Original Article

Ceramic Surface Polishing Techniques After Removal of Orthodontic Adhesive

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ABSTRACT

Objective: Verify the in vitro effectiveness of different porcelain surface polishing systems used after orthodontic debonding.

Materials and Methods: Restorations were simulated by 52 metallic samples covered with glazed feldspathic porcelain. Four of these intact samples composed the control group (C). The remaining samples were divided into four groups (n = 12), according to the surface preparation they were to receive: no surface treatment (G1); roughened with a diamond bur (G2); etched with 10% hydrofluoric acid (G3); and sandblasted with aluminum oxide (G4). All experimental samples were treated with silane and bonded with a primer and standardized amount of adhesive. After composite removal, each group was divided into subgroups randomly (n = 4), according to the porcelain polishing system used: Edenta (P1); Identoflex (P2); and Komet (P3). All 52 sample-surfaces were evaluated quantitatively with a profilometer, and a mean roughness profile (Ra) value was determined for each sample. Both control and experimental specimens were evaluated qualitatively using a scanning electron microscope (SEM) to assess surface morphology.

Results: Statistical analysis with analysis of variance (ANOVA) and post-hoc Tukey multiple comparisons test showed statistical differences between surface preparation groups (G1 $\neq$ G2 = G3 = G4), at α = .05 level of significance; as for polishing protocols, no statistical difference was found.

Conclusions: The surface preparation was the determinant for final surface texture. No combination between surface preparation and polishing system was able to reestablish the original glazed porcelain smoothness. (*Angle Orthod.* 2009;79:790–795.)

KEY WORDS: Porcelain; Polishing; Orthodontic adhesive

INTRODUCTION

Scientific and technological research and advancements have scored out age as a limiting factor for orthodontic treatment. For this reason, there has been a marked increase in the number of adult patients seeking to improve their smile. The shift in age pattern witnessed at the office has faced the orthodontist with new challenges. In some cases, noteworthy prosthodontic work has been carried out that will suffer at least some damage when faced with orthodontic treatment. Very often, ceramic materials are found in such cases.

The need for mechanical and chemical retention for brackets over preexisting porcelain restorations impelled the development of materials and techniques designed to resist orthodontic and masticatory forces. Such procedures should keep accessories bonded throughout the orthodontic treatment and ideally avoid permanent damage to esthetic ceramic surfaces.[1] Commonly after debonding and resin removal, ceramic surfaces are altered,[2] and reglazing is not always convenient or possible.[3]

Orthodontic bonding over porcelain demands certain finishing cares at debonding; roughness resulting

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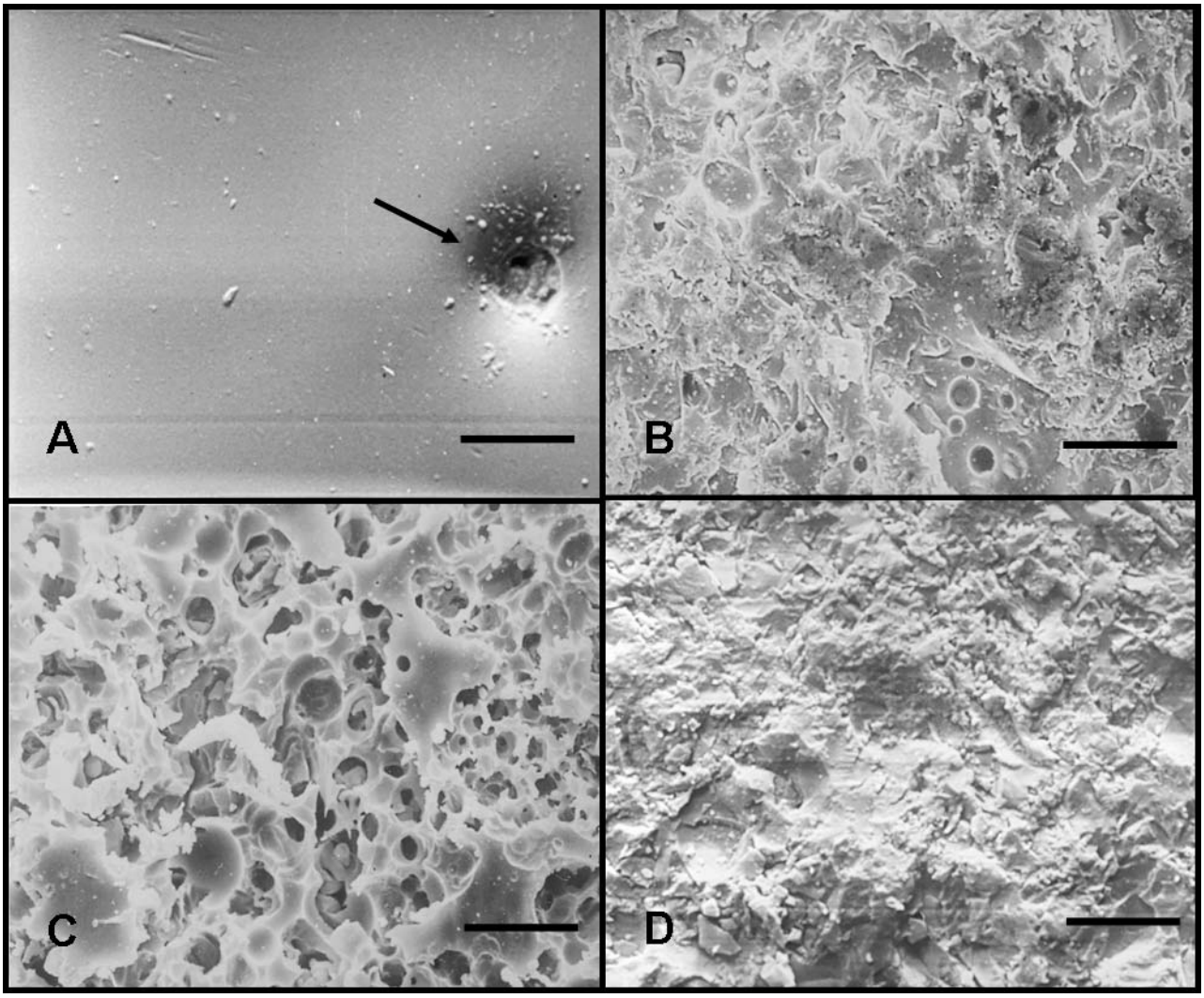

Figure 1. Scanning electron microscope (1000×) illustrating different methods of surface preparation. (A) Intact glaze (arrow indicating a void). (B) Bur. (C) Hydrofluoric acid. (D) Aluminum oxide. Scale bar = 20 μm.

from surface preparation or resin remains, alters esthetic appearance, diminishes longevity, and increases plaque adhesion.[4,5] Moreover, most patients can detect differences in mean roughness of about 0.3 μm as shown by a clinical trial.[6,7]

Table 1. Sample Subgroups Arrangement According to Surface Preparation and Polishing Material

Polishing Material		Surface Preparation			
		G1 Glaze	G2 Bur	G3 Hydrofluoric Acid	G4 Aluminum Oxide
P1	Edenta	G1P1 n = 4	G2P1 n = 4	G3P1 n = 4	G4P1 n = 4
P2	Identoflex	G1P2 n = 4	G2P2 n = 4	G3P2 n = 4	G4P2 n = 4
P3	Komet	G1P3 n = 4	G2P3 n = 4	G3P3 n = 4	G4P3 n = 4

The aim of this in vitro study was to compare three ceramic polishing systems with regard to surface roughness after clinically simulated resin clean-up. Samples had been previously subjected to different surface preparation methods.

MATERIALS AND METHODS

Fifty-two flat samples of glazed porcelain (Biobond II—Ceramco II, Dentsply Indústria e Comércio Ltda, Rio de Janeiro, RJ, Brazil) were fired over metallic square bases (10 × 10 × 1.5 mm), simulating porcelain veneers (10 × 10 mm). Surfaces were pumiced with a rubber prophylaxis cup (Viking, São Paulo, SP, Brazil), replaced at every five samples, using a low-speed handpiece (Dabi Atlante, Ribeirão Preto, São Paulo, Brazil).

The surface area of each specimen was checked for voids; if significant voids were present, glazing was

repeated.[7] If these voids persisted, specimens were eliminated.[6,8]

Preparation of Specimens

All specimens were fixed in rounded props, washed with a water spray, and dried with a continuous stream of compressed oil-free air. Four samples did not receive any treatment and composed the control group; the remaining 48 samples were divided randomly into four groups of 12 specimens each, according to the surface preparation they were to receive, and numbered as follows: group 1 (G1)—glazed layer left intact; group 2 (G2)—ceramic surfaces were roughened with diamond burs FG 1024 (KG Sorensen, São Paulo, SP, Brazil) using a low-speed handpiece (Dabi Atlante); group 3 (G3)—ceramic surfaces were treated with 10% hydrofluoric acid (Dentsply) for 4 minutes; and group 4 (G4)—ceramic surfaces were sandblasted with 50 μm aluminum oxide (Microetcher II Dental Bonding System, Denville Engineering Inc, San Ramon, Calif) under 90 psi air pressure at a 10-mm distance until porcelain appeared frosted (Figure 1).

After surface preparation (G1 to G4), a silane-coupling agent (Scotchprime Ceramic Primer, 3M Unitek, Monrovia, Calif) was applied to the samples, which then received a coating of Transbond XT Light Cure Adhesive Primer (3M Unitek) and a standard volume (30.25 mm^3—5.5 mm × 5.5 mm × 1 mm) of Transbond XT adhesive (3M Unitek). An acetate template was constructed with dimensions of 20 × 20 × 1 mm and a center hole of 5.5 × 5.5 × 1 mm, simulating the bracket's base dimensions. Resin-covered surface samples were then pressed with a glass slide, and an Ultralux device (450 mW/cm^2, Dabi Atlante) was used for photopolymerization during 40 seconds.[9] All procedures were carried out by the same calibrated operator.

For all samples, a 12-blade tungsten carbide bur (Busch, Germany) adapted to a low-speed handpiece (Dabi Atlante) was used to remove the composite resin off the porcelain surface, in a continuous manner. The four groups ($n = 12$) that underwent surface preparation were split randomly into three subgroups each, according to the polishing treatment received (Table 1).

The following polishing materials were used per group:

— Polishing 1 (P1) followed by use of Edenta polishing system (Edenta AG, Au, St. Gallen 7, Switzerland), points Cerapol Super #374 PM, Exa Cerapol #384 PM, and Exa Cerapol #394 PM;
— Polishing 2 (P2) followed by use of Identoflex polishing system (KerrHawe, Bioggio, Switzerland), points #PH 7054, #PS 7154, and #PF 7254;
— Polishing 3 (P3) followed by use of Komet polishing system #267204 (Komet, Lemgo, Germany), rubbers #9679 047, #9680 047, and #9547 030.

The 12-blade tungsten carbide bur was used until a composite-free surface was obtained, visible to the naked eye. All polishing kits were used for 6 minutes, closely simulating the clinical procedure. All systems were used in a low-speed handpiece (Dabi Atlante) following manufacturer's instructions. The samples were washed and dried.

Profilometer and Scanning Electron Microscopy

After composite removal and polishing, surface roughness of specimens was evaluated using a profilometer Sloan Dektak IIL (Veeco Instruments Inc, Woodbury, NY). A stylus diamond tip (radius 12.5 μm) was used under a constant measuring stylus tracking force of 20 mgf at 90°. The instrument was calibrated using a standard reference specimen set to travel at low speed. The profilometer scanned all 48 experimental and 4 control samples, and readings were made with a HyperTerminal software script (RS232) for the roughness parameter Ra (represented by the arithmetical mean of the profile deviations from the center line). The scanning area was situated at the center of the specimens and six different readings of 2-mm length were performed for each specimen.

After the quantitative profilometer evaluation, the most representative specimens of each subgroup and control sample were selected and placed on stubs, coated with a conductive layer of gold and palladium (300 Å; Balzers Union FL-9496, Liechtenstein) and examined with a Jeol JSM-5800LV scanning electron microscope (Jeol, Tokyo, Japan). The objective was to assess the potential surface alteration over the ceramic surface possibly induced by different combinations of surface preparation and polishing processes. Comparisons were made between specimens polishing and control (C) intact glazed porcelain. The electrophotomicrographs were obtained at 1000× magnification.

Statistical Analysis

The results were assessed by analysis of variance (ANOVA) and post-hoc Tukey multiple comparisons test, setting surface preparation and polishing variables at $\alpha = .05$ level of significance. The statistical software SPSS 13.0 for Windows (SPSS Inc, Chicago, Ill) was used.

RESULTS

The mean values obtained for each subgroup, from the six scans in each of the four pieces, are presented in Table 2. The control group was used as a reference,

Table 2. Ra Mean Values (μm) and Standard Deviation in Each Subgroup

Polishing Material	Surface Preparation			
	G1 Glaze	G2 Bur	G3 Hydrofluoric Acid	G4 Aluminum Oxide
P1 Edenta	0.45 ± 0.30	2.08 ± 0.25	3.27 ± 1.37	2.89 ± 1.31
P2 Identoflex	0.95 ± 0.39	2.41 ± 0.74	2.25 ± 0.21	1.80 ± 0.36
P3 Komet	0.76 ± 0.29	1.90 ± 0.34	2.16 ± 0.37	1.54 ± 1.06

with a mean roughness value (Ra) of 0.27 μm and a standard deviation of 0.05 μm. The surface preparation G1 showed the lowest roughness mean values among all four surface preparation groups. For G2 and G3, Ra mean values were higher than 2 μm, except for the combination of G2 with P3 (1.90 μm). G4 showed Ra mean values between 1 μm and 2 μm, except for G4P1 (2.89 μm).

The surfaces preparations (Gs) showed no significant difference ($P < .05$) between subgroups as seen in Table 3, except G1, which differed from the others. The standard error was 0.29.

Statistically, the polishing method showed no significant difference ($P < .05$) between groups, as seen in Table 4. This occurs because of the variability of the Ra values.

Assessment with the scanning electron microscope (SEM) made it possible to observe a characteristic topography for each surface preparation (Gs). None of the polishing materials (Ps) could be differentiated under examination via scanning electron microscope (Figure 2).

DISCUSSION

The present study found better results regarding surface roughness ($P < .05$), after removal of orthodontic adhesive and polishing, when surfaces were left intact before bonding (G1). In all subgroups, a sufficiently smooth surface could not be reestablished when compared with a control sample, even after final polishing had been carried out.

Likewise, according to Campbell,[5] using SEM, the Shofu polishing system was not able to achieve ceramic glaze smoothness where porcelain glazing had been removed. However, Goldstein et al[10] evaluated five different porcelain polishing systems using a profilometer, SEM, and visual assessment, and concluded that four of them were clinically acceptable for polishing ground porcelain. It is important to observe that these studies did not remove composite from samples, only attempted to simulate prosthetic clinical adjustments.

Based on SEM visualization alone, it could be observed that polishing is strongly influenced by surface preparation methods. However, with regard to the final ceramic aspect and roughness after debonding, polishing materials should be critically considered.

Because bond strengths to glazed and deglazed porcelain were not significantly different, it may be desirable to bond to glazed porcelain to minimize surface damage.[2] Studies indicate that deglazing may not be necessary and must be avoided during the attachment of orthodontic brackets to feldspathic porcelain surfaces. Feldspathic porcelain fractures occurred more often on deglazed porcelain (71%) than on glazed porcelain (36%) during bond strength determination.[8,11] Phillips[12] has shown that the removal of surface glaze by grinding reduces porcelain's transverse strength by half. In spite of this, there are bonding systems for porcelain that recommend surface roughening as a starting step.[13,14]

A silane-coupling agent was used prior to adhesive application on samples, which greatly increases bond strength.[15] However, had there been an alumina overglaze, which cannot be clinically distinguished, the silane would not have been effective due to the small amount of silica.[16]

All procedures that can contribute significantly to increased bond strength also produce greater risk of

Table 3. Paired Comparisons of Surface Preparation Groups Using Tukey's Test After One-Way ANOVA, Showing Average Differences and Statistical Significances

Groups	G1 Glaze	G2 Bur	G3 Hydrofluoric Acid	G4 Aluminum Oxide
G1	—	*−1.41*	*−1.84*	*−1.35*
G2	**< .001***	—	*−0.43*	*0.05*
G3	**< .001***	**0.450**	—	*0.48*
G4	**< .001***	**0.998**	**0.355**	—

Italic type presents average differences (Ra).
Bold type represents the significance (*P* value).
* Statistical significance ($P < .05$).

Table 4. Paired Comparisons of Polishing Methods Using Tukey's Test After One-Way ANOVA, Showing Average Differences and Statistical Significances

Groups	P1 Edenta	P2 Identoflex	P3 Komet
P1	—	*0.32*	*0.58*
P2	**0.419**	—	*0.26*
P3	**0.068**	**0.565**	—

Italic type presents average differences (Ra).
Bold type represents the significance (*P* value).

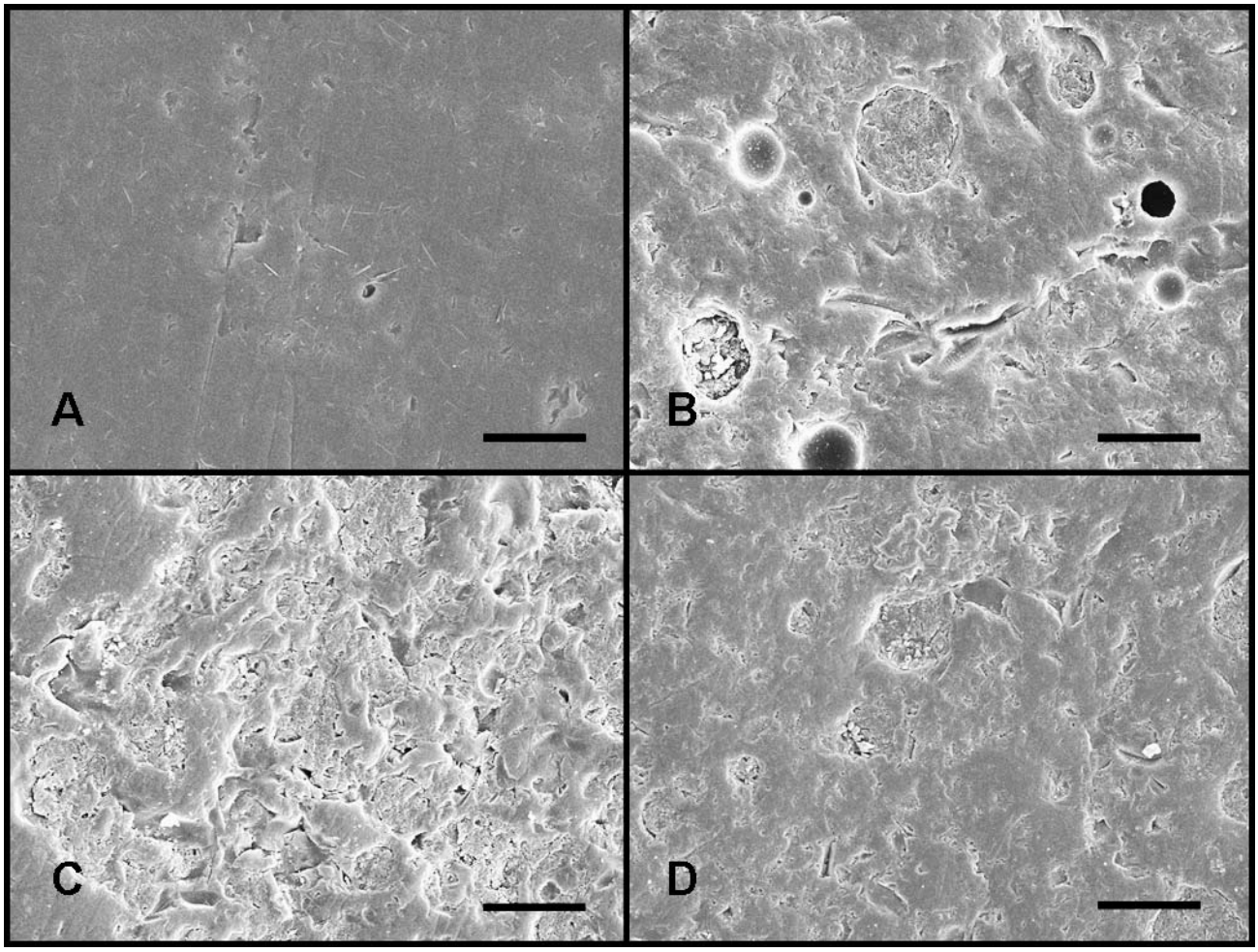

Figure 2. Scanning electron microscope (1000×) illustrating subgroups with different Ra values. (A) G1P1 (Ra = 0.455 μm). (B) G2P3 (Ra = 1.903 μm). (C) G3P1 (Ra = 3.274 μm). (D) G4P2 (Ra = 1.805 μm). Scale bar = 20 μm.

porcelain fracture at debonding,[11,17] since the glaze is effective in strengthening the porcelain, thereby reducing crack propagation.[12] It also seals the open pores of the fired porcelain, providing a smooth and dense surface.[18]

A standardized composite volume was bonded to porcelain surfaces in this study, which did not include bracket bonding and debonding. This simulated a score 3 adhesive remnant index (ARI), where all adhesive is left at the prosthetic piece after debonding. The intention was to spend equal time to remove the composite before polishing the piece.

There is a noteworthy lack of evidence in investigations assessing the variability of forces for debonding over different porcelain surfaces or for failure mode of porcelain systems. This is an issue of great concern, because the orthodontist is often faced with the problem of bonding surfaces for which there is little information (traditional high-fusing and new, low-fusing porcelain).

CONCLUSIONS

- Final roughness is closely dependent on previous surface preparation.
- Orthodontic bonding should be tried over intact glazed surfaces. In case of bonding failure, surface preparation should then be carried out.

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