushes (usually in silicon carbide) or brushes with separate polishing pastes can be used, such as aluminum oxide or diamond paste.[12]

In this study, the surfaces were analyzed with a profilometer on class V restorations. The points in which the measurements were taken are the central surfaces of the restoration in composite (C) and the interfaces composite-enamel (CE) (crown middle third) and the composite-dentin (CD) (cervical third under the cementoenamal junction [CEJ]).

With this *in vitro* study, three different questions were asked: the first is relative to the degree of polishing after the use of rubber tips and pre-impregnated brushes (silicon carbide), previously finished with two different types of burs (tungsten carbide vs diamond burs), to understand if different roughness values are obtained on surfaces C, CE, and CD. The null hypothesis is represented by the fact that there are no significant differences on the roughness of restorations that were polished after finishing with tungsten carbide or diamond burs.

The second question was if maintaining fixed the variable of the sequence of finishing and polishing, whether the different surfaces C, CE, and CD represented different values of surface roughness. The null hypothesis is represented by the fact that there are no differences on roughness values in C, CE and CD surfaces.

The third question was relative to the material used for the restoration and its degree of polishing, comparing two masses of the same composite with different translucencies. The null hypothesis is represented by the fact that there were no differences on roughness values after finishing and polishing between two composites with different translucency levels. The material used is a nanoparticle, but different from other studies that examined material with different compositions. In this case, it was asked if using the same material with an enamel mass and a body (indicated for the reconstruction of tooth body or as a mass for simplified stratification, with intermediate translucency between enamel and dentin) made a difference in the surface roughness. Both materials used had the same quantity of filler by volume. For this analysis, restorations were carried out on buccal surfaces with composite enamel on surfaces, and on the palatal surfaces with composite body. The comparison of the roughness was done with fine and ultrafine grit and toothing burs, both in diamond and tungsten carbide, and finally polishing with rubber tips and brushes. All the measurements that were taken can be summarized by three main aspects:

- Comparison of the surface roughness after polishing on earlier finished restorations with different burs, on different interfaces.
- Comparison after finishing and polishing of the different interfaces of the restoration.
- Comparison of surface roughness between composite with different translucency (enamel and body), on different interfaces.

Finishing and polishing protocol

The finishing protocol considered in this study includes a sequence of burs (diamond vs tungsten carbide) from fine to ultrafine for the finishing phases (analyzed in Part I of this study[13] and also in this paper when comparing two composites with different translucency). The polishing protocol includes a sequence of polishers (from the coarsest to the finest) and a pre-impregnated polishing brush (analyzed in this paper). All details of manufacturing and codes of burs and polishers, number of passages for surfaces, number of restorations finished and polished with each single bur, are discussed in the materials and methods section.

Materials and methods

Cavity preparation and composite restorations

For this study, 28 fresh extracted non-carious human teeth were selected, stored for 15 days in solution saturated with thymol, and then in water for the duration of the study. They were mounted in resin cylinders up to the cervical third of the root and fixed with transparent acrylic resin (Ortho-jet, Lang Dental). Teeth were mounted in a special positioning device with acrylic resin embedding the root up to 4.0 mm below the cementoenamel junction (CEJ). All teeth were molars (Fig 1).

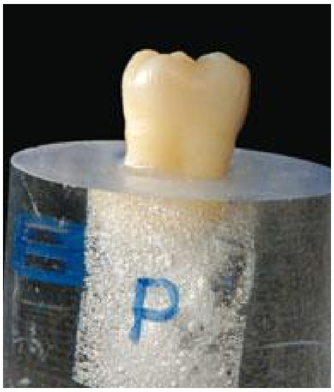


Fig 1 Specimen ready for the test.

Fig 2 An overview of all polishers and brush prepared for the *in vitro* study.

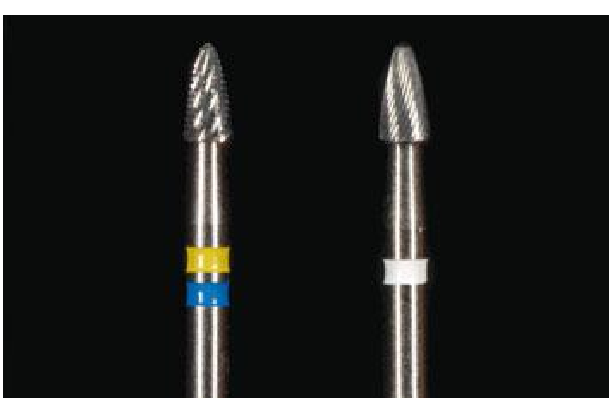


Fig 3 The carbide finishing version: a tungsten carbide fine toothing bur (16 blades) and a special tungsten carbide ultrafine cut bur (30 blades).

Two operators made the cavities, the restorations, and the finishing procedures, and the samples were assigned in a random fashion. A random draw among the two operators decided the cavities that each would carry out, each operator then made the 14 buccal cavities and the 14 palatal cavities with respective adhesive phases, stratification, finishing and polishing.

To reduce variability, specimen preparation, finishing and polishing procedures were carried out by the same operator.

All restorations and finishing procedures were carried out with prismatic magnifying loupes systems with 4 X magnification and 300 mm focal distance (Zeiss).

Tooth preparation and restoration

A standardized tooth preparation was applied to all specimens. Class V buccal and palatal cavities, were made on each specimen, the cavity dimensions all observed the same parameters and diamond burs mounted on a red ring speed-increasing handpiece, transmission 1:5 with water spray were used (INTRAcompact 25 LCS, Kavo). The bur used was rounded shape with a diameter of 1.6 mm with granulometry of 107 μm (801 314 016 Komet) and then a coherent form to the previous one, but with granulometry of 46 μm for the finishing phases (801 314 016 Komet). Finally for the finishing phases another polishing tip was used (9608 314 030, Komet).

The cavity dimensions are approximately the following: 1.6 to 2.0 mm depth, 5.0 to 6.0 mm width, and 3.0 mm height in the central part and 1.6 mm on

Fig 4 The appearance of the roughness surface of a class V composite restoration after the second phase, step 2, of finishing with a special tungsten carbide ultrafine toothing bur.

Fig 5 The first step of polishing procedures using composite polisher 95 μm interspersed with diamond grit.

the sides. The cervical extension under the CEJ is approximately 1.5 mm, in order to have a composite-dentin margin on which to carry out the finishing procedures.

Once the cavity preparation was completed, adhesive procedures were carried out to allow for composite restoration by etching with phosphoric acid 35% (Ultratech, Ultradent) for 30 s in enamel and 20 s in dentin. The cavity was rinsed for 60 s with a constant spray of water and air, and a chlorexidine galenic digluconate solution at 0.2% was applied on the dentin for 20 s[14] and then proceeded to aspirate slightly without dehydrate dentinal substratum, in order to avoid the the collagen fibers collapsing. The adhesive used was a three-step etch and rinse system (Optibond FL, Kerr), the alcohol based primer was applied for 60 s and after drying, a resinous bond was applied on the enamel and dentin for 30 s and polymerized for 30 s with a halogen lamp (Optilux 501, Kerr) at approximately 800 mW/cm^2.

A thin layer of flowable composite resin (less than 0.5 mm) of shade A3 (Tetric Flow, Ivoclar Vivadent) (Fig 15) was then applied at the bottom of the cavity and cured.

All cycles of polymerization of composite were carried out in the same fashion: a first ramping cycle for 20 s (10 s from 100 to 400 mW/cm2 and the last 10 s at 800 mW/cm^2), and a second cycle for 30 seconds at 800 mW/cm^2.

Finally, in the buccal cavity, two layers of nanofilled composite were applied, the first to simulate dentin with a thickness of approximately 0.5 to 1 mm A3 Body (Filtek XTE, 3M Espe), and the second, more superficial layer, with a thickness of approximately 0.5 to 1 mm A3 Enamel (Filtek XTE, 3M Espe) (filler by volume 63.3%), while in the palatal cavity, two layers of the same nanofilled composite were applied, in order to obtain a single type of composite A3 Body (Filtek XTE, 3M Espe) (filler by volume 63.3%), having a thickness of approximately 1.0 to 1.5 mm. The composites

Fig 6 The appearance of the roughness surface of a class V composite restoration after the first step of polishing procedures.

Fig 7 The second step of polishing procedures using composite polisher 40 μm interspersed with diamond grit.

Fig 8 The appearance of the roughness surface of a class V composite restoration after the second step of polishing procedures.

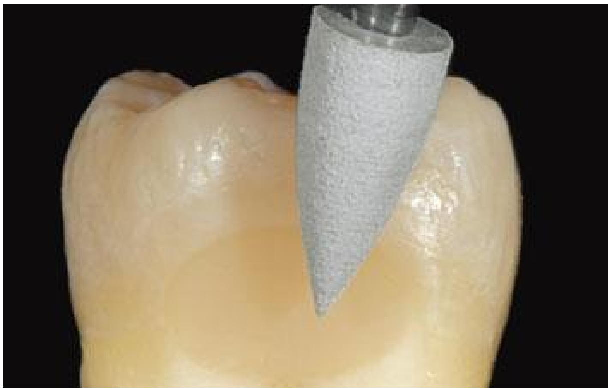


Fig 9 The third step of polishing procedures using composite polisher 6 μm interspersed with diamond grit.

Fig 10 The appearance of the roughness surface of a V class composite restoration after the third step of polishing procedures.

Fig 11 The last polishing step using a brush with special fibers interspersed with silicon carbide polishing particles.

were selected from the same batch number.

This is to evaluate if there is a difference of superficial roughness after the finishing and polishing, between the body mass and the enamel mass.

To complete the restoration, a sealer was applied to the margins of the composite to seal any tiny gaps (Optigard, Kerr), which was then polymerized for 30 s at 800 mW/cm². To completely convert the superficial composite, a gel air block was used on the restoration that was further polymerized for 30 s at 800 mW/cm² (Deox, Ultradent).

Having completed the restorations, the specimens were ready for the finishing and polishing procedures.

The specimens, once finished with carbide and diamond burs, will be polished using rubber tips and brushes by the same operator who carried out the restoration.

Finishing procedures

The finishing steps were divided into three phases (Table 1): phase 1 – fine grit or toothing bur; phase 2 – ultrafine grit or toothing bur; and phase 3 – rubber tips and polishing brushes. In both phases 1 and 2, a distinction was made between those specimens that are treated with diamond or tungsten carbide burs, while phase 3 included the same applications both for the specimens treated with diamond burs and those treated with tungsten carbide. In the first part of these two articles, only phases 1 and 2 were discussed.[13] In this second part, phase 3 will be examined, which compares polishing after finishing with tungsten carbide and diamond burs, and phases 1, 2 and 3 compares enamel composite and body composite.

Diamond and carbide burs were applied using light pressure in a single direction that was previously traced onto the specimen surface. After application on three surfaces, a new bur was used.

Fig 12 The appearance of the roughness surface of a class V composite restoration after the last polishing step with brush.

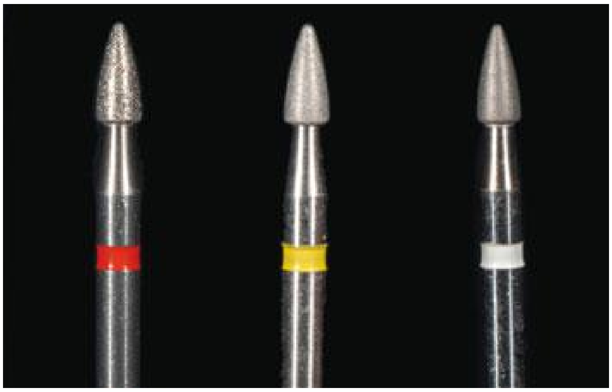


Fig 13 The diamond finishing phase: a fine grit diamond bur (46 µm), an extrafine grit diamond bur (25 µm) and an ultrafine grit diamond bur (8 µm).

Table 1 Details and codes of the rotary instruments used in the finishing phases

Type of burs	Manufacturer	Order number	Particle size/ number of blades
Phase 1 carbide fine	Komet	H390Q 314 018	16 blade
Phase 1 diamond fine	Komet	8390 314 016	46 micron
Phase 2 carbide ultrafine	Komet	H390 UF 314 018	30 blades
Phase 2 diamond extra/ultrafne	Komet	390EF 314 016/ 390UF 314 016	25/8 micron
Phase 3 polishers/ brush	Komet	9400 204 030/9401 204 030 9402 204 030/9685 204 060	95/40/6 microns and brush

Phases 1 and 2 of the finishing were carried out on 28 specimens (14 for each operator). For each of these, a buccal restoration and a palatal restoration were made (considering that the latter are only for comparison between enamel and body composite). The specimens were assigned in a random fashion for the cavity preparation and for completing the restoration. Furthermore, the specimens that were treated with tungsten carbide or diamond burs were also randomly selected. All finishing phases (phases 1 and 2) were carried out as described in part I of the article, using only burs with FG attachments mounted on a red ring speed-increasing handpiece, transmission 1:5 with water spray (INTRAcompact 25 LCS, Kavo); the speed of use is between 80,000 and 100,000 rpm. For every surface, the bur was applied five times, considering for the carbide burs the movement of the blades as well as the natural direction of the work and rotation, considering also that one of the two operators was left-handed.

According to the parameters already described, phase 1 was carried out using a cone-shaped diamond bur fine grit (red ring – 46 μm) (8390 314 016, Komet) on seven specimens (Fig 13) and a conical rounded tip with special cross-cut, tungsten carbide fine toothing (blue and yellow ring, 16 blades), (H390Q 314 018, Komet) on the other seven specimens (Fig 3).

The specimens were then analyzed in an anonymous fashion (the roughness profilometer operator did not know which burs were used on the various specimens) in the Komet center in Lemgo with the roughness profilometer (Perthometer S8P 4.51, Mahr) and the superficial roughness was analyzed by choosing three different substrates: composite (at the center of the restoration (C), interface composite-enamel (CE) and the composite-dentin interface (CD). After the measurements of superficial roughness, the second phase of finishing took place.

The results that were obtained were supplied according to different parameters: highest peak (Rmax); mean roughness average (Rz); average roughness (Ra); and the difference between the highest peak and the lowest valley (Rt), which were all measured in yoctometers (ym) 10^{-24} m. It was decided to use the Rz data that represents the average height difference between the five highest peaks and the five deepest valleys. This is a method suggested for short surfaces.

Phase 2 was carried out following the same principles as those employed in phase 1, using extrafine burs (yellow ring, 8 μm) and ultrafine diamond burs (white ring, 25 μm) respectively (390 EF 314 016 and 390 UF 314 016, Komet) (Fig 13) with five applications each, on those specimens already treated with diamond burs, while the seven specimens treated with tungsten carbide fine burs were finished with burs of the same type, but ultrafine (white ring, 30 blades) (H390 UF 314 018, Komet) (Fig 3). The speed of use remained between 80,000 and 100,000 rpm. The specimens were analyzed again with the roughness profilometer following the same parameters as in phase 1.

Phase 3 was carried out after phase 2 was complete (Figs 4 and 14), and therefore passing from finishing to polishing. The procedures that follow were the same for all the cavities with the use of rubber tips for composite polishers, interspersed with diamond grit used

Fig 14 The appearance of the roughness surface of a class V composite restoration after the second phase, step 2, of finishing with an ultrafine grit diamond bur.

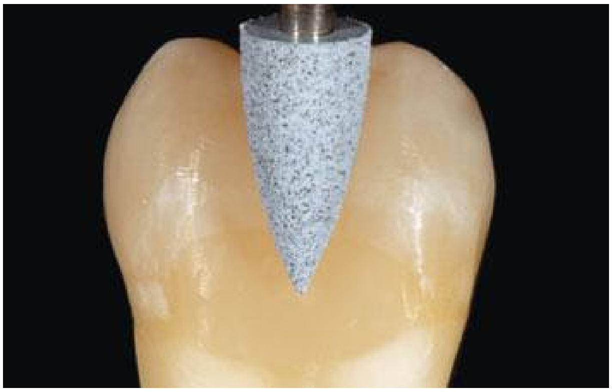


Fig 15 The first step of polishing procedures using composite polisher 95 μm interspersed with diamond grit.

Fig 16 The appearance of the roughness surface of a class V composite restoration after the first step of polishing procedures.

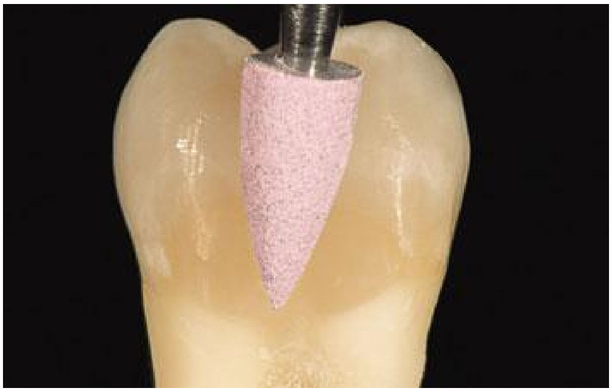


Fig 17 The second step of polishing procedures using composite polisher 40 μm interspersed with diamond grit.

Fig 18 The appearance of the roughness surface of a class V composite restoration after the second step of polishing procedures.

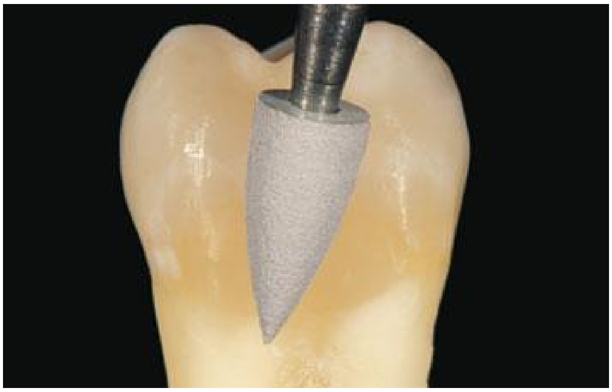


Fig 19 The third step of polishing procedures using composite polisher 6 μm interspersed with diamond grit.

Fig 20 The appearance of the roughness surface of a class V composite restoration after the third step of polishing procedures.

Fig 21 The last polishing step using a brush with special fibers interspersed with silicon carbide polishing particles.

Fig 22 The appearance of the roughness surface of a class V composite restoration after the last polishing step with brush.

with spray coolant, mounted on a blue ring handpiece, transmission 1:1 (INTRAcompact 20 LH, Kavo, Biberach, Germany) (Fig 2).

A blue-colored rubber tip with coarse grit (95 μm, 9400 204 030, Komet) was applied first on the restorations finished with tungsten carbide burs (Figs 5 and 6) and diamond burs (Figs 15 and 16), a pink-colored rubber tip with a medium grit (40 μm, 9401 204 030, Komet) (Figs 7, 8, 17, and 18) was then applied, and finally a third grey-colored rubber tip with a fine grit (6 μm, 9402 204 030, Komet) was applied (Figs 9, 10, 19, and 20). The rubber tips were used, as advised by the manufacturer, with cooling spray and at a high speed of rotations between 6,000 and 15,000 rpm. Finally, the restorations were further polished using a brush (9685 204 060, (Komet) (Figs 11, 12, 21, and 22) containing special fibers interspersed with silicon carbide polishing particles used without polishing paste. The brush was used, as suggested by the manufacturer, without cooling spray and at a speed ranging from 6,000 to 10,000 rpm. The rubber tips and brushes were applied 5 times on the surfaces to be polished. Once the polishing procedures of this phase were completed, the specimens were once again measured with the roughness profilometer (Fig 23).

Statistical analysis

Descriptive statistics were used to present the sample (mean ± SD); data were expressed in ym (10-24 m). Evaluation of the finishing phase was performed using the c2 test. Data analysis was performed using the software STATA (Stata Statistical Software: Release 10. College Station, StataCorp 2007). An a error of 0.05 was accepted as a statistically significant difference.

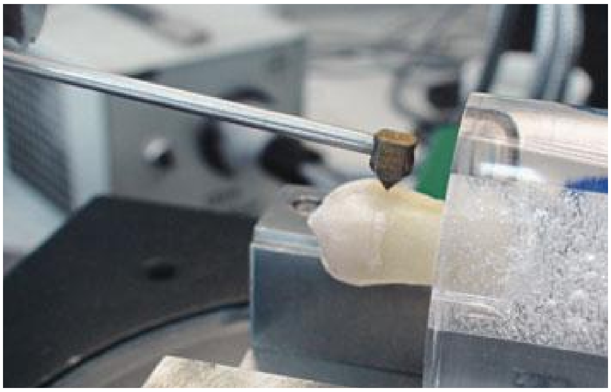
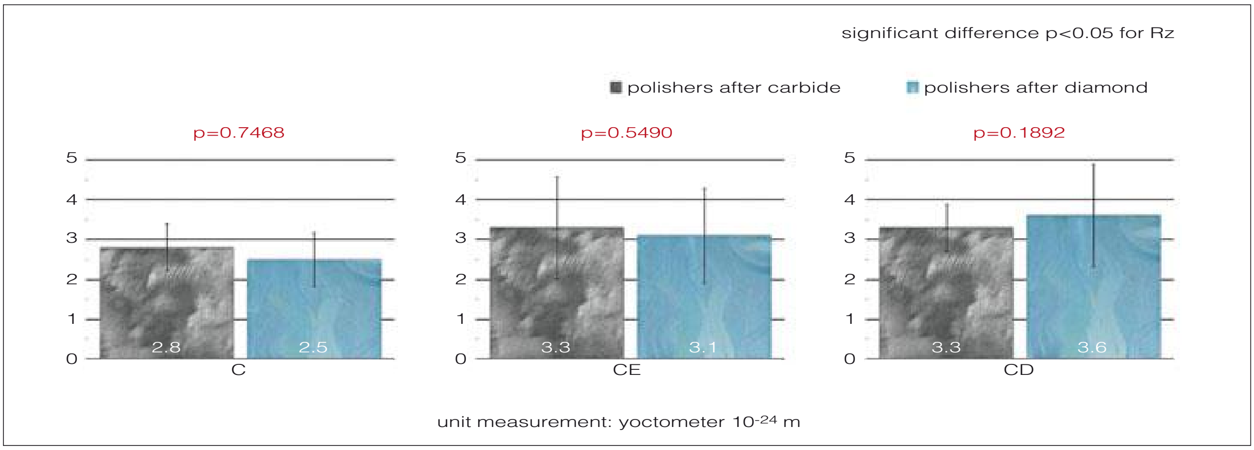


Fig 23 The profilometer in action after the last polishing step.

Fig 24 The composite surface after all finishing and polishing phases.

Table 2 Mean roughness depth (Rz) in ym of polishers after tungsten carbide or diamond burs on buccal surfaces on different substrates

	Composite dentin	Standard deviation	Composite enamel	Standard deviation	Composite	Standard deviation
Tungsten carbide	3.3	0.6	3.3	1.3	2.8	0.6
Diamond	3.6	1.3	3.1	1.2	2.5	0.7



Results

Finishing: polishers after carbide burs vs polishers after diamond burs

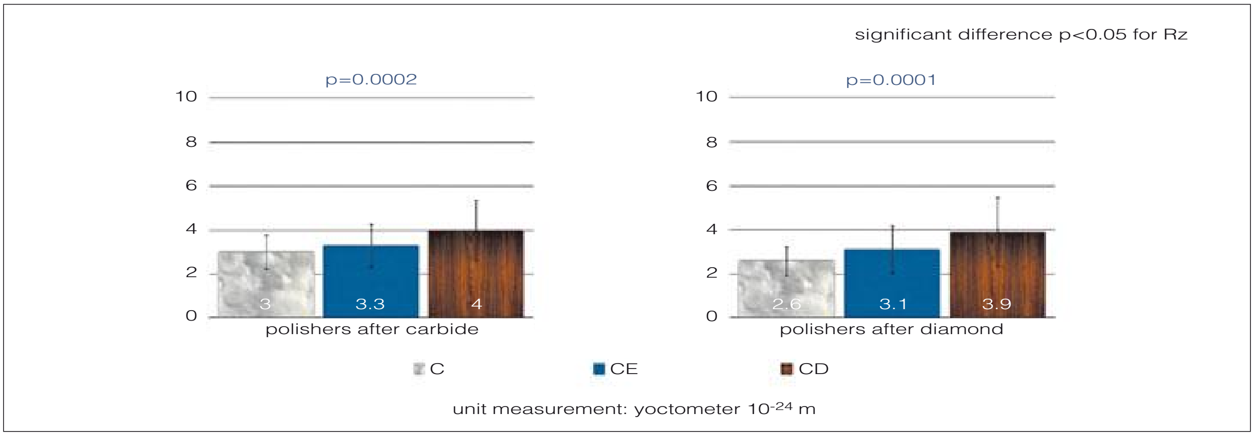
Considering that the polishing with rubber tips and brushes was carried out on surfaces of nanofilled composite (enamel) finished with a sequence of tungsten carbide burs, statistically significant differences were not observed with regards to surfaces polished in the same manner after finishing with a sequence of diamond burs, in any of the three areas of measurement: composite surfaces (C), composite-enamel interface (CE) and composite-dentin interface (CD) (Table 2).

Surfaces: composite vs composite-enamel junction vs composite-dentin junction

Considering the surface to be polished as the principle variable, it was observed that there was a statistically significant difference between C (surface with the least roughness), CE (junction with intermediate roughness) and CD (junction with the most roughness). This data refers both to the polishing after tungsten carbide sequence as well as diamond burs (Table 3).

Table 3 Mean roughness depth (Rz) in ym on different interfaces using polishers after finishing with tungsten carbide or diamond burs

	Polishers tungsten carbide	Standard deviation	Polishers diamond	Standard deviation
Composite	3.0	0.8	2.6	0.7
Composite enamel	3.3	1.0	3.1	1.1
Composite dentin	4.0	1.4	3.9	1.6



Materials: composite enamel vs composite body

The comparison carried out on the superficial roughness between the composite enamel and composite body was articulated in 18 different situations, combining the variables tungsten carbide and diamond burs, fine and ultrafine grit, polishing with rubber tips, and the different surfaces C, CE, and CD.

A statistically significant difference was not noted among most of the surfaces in comparison with the same finishing or polishing treatment received.

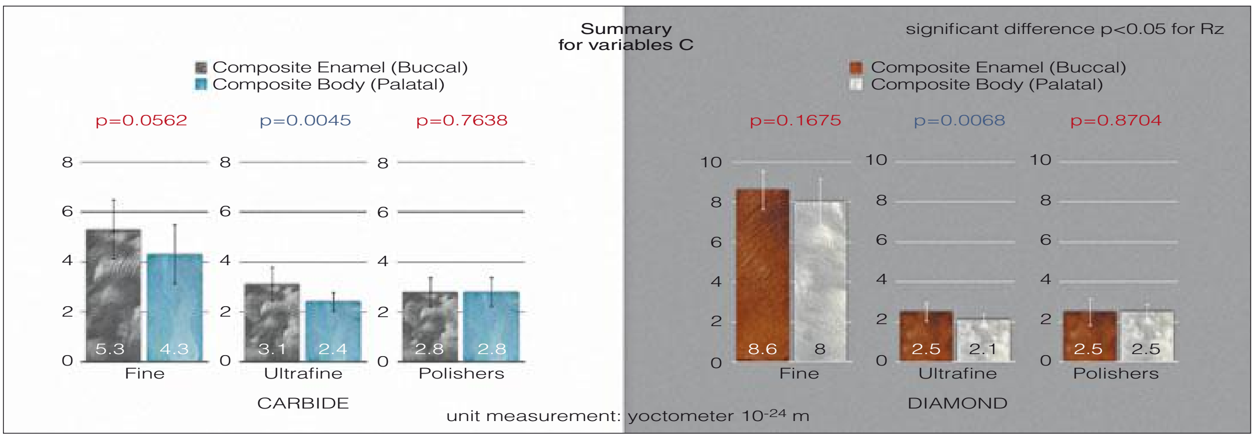
Only in four cases was a significant difference noted, with a minor superficial roughness in favor of the CE with polishing after tungsten carbide burs on junction CD. In three cases, there was a difference with minor superficial roughness in favor of the composite body with ultrafine burs, both tungsten carbide and diamond on surface C and with fine grit diamond burs on junction CE (Tables 4 to 6).

Discussion

The relevance of a good superficial finishing is a determining factor towards the final result in terms of esthetic integration and should therefore not be

Table 4 Mean roughness depth (Rz) in ym on C considering different surfaces: buccal (enamel composite on top) and palatal (body composite on top) with different types of rotary instruments

	Carbide						Diamond					
	Fine	Sd	Ultrafine	Sd	Polishers	Sd	Fine	Sd	Ultrafine	Sd	Polishers	Sd
Buccal	5.3	1.2	3.1	0.7	2.8	0.6	8.6	1.0	2.5	0.5	2.5	0.7
Palatal	4.3	1.2	2.4	0.4	2.8	0.6	8	1.2	2.1	0.3	2.5	0.4



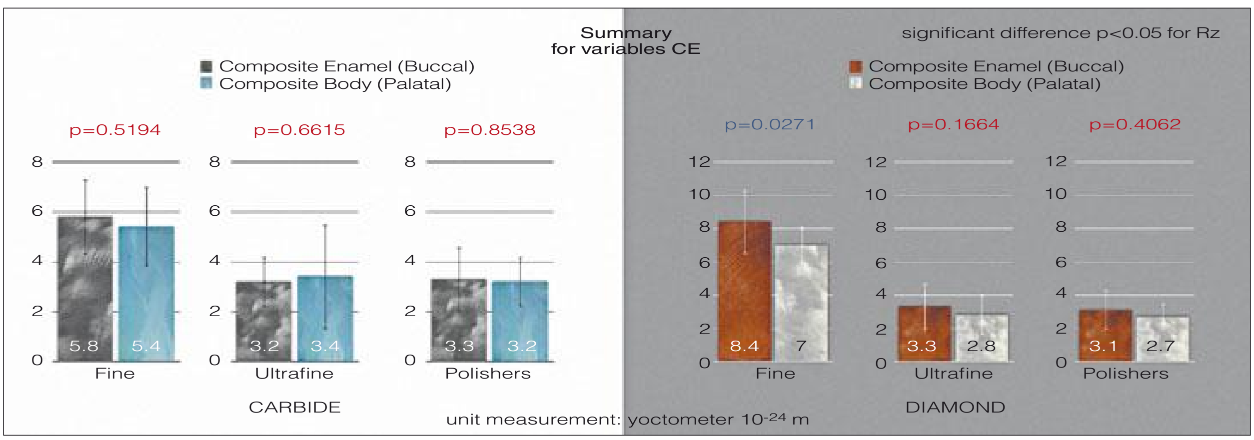
underestimated when searching for an elevated level of integration of the restoration. Simulating the smoothness and the roughness of natural tooth surfaces can give a final natural quality that is otherwise not attainable.

In addition, the importance of having a restoration with surface characteristics similar to the tooth diminishes the possibility of the formation of a biofilm that increases the ability of bacteria to colonize in the oral cavity.[7,15] The accumulation of this biofilm on the dental structures can cause secondary caries. The mechanical action of brushing produces a disorganization of the biofilm that can prevent or arrest the development of caries.[16]

Nonetheless, according to some studies it can be concluded that microleakage and surface roughness do not influence the formation of white spot lesions around the composite resin restorations,[17] as other studies found that the presence of microleakage at the adhesive interface did not significantly affect the enamel demineralization, reinforcing the lack of association between microleakage and caries adjacent to the restoration.[3-5,7] On the contrary, microleakage is still considered, by some authors, as an etiologic factor for secondary car-

Table 5 Mean roughness depth (Rz) in ym on CE considering different surfaces: buccal (enamel composite on top) and palatal (body composite on top) with different types of rotary instruments

	Carbide						Diamond					
	Fine	Sd	Ultrafine	Sd	Polishers	Sd	Fine	Sd	Ultrafine	Sd	Polishers	Sd
Buccal	5.8	1.5	3.2	1.0	3.3	1.6	8.4	1.9	3.3	1.4	3.1	1.2
Palatal	5.4	1.6	3.4	2.1	3.2	1.0	7	1.1	2.8	1.2	2.7	0.8



ies.[8] Furthermore, the bacterial adhesion on the surface of composite resins has been considered an important parameter in the etiology of caries formation around restorations.[18]

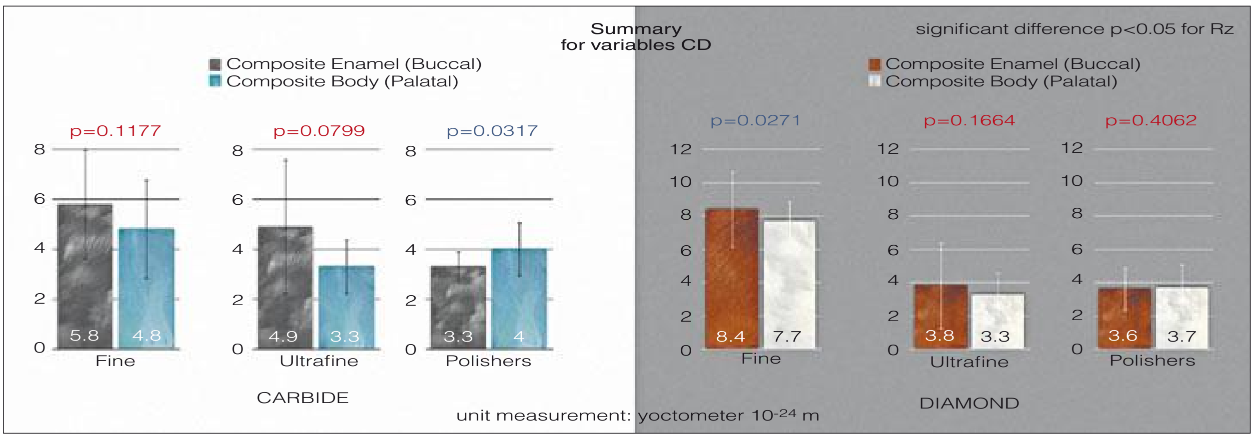
It is therefore considered an act of common sense, even if some literature does not agree, to retain that there is a correlation between marginal irregularities and superficial bacteria accumulation of restorations and secondary caries, and that it is appropriate to obtain a surface that is as free of microleakage as possible, not just for esthetic reasons.

The application of polishing systems after having carried out the restoration with cutting instruments (tungsten carbide) or abrasive (diamond) is generally required for an optimal final result. In the past, Goldstein has pointed out that hybrid composites could achieve a smoother surface with a fine diamond bur and two grades of rubber cups.[19,20]

Two systems of polishing exist: one-step and multiple-step. When looking at the literature, there are disagreements on which of the two is the more effective method to obtain a better result, in fact, according to some studies it was shown that one-step systems were superior or at least comparable to multi-step techniques for traditional composites,[21-24]

Table 6 Mean Roughness Depth (Rz) in ym on CE considering different surfaces: buccal (enamel composite on top) and palatal (body composite on top) with different types of rotary instruments

	Carbide						Diamond					
	Fine	Sd	Ultrafine	Sd	Polishers	Sd	Fine	Sd	Ultrafine	Sd	Polishers	Sd
Buccal	5.8	2.2	4.9	2.7	3.3	0.6	8.4	2.3	3.8	2.6	3.6	1.3
Palatal	4.8	2.0	3.3	1.1	4	1.1	7.7	1.2	3.3	1.3	3.7	1.4



but in some cases the results were product-related.[9,25]

In accordance with the current results, Watanabe et al[26] showed that the surface finishing using multiple-step polishing systems was superior to that obtained with one-step systems and Jung et al[27] demonstrated how three-step rubber polishers were more efficient than two-step and one-step polishing methods on nanoparticle and hybrid composite resins.

This study takes into account a multi-step system with polishers followed by silicone tips soaked with diamond (containing special fibers interspersed with silicon carbide polishing particles used without separated polishing pastes). The polisters were at different levels of abrasiveness, used in decreasing order. The grit of the three polishers is 95 μm (blue), 40 μm (pink) and 6 μm (grey), so the first two are rougher compared the burs used for the previous finishing. The clinical consideration is represented by the fact that if we use a full sequence of polishers after the fine or ultra-fine finishing with burs, we come back in roughness and we could eliminate some benefits obtained before the polishing. We have to underline how only the grey polisher was more fine compared the burs. To use more polishers could have some clinical sense considering that not only the grit is the issue but also the type of tip (burs vs polishers) and the speed the polisher is set at. Finally, the special fibers interspersed with silicon carbide polishing particles brushes were used and were proven inefficient after finishing with a single fine diamond bur,[27] but it must be the last step of a careful polishing. In addition, some analysis found, at both the enamel and the dentin margins, no statistically significant differences in microleakage across bur types. Further results show that dentin margins leaked significantly more than enamel margins for all bur types,[28] a conclusion that the first part of this study confirms. Another difference of surface roughness can be present after using the tungsten carbide bur rather than the diamond bur.

A clinical indication that is derived from the data obtained in this study is that surface roughness after polishing (that was preceded by finishing with tungsten carbide or diamond burs) does not show differences, on the various substrata, between the two different types of burs. With both systems of burs and the subsequent polishing, the junction CD always shows more surface roughness with respect to CE and C.

For this *in vitro* study, nanofilled composite material was used, because this vast category has demonstrated that it is able to offer an excellent surface polishing,[9,10] together with other aspects that cannot be overlooked, such as excellent mechanical properties[29] and low shrinkage.[30]

Furthermore, in reference to the characteristics of surfaces, nanofilled materials show low wear[21] and increased wear resistance.[25,31]

The material used for this study was Filtek Supreme XTE (3M Espe), it is not simply nanofilled, but is a nanoparticle, substituted by nanoparticles that form a cluster of greater dimensions and are therefore called nanoclusters. This material gives excellent results with regards to surface roughness.[32]

Another specification with regards to the Filtek XTE (3M Espe) is regarding the colorimetric scale. First, the different colorations follow a vita shade guide for three types of principle masses, which are enamel, body, and dentin. The enamel is a mass with high translucency (in the Filtek system only the composites called "translucents" are less opaque compared to "enamles", and are usually used to give particular translucent effects, especially in the incisal restorations) that are applied in multilayer stratifications on the surface to simulate the enamel of natural teeth, the dentin mass is the most opaque and has indications for use on the bottom of the cavity to mask deep dyschromia or create a base on which to layer the other masses. The body is a mass of intermediate opaqueness between enamel and dentin, which has the purpose of representing the body of a tooth in a restoration with multilayer stratification, or it is the advised mass in a stratification simplified to only one mass.

For this last alternative, to have the body on the surface with respect to composite enamel (the two materials have the same filler percentages), this study sought to compare the roughness after finishing and polishing of class V restorations with the two different masses to represent the surface layer, as can be deduced from the paragraph of materials and methods. Therefore the class V cavities were reconstructed with composite enamel on the surface. To not have a variable determined by other teeth, the restorations with composite body on the surface were carried out on cavities on palatal surfaces of the same samples.

In some conditions, the clinician may choose not to use the complete layering with enamel on the surface, and position material with slightly higher opaqueness on the surface of the restoration, or use a single mass of material with intermediate translucency. The change of translucency of a material can be obtained by the manufacturer in different manners, acting on the composition, for example changing the percentage of filler and resinous matrix or the most suitable way is represented by the use of fillers with different refractive indexes. For the clinician, it is important to know that the degree of polish of the material remains the same, even with different translucency properties. This study affirms that using the two masses of the nanoparticle system Filtek Surpeme XTE (3M Espe), which is most regularly used for the surface of restorations (enamel and body) achieves the same levels of superficial polishing.

Conclusions

Within the limitations of this study, the following conclusions can be drawn for clinical purposes, relative to direct composite restorations:

- Comparing the surface roughness of the same sequence of polishing with rubber tips in decreasing order of abrasiveness and self-polishing brushes, on surfaces earlier finished with tungsten carbide or diamond burs, no statistically significant differences were noted. The observations and the comparisons interested both the surfaces in composite (C) and the composite-enamel (CE) and composite-dentin (CD) interfaces.
- Comparing the different surfaces after polishing, whether previously finished with tungsten carbide or diamond burs, statistically significant differences of superficial roughness were noted between the surface C (the least), CE (intermediate) and CD, which showed the highest coarseness.
- Comparing the surface roughness of the same material of restoration at different translucencies, composite enamel and composite body, with different variables (types of finishing, polishing, and surfaces C, CE, and CD), in most conditions statistically significant differences were not noted. Clinically, it can be concluded that there are not differences between the two materials with regards.

Clinical relevance

Considering the measurement unit to analyze the roughness with the profilometer, the yoctometer (10^{-24} m), this study shows some statistical differences that could not be clinically perceivable.

- The null hypothesis that considers that there are no significant differences on the roughness of composite restorations polishing after finishing with tungsten carbide or diamonds burs, can be accepted. If you polish, it is irrelevant what type of bur is used for previous finishing.

- The null hypothesis that considers that there are no significant differences in roughness between polishing on composite surfaces, composite-enamel and composite-dentin interfaces could be rejected because from a clinical point of view, the CD interface is the most difficult to finish compared to C and CE surfaces.
- The null hypothesis that considers that there are no differences in roughness after the finishing and polishing of composites with different translucency (enamel and body) with the same quantity of filler by volume, can be accepted.

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References

1. Ozgunaltay G, AR Yazici, J Gorucu. Effect of finishing and polishing procedures on the surface roughness of new tooth-coloured restoratives. J Oral Rehabil 2003;30:218–224.
2. Yap AU, CW Sau, KW Lye. Effects of finishing/polishing time on surface characteristics of tooth-coloured restoratives. J Oral Rehabil 1998;25:456–461.
3. Kidd EAM, J-BS, Beighton D, Diagnosis of secondary caries: a laboratory study. Br Dent J 1994;176:135–139.
4. Mjor IA. Clinical diagnosis of recurrent caries. J Am Dent Assoc 2005;136:1426–1433.
5. Özer L, Thylstrup A. What is known about caries in relation to restorations as a reason for replacement? A review. Adv Dent Res 1995;9:394–402.
6. Mjor IA and Toffenetti F. Secondary caries: a literature review with case reports. Quintessence Int 2000 31:165–179.
7. Cenci MS, Tenuta LM, Pereira-Cenci T, Del Bel Cury AA, ten Cate JM, Cury JA. Effect of microleakage and fluoride on enamel-dentine demineralization aroud restorations. Caries Res 2008 42:369–379.
8. Fontana M, Gonzalez-Cabezas C. Secondary caries and restoration replacement: an unresolved problem. Compend Contin Educ Dent 2000 21:15–18, 21–24, 26 passim; quiz 30.
9. Yap AU, Yap SH, Teo CK, Ng JJ. Comparison of surface finish of new aesthetic restorative materials. Oper Dent 2004 29:100–104.
10. Silikas N, Kavvadia K, Eliades G, Watts D. Surface characterization of modern resin composites: a multitechnique approach. Am J Dent 2005;18:95–100.
11. Hoelscher, D.C., et al., The effect of three finishing systems on four esthetic restorative materials. Oper Dent 1998 23:36–42.
12. Vanini L, Mangani F, Klimovskaia O. The Conservative Restoration of Anterior Teeth. Treatment of Composite Surfaces. Viterbo: Acme Edizioni, 2005:449–455.
13. Ferraris F, Conti A. Superficial roughness on composite surface, composite enamel and composite dentin junctions after different finishing and polishing procedures. Part I: roughness after treatments with tungsten carbide vs diamond burs. Int J Esthet Dent 2014;9:70–89.

14. Breschi L, Mazzoni A, Nato F, Carrilho M, Visintini E, Tjäderhane L, et al. Chlorhexidine stabilizes the adhesive interface: a 2-year in vitro study. Dent Mater 2010 26:320–325.
15. Marsh P, Nyvad B. The oral microflora and biofilm on teeth. In: Fejerskov O, Kidd EAM (eds). Dental Caries: The Disease and its Clinical Management. London: Wiley-Blackwell, 2003:29–48.
16. Holmen L, Thylstrup A, and Artun J. Clinical and histological features observed during arrestment of active enamel carious lesions in vivo. Caries Res 1987 21:546–554.
17. Lima FG, Romano AR, Correa MB, Demarco FF. Influence of microleakage, surface roughness and biofilm control on secondary caries formation around composite resin restorations: an in situ evaluation. J Appl Oral Sci 2009;17:61–65.
18. Montanaro L, Campoccia D, Rizzi S, Donati ME, Breschi L, Prati C, et al. Evaluation of bacterial adhesion of Streptococcus mutans on dental restorative materials. Biomaterials 2004;25:4457–4463.
19. Goldstein GR, Waknine S. Surface roughness evaluation of composite resin polishing techniques. Quintessence Int 1989;20:199–204.
20. Quiroz L, Lentz D. The effect of polishing procedures on light-cured composite restorations. Compendium Contin Dent Educ 1985;6:437–439.
21. Turssi CP, Ferracane JL, Serra MC. Abrasive wear of resin composites as related to finishing and polishing procedures. Dent Mater 2005;21:641–648.
22. Paravina RD, Paravina RD, Roeder L, Lu H, Vogel K, Powers JM, et al. Effect of finishing and polishing procedures on surface roughness, gloss and color of resin-based composites. Am J Dent 2004;17:262–266.
23. Turkun LS, Turkun M. The effect of one-step polishing system on the surface roughness of three esthetic resin composite materials. Oper Dent 2004;29:203–211.
24. St-Georges AJ, Bolla M, Fortin D, Muller-Bolla M, Thompson JY, Stamatiades PJ. Surface finish produced on three resin composites by new polishing systems. Oper Dent 2005;30:593–597.
25. Yap AU, Tan CH, Chung SM. Wear behavior of new composite restoratives. Oper Dent 2004 29:269–274.
26. Watanabe TM, Miyazaki M, and Moore BK. Influence of polishing instruments on the surface texture of resin composites. Quintessence Int 2006 37:61–67.
27. Jung M, Voit S, Klimek J. Surface geometry of three packable and one hybrid composite after finishing. Oper Dent 2003;28:53–59.
28. Shook LW, Turner EW, Ross J, Scarbecz M. Effect of surface roughness of cavity preparations on the microleakage of Class V resin composite restorations. Oper Dent 2003. 28(6): 779–785.
29. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc 2003 134:1382–1390.
30. Chen MH, Chen CR, Hsu SH, Sun SP, Su WF. Low shrinkage light curable nanocomposite for dental restorative material. Dent Mater 2006;22:138–145.
31. Xu HH, Quinn JB, Giuseppetti AA. Wear and mechanical properties of nano-silica-fused whisker composites. J Dent Res 2004;83:930–935.
32. Janus J, Fauxpoint G, Arntz Y, Pelletier H, Etienne O. Surface roughness and morphology of three nanocomposites after two different polishing treatments by a multitechnique approach. Dent Mater 2010;26:416–425.