Comparison of traditional orthodontic polishing systems with novel non-orthodontic methods for residual adhesive removal

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Background: Following the debonding of orthodontic brackets, the removal of residual adhesive from the enamel surface is required. Published adhesive removal protocols present conflicting advice.  
Aims: The present study evaluated the surface roughness of enamel after debonding and instrumentation with non-traditional orthodontic polishing systems.  
Methods: The facial aspects of 35 extracted human incisor teeth were scanned with a surface profilometer for surface roughness prior to the bonding of orthodontic brackets. After debonding, residual adhesive was removed with a 12-fluted titanium carbide bur. The teeth were randomly divided into seven groups (N = 5 per group) and the enamel surface was polished with one of seven products. All samples were re-scanned for surface roughness and subjectively evaluated via SEM.  
Results: There was no significant difference in enamel surface roughness between the groups when compared using surface profilometry. Visual observations from the SEM evaluations demonstrated differences in the enamel surface at the microscopic level that were not detected by profilometric analysis.  
Conclusions: The present study found no statistically significant difference in mean enamel smoothness change from pretreatment to posttreatment between the seven polishing methods studied via profilometer surface reading measurements. An SEM analysis showed visual differences in enamel striations viewed at 1000× magnification in a comparison of traditional versus non-traditional polishing methods.  
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Introduction

The introduction of direct bonded orthodontic attachments, compared with the era of banding all teeth, has forever changed the practice of orthodontics. Fixed orthodontic appliances that are directly bonded to the facial or lingual surfaces of teeth provide a faster and more comfortable experience for the clinician and patient. Some additional advantages of direct bonded attachments include improved gingival health, increased patient comfort and increased clinical efficiency.1

The bonding of orthodontic brackets to the facial surfaces of the teeth requires an interface of adhesive between the tooth and the bracket base. This interface can be accomplished via direct or indirect bonding, utilising an etch and prime protocol, a self-etching primer protocol, or by the use of light-cured or self-cured adhesives.2,3 Fortunately, the bond of the bracket to the facial surfaces of teeth is strong enough to withstand clinical orthodontic forces. However, the strength of the bond should be broken with ease by the clinician at the desired completion of appliance treatment. In addition, the orthodontic practitioner should be able to readily remove orthodontic brackets for repositioning to a more favourable position if
necessary during treatment. After bracket removal at the completion of treatment, the practitioner should return the surfaces of the teeth to their pretreatment condition. The restoration of the enamel surfaces without abrasion or scarring will provide for optimum surface optical properties that are sufficiently capable of withstanding future bacterial and cariogenic insults.

A significant disadvantage of bonded orthodontic attachments is the residual adhesive remaining on the tooth following debonding and its removal without harming the enamel surface. An ideal polishing protocol should remove all excess adhesive, remove no (or a minimal amount of) enamel and allow for clinical efficiency. This difficult task was noted by Campbell, who showed that over 80% of surveyed orthodontists recognised enamel scarring following debonding procedures. In certain cases, the extent of the enamel damage was severe and resulted in significant malpractice settlements against the clinicians.

No standard procedure has yet been recognised as the most favourable and preferred for removing excess adhesive from enamel. Webb et al. compiled a list of the most popular procedures and products used to polish enamel. A total of 898 practitioners across the United States with varying educational backgrounds responded to a survey. According to the results, initial residual adhesive was commonly removed using either a 12-fluted, 16-fluted, or 20-fluted titanium carbide bur. The two popular methods for subsequent polishing of the enamel were the use of a white Arkansas stone and/or pumice paste. A review of literature that described protocols for adhesive removal after orthodontic treatment presents conflicting advice. Caspersen believes that pumicing is not a worthwhile procedure at debonding. However, others including Campbell and Zachrisson et al. believe that it is beneficial. There is disagreement on the use of a fluted carbide bur, and whether its use should involve coolant water spray. Webb et al. found no significant differences in enamel smoothness following the use of various fluted carbide burs or with additional pumice polishing or ‘Renew’ points (Reliance Orthodontics Products, Inc., IL, USA). While opinions may vary, few papers recommend a specific debonding and polishing protocol. A standard, well defined and efficient protocol would be beneficial to orthodontic practitioners and their patients.

The purpose of the present study was to determine which polishing system resulted in the smoothest enamel surface after debonding. It was hypothesised that novel polishing systems not designed or specifically marketed for orthodontic use could be equal in achieving enamel smoothness with less enamel abrasion compared with traditional orthodontic polishing systems.

**Methods**

**Teeth selection/preparation**

The present study used 37 non-carious, previously-extracted, human, incisor teeth. The teeth were washed of all debris and stored in distilled water at room temperature until required. The inclusion criteria included a visual observation of labial surface integrity, no caries or restorations, no visible cracks on the coronal portion, and no visibly evident exposure to chemicals. Each tooth was randomly assigned to one of seven test groups (N = 5) as outlined below. The lingual surface of each tooth was bonded to a straight piece of wire to align the labial surfaces of each test tooth parallel to the base of a test block. A wire jig was used to mount each sample group in self-cured epoxy resin blocks, such that the labial surfaces were exposed and parallel to the block base (Figure 1). The labial surfaces of the teeth were cleaned and polished with non-fluoridated pumice, rinsed with water and dried with oil-free compressed air.

Each tooth was labelled and its labial surface analysed using a profilometer to establish a baseline roughness measurement. The enamel surface roughness was measured as the centre line average using a TalyScan 150 3D Surface Profilometer (Taylor Hobson, IL, USA). Profilometry, used frequently in engineering, involves the measurement of the profile of an

![Figure 1. Samples mounted in epoxy block.](image)
object and can be used to obtain a highly objective measurement of surface roughness for comparison. The profilometer measured to an accuracy of 5 µm following a standardised protocol. Three different areas measuring 0.8 mm by 0.8 mm were measured on each tooth by a stylus passing over the labial surface in a mesial-distal direction in the anatomic centre of the crown where the bracket was to be placed. The three measurements per tooth were averaged to provide a mean surface roughness before bonding and for later comparison.\textsuperscript{12} A grid overlay was used to identify the area to be scanned to assure analysis of the same area in subsequent scans.

Prior to assigning the sample teeth to the experimental groups, two teeth, which met the inclusion criteria, were selected at random and mounted in self-cured acrylic resin blocks for SEM visualisation. The teeth received no treatment and were stored in distilled water until SEM analysis was performed at the conclusion of the testing procedures. The remaining 35 teeth were assigned to the seven test groups.

**Bonding protocol**

After obtaining baseline surface roughness measurements, the 35 incisors were prepared and bonded following a standard bonding protocol. The teeth were dried with oil-free compressed air and 3M\textsuperscript{TM} Prompt\textsuperscript{TM} L-Pop\textsuperscript{TM} Self-Etch Adhesive (3M Unitek, CA, USA) was applied for four seconds and lightly air dried. Transbond XT (3M Unitek, CA, USA) light cure adhesive was applied into the mesh of a lower incisor twin orthodontic bracket (Mini Master Series, American Orthodontics; WI, USA) and each bracket was placed on the labial surface and aligned with the long axis of the tooth in the centre of the clinical crown over the area previously scanned by the profilometer. All visible excess adhesive was removed under 3.5x loupe magnification prior to light curing for 12 seconds (Elipar 3M ESPE; CA, USA). The teeth were stored in distilled water at 37°C for 24 hours to allow for complete resin polymerisation and to simulate the moist oral environment.

**Bracket removal**

All brackets were removed with a generic bracket removing plier (Orthopli; PA, USA) by gripping the bracket base occluso-gingivally and applying even pressure at the bracket-adhesive interface. Visual inspection indicated that all teeth required instrumentation with a hand-piece for removal of residual resin adhesive. All tooth preparation, bonding, debonding, and resin removal procedures were performed by the same operator (JA) and a new bur/polishing instrument was used for each tooth.

**Initial adhesive remnant removal**

Using a high speed hand-piece and a brush-stroke technique under 3.5x loupe magnification, a 12-fluted carbide bur (Reliance; IL, USA) was used on all specimens until all visible excess adhesive was removed. The removal was considered complete when the tooth surface appeared smooth and free of adhesive under the light of an operative lamp as described by Rouleau BD et al.\textsuperscript{10}

**Polishing protocol following initial adhesive removal**

The enamel surfaces of the 35 teeth were then polished using one the following procedures:

1. Komet H48L FG012 Bur only (5 teeth) (Komet; SC, USA)
2. Arkansas white stone alone (5 teeth) (Komet; SC, USA)
3. Reliance ‘Renew’ point (5 teeth) (Reliance Orthodontics Products; IL, USA)
4. Komet Diamond Composite Polishers (5 teeth) (Komet; SC, USA)
5. Cosmedent Nano polishing point (5 teeth) (Cosmedent; IL, USA)
6. OptraPol (5 teeth) (Ivoclar Vivadent; NY, USA)
7. DFine Shape and Shine (5 teeth) (Clinician’s Choice Dental Products; CT, USA)

The enamel surface produced by the Komet H48L bur served as the control surface as no further polishing was performed. The Arkansas white stone and the Reliance ‘Renew’ point served as the conventional orthodontic polishing methods as described by Webb et al.\textsuperscript{7} The other four products served as the ‘novel’ non-orthodontic polishing systems. Each polishing product was applied for 10 seconds using a latch-style attachment on a slow speed hand-piece to standardise polishing protocols for time and polishing speed. While the Reliance ‘Renew’ point was also available with a friction grip shank, the manufacturer recommends that it should not be used above 20,000 rpm.\textsuperscript{13}
The Arkansas white stone was only available in the friction grip style and was therefore standardised for use in the slow speed hand-piece friction grip attachment. Polishing with each product for the same amount of time (10 seconds) was done to standardise results and draw clinical efficiency relevance to the initial data set. Surface smoothness was reassessed via profilometer testing following the same protocol previously outlined. One sample from each group was selected at random for SEM evaluation and comparison with a non-bonded or instrumented tooth.

SEM protocol

The facial enamel surfaces of the selected control surface-prepared teeth were coated with carbon and observed under an S-2700 Scanning Electron Microscope (Hitachi, Japan) at 15kV accelerated voltage. Images were acquired through a Thermo-Noran digital acquisition system at 1000× magnification. (Figures 2–9)

Results

The results represent the mean change and standard deviation of enamel smoothness between the products (Table I). A one-way analysis of variance (ANOVA) was used to compare the mean change in smoothness, as well as enamel abrasion between the seven tested techniques. The results of the ANOVA between the traditional orthodontic polishing products (Komet H48L, Arkansas white stone, and Renew point) and the four novel non-orthodontic polishing products were significant ($p = 0.045$). Tukey’s Honestly Significant Difference test was used for post-hoc analysis and did not reveal any statistically significant differences in the groups’ mean change in smoothness (Table II). SEM images revealed visual differences between the groups (Figures 2–9). The products providing the smoother appearing enamel surface were judged to provide superior polishing efficiency since the use of each evaluated product was standardised at 10 seconds of polishing per tooth.

Discussion

Orthodontists employ various surface polishing procedures when fixed orthodontic brackets are removed, but no comprehensive data are available regarding their efficacy at restoring teeth to their pretreatment surface state.

A report by Webb et al. in a survey of 898 practitioners across the United States identified that polishing

| Group                                      | N | Mean change ± SD |
|--------------------------------------------|---|------------------|
| Komet H48L FG012 Bur                       | 5 | 1.786 ± 2.6      |
| Arkansas white stone alone                 | 5 | 3.445 ± 3.7      |
| Reliance ‘Renew’ point                     | 5 | -0.379 ± 1.5     |
| Komet Diamond Composite Polishers         | 5 | 0.724 ± 0.7      |
| Cosmedent Nano polishing point             | 5 | -1.051 ± 1.4     |
| Ivoclar OptraPol                           | 5 | 0.805 ± 1.0      |
| Clinician’s Choice DFine Shape and Shine  | 5 | 2.803 ± 3.3      |

Table I. Mean change in enamel smoothness as measured by profilometer. A positive mean change indicated the enamel had a greater surface roughness than the tooth prior to testing, and a negative mean change indicated the enamel had a lower surface roughness than prior to testing.

| Group                                      | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|--------------------------------------------|----|----|----|----|----|----|----|
| 1                                          | 0.9092 | 0.7479 | 0.9893 | 0.4646 | 0.9930 | 0.9915 |
| 2                                          | 0.9092 | 0.1543 | 0.5133 | 0.0593 | 0.5478 | 0.9993 |
| 3                                          | 0.7479 | 0.1543 | 0.9870 | 0.9991 | 0.9814 | 0.3319 |
| 4                                          | 0.9893 | 0.5133 | 0.9870 | 0.8796 | 1.0000 | 0.7807 |
| 5                                          | 0.4646 | 0.0593 | 0.9991 | 0.8796 | 0.8563 | 0.1483 |
| 6                                          | 0.9930 | 0.5478 | 0.9814 | 1.0000 | 0.8563 | 0.8097 |
| 7                                          | 0.9915 | 0.9993 | 0.3319 | 0.7807 | 0.1483 | 0.8097 |

Table II. Tukey’s Honestly Significant Difference Test.
procedures varied widely.7 Restoring the enamel surface to its pretreatment state following fixed orthodontic appliances was arguably a challenging aspect of treatment¹ and remains the primary concern.⁵ Less than ideal debonding techniques can result in cracks in the enamel surface and enamel prism fractures.

Zarrinnia et al.¹⁴ found that the bracket-removing plier produced the most consistent separation at the bracket-adhesive interface and was therefore used for all bracket removals in an attempt to control for compounding variables.
After bracket debonding, many procedures may produce a sound enamel surface in structure and appearance. The mechanical removal of residual composite resin with rotary instruments including tungsten-carbide burs may cause enamel damage. Tungsten-carbide burs are available in various sizes and many fluted shapes. Webb et al. found that the most commonly used carbide bur was 12-fluted, which was found by Rouleau et al. to be effective in residual resin removal and therefore was employed in the present study.

The search for the best method to restore the enamel surface to its pretreatment condition has led to the introduction of new instruments and procedures, including Nd:YAG laser application and air-powder abrasive systems. Introducing novel methods has resulted in the development of new instruments, such as specially designed burs, discs, and diamond or silicone coated polishers, which have been considered less aggressive in enamel polishing.

The results of the present study indicate that, while there was a small higher mean smoothness change from pre- to post-treatment between Group 2 (Arkansas white stone) and Group 5 (Cosmedent Nano polishing point), there was no statistically significant difference when comparing all groups between traditional and the novel polishing methods.

While the mean smoothness profilometer measurement for each polishing method did not reveal statistically significant differences between individual groups, the visual observations from the SEM evaluations indicated that there were post-treatment surface differences at the microscopic level that cannot adequately be identified or evaluated using a profilometer.

A visual comparison of the two groups with the greatest difference in profilometer readings, however, appeared to support the mean smoothness changes. Group 2 (Arkansas white stone) had a large mean change and a rougher SEM surface appearance, compared with Group 5 (Cosmedent Nano Point), which had a smaller mean change and a smoother SEM surface appearance. The difference between profilometer measurements and visual assessments could be due to a lack of sensitivity of the profilometer stylus in detecting the changes that were visible at the microscopic level.

The design of the present study included the profilometer measurement of the enamel surface at three different areas on each facial surface in the middle of the crown. This design was employed to help minimise sample variability by averaging the smoothness values in the area where the bracket was to be bonded. While there were variations in measurements of the sample teeth, the small sample size may have contributed to the inability to gain statistical significance from the profilometer values obtained when evaluating intergroup significance (Table II). Additionally, Tukey’s Honestly Significant Difference test was more conservative than other methods for post-hoc analysis, so it was possible that more liberal methods may have yielded statistically significant differences.

The traditional methods used in the present study included the Komet 12-fluted carbide bur (Group 1), the Arkansas white stone (Group 2), and the Reliance ‘Renew’ point (Group 3). In a visual comparison of these traditional methods with the other groups of novel, non-orthodontic products using SEM analysis, the striations in the enamel surface at 1000× magnification appeared to be deeper and more pronounced following the traditional methods of polishing. This visual difference did not directly correlate with the mean value of change from pre- to post-treatment or with the final enamel smoothness values. This may possibly be explained by a lack of sensitivity of the profilometer.

The variability of the data set and small sample size likely contributed to a statistically significant difference when comparing mean surface smoothness changes in the ANOVA test but no statistically significant differences between the groups. It is suggested that future studies might overcome these challenges by employing a more focused approach that evaluates a larger sample size of a smaller number of polishing products. The future study could provide insight into which method of polishing provides superior clinical results of enamel smoothness.

**Conclusion**

There was no statistically significant difference in mean enamel smoothness from pretreatment to post-treatment between the traditional and novel polishing methods assessed by profilometer surface reading. The results of the present research support the hypothesis that novel polishing systems, not designed or specifically marketed for orthodontic use, could be
equal in achieving enamel smoothness compared with traditional orthodontic polishing systems. However, SEM analysis showed visual differences in enamel striations when viewed at 1000× magnification in a comparison of traditional and novel polishing methods.

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