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Original Research Article

Enamel surface roughness evaluation after debonding and residual resin removal using four different burs

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ABSTRACT

Introduction: There is a risk of damaging the enamel surface and changing its original morphology during orthodontic bonding and debonding procedure. Research on better adhesive removal methods which can effectively remove the residual resin and restore it best, to its original form are continuing till now. Studies have shown that Stain buster bur creates a smooth enamel surface close to natural enamel when compared to other polishing systems. Recently a new bur called Adhesive Residual Removal bur was introduced by Dentarum company to achieve a smooth enamel finish after debonding. In this study I have compared the enamel surface roughness after debonding and polishing with 4 different polishing burs.

Aim: The objective of this study is to compare and evaluate enamel surface roughness after debonding and evaluated using four different finishing and polishing systems.

Materials and Methods: After debonding adhesive resin is removed from the buccal surface of 80 premolars. Based on the Bur used for polishing the tooth surface it is divided into four groups of 20 each. Group 1-Tungestine carbide system, Group 2-Enhance finishing and polishing system, Group 3-fiber reinforced stainbuster bur, and Group 4- adhesive residual remover bur. Quantitatively measurement was done with the help of surface roughness tester and qualitative measurement was done using scanning electron Microscope (SEM).

Results: Highest post-polishing roughness was observed in tungsten carbide bur (1.37 μm) followed by enhance pogo bur (1.05 μm), adhesive residual remover bur system (0.83 μm), and Stainbuster bur (0.72 μm) (p value < 0.05).

Conclusion: The smoothest enamel surface was produced by Stainbuster bur that was close to the natural enamel followed by Adhesive residual remover bur, Enhance system, and tungsten carbide bur.

1. Introduction

Bracket debonding procedure is the removal of Orthodontic attachments and the entire residual adhesive from the surface of enamel after the completion of Orthodontic treatment. The enamel surface must be restored to resemble the natural enamel as closely as possible without inducing any iatrogenic damage to it and with minimal loss of enamel structure. [1]

All the steps that involve bonding of brackets to the enamel like acid etching, application of primer and adhesive will risk damaging the enamel surface and change its morphology. The removal of residual resin further damages the enamel producing scratches and grooves. Various mechanical methods used to remove residual enamel that includes band removing pliers, hand scalers, ultrasonic

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cleaning, Intraoral sandblasting, sandpaper discs, diamond burs, stainless steel burs, rubber cups, Tungsten carbide burs, lasers and composite burs.[2]

The most popular tool for residual resin removal is the use of Tungsten carbide bur as this method is rapid and effective.[3,4] One step polishing systems which have diamond impregnated points like Pogo micropolishers showed to be promising to the clinician in removal of residual resin after bracket removal.[1] A new composite bur (Stainbuster bur) designed to gently remove cement, stains and color coatings form the surface of enamel is being widely used by orthodontists to remove residual enamel after debonding.[2] Adhesive Residue Remover is a stiff abrasive bur. Studiesshowed that Adhesive Residual remover bur is used to remove residual resin with minimal damage to the enamel surface.[5]

There is no study where all these four burs (30 fluted Tungsten carbide bur, Pogo micro-polisher bur, stainbuster bur or Residual adhesive remover bur for residual resin removal) were compared to assess the extent of enamel surface roughness.

2. AIMS and Objectives

To evaluate and compare enamel surface roughness after debonding using 30 fluted TC bur, Pogo bur, Stainbuster bur, Adhesive Residual Remover bur.

3. Objectives

1. To evaluate and compare enamel surface roughness after residual resin removal with Tungsten Carbide bur, Pogo bur, Stainbuster bur, Adhesive remover bur.
2. To compare enamel surface damage through scanning electron microscope (SEM) analysis.

4. Materials and Methods

80 Premolars extracted for Orthodontic purpose were included in the study. The buccal surfaces of the teeth selected should not have any restorations, visible cracks, carious lesions, hypoplasia and visual disturbances.

The teeth were randomly divided into 4 groups of 20 each and mounted on resin blocks (Figure 1) with their buccal surfaces exposed. The resin blocks were colour coded to differentiate the groups. Both Quantitative and Qualitative observations were made by using surface roughness testing and scanning electron microscope analysis.

5. Quantitative Observations

Initial Surface roughness measurement (Baseline roughness) for each sample was done with surface roughness tester of Mitutoyo SI-410 series (Figure 2). The surface roughness was measured using 3 parameters.

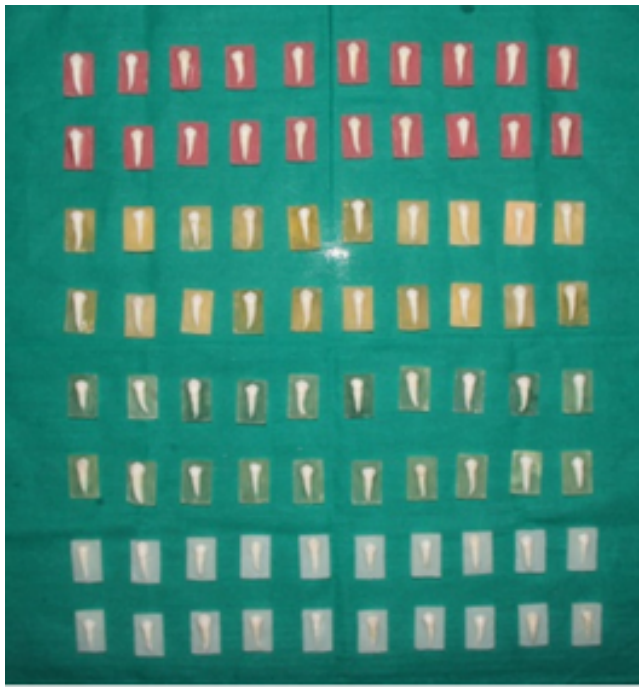

Figure 1: 80 Teeth sample groups

Figure 2: Surface roughness tester

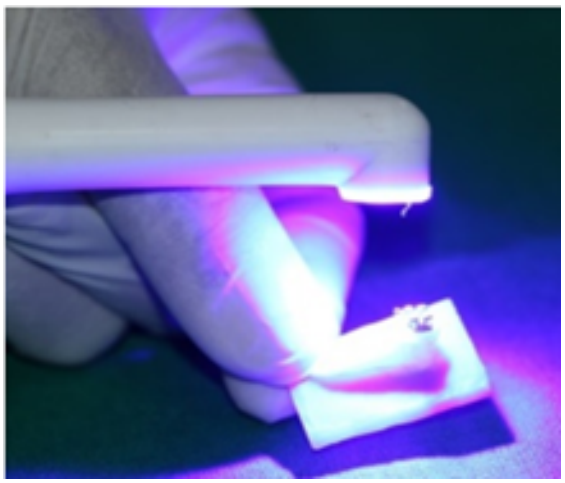

Figure 3: Curing of adhesive

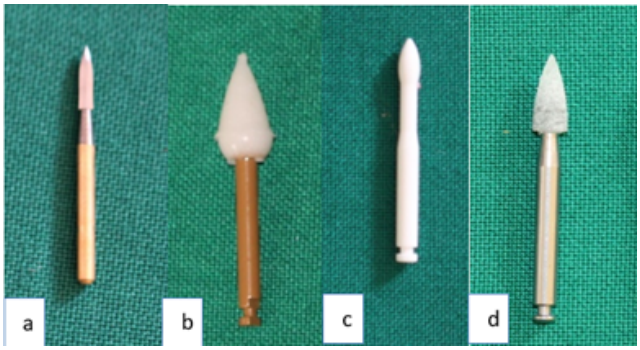

Figure 4: a: 30 flute Tungsten carbide bur, **b:** Pogo Bur, **c:** Stain buster bur, **d:** Adhesive residual removal bur

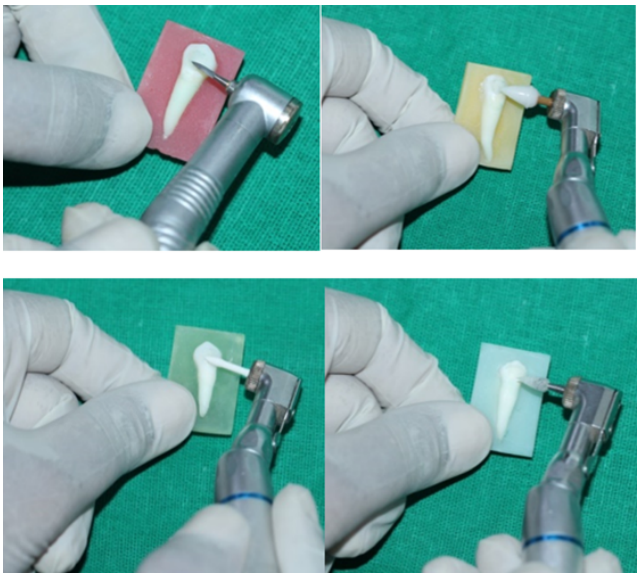

Figure 5: Removal adhesive resin with 30 flute tungsten carbide bur, pogo bur, stainbuster bur, adhesive residual remover bur

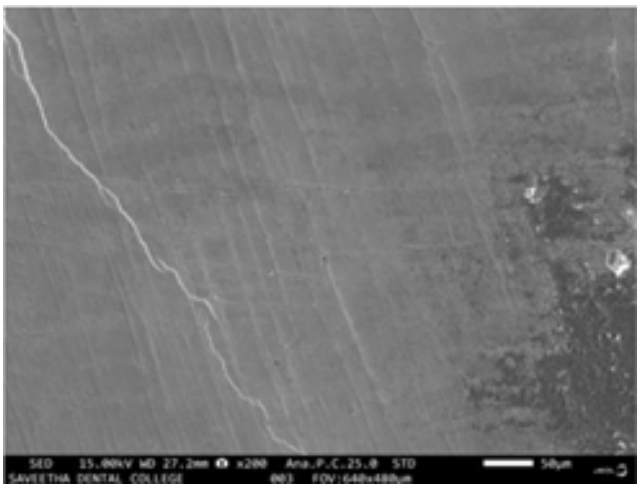

Figure 6: SEM analysis of normal enamel

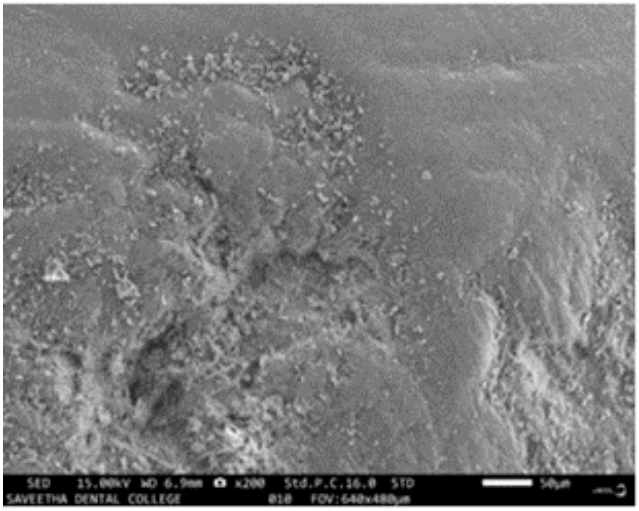

Figure 7: SEM analysis of 30 flute tungsten carbide bur

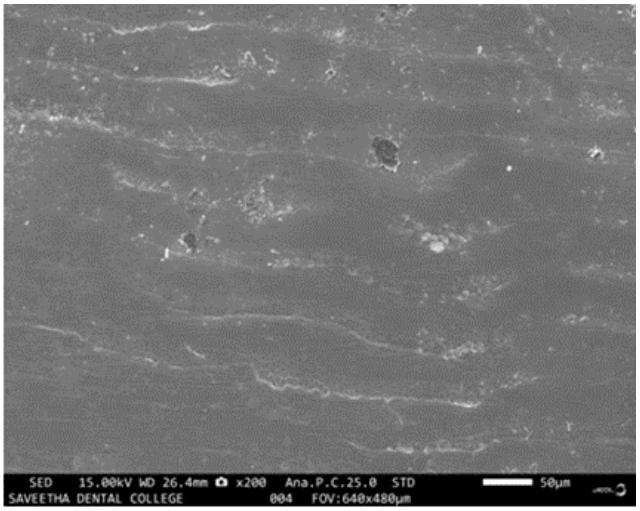

Figure 8: SEM analysis of pogo bur

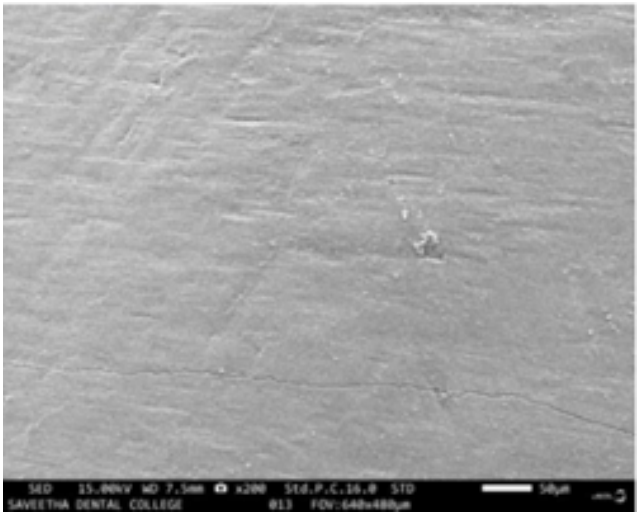

Figure 9: SEM analysis of stainbuster bur

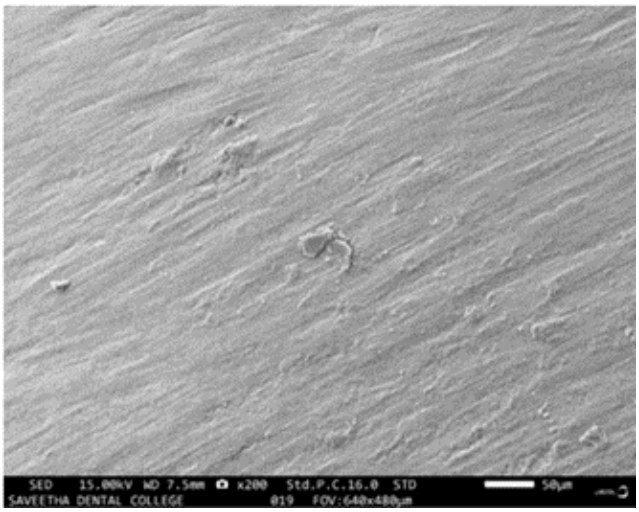

Figure 10: SEM analysis of adhesive residual remover bur

1. Ra (Average roughness) – It is an average roughness of the sample which shows arithmetic mean deviation.
2. Rt (Maximum Roughness Height) – It is the maximum roughness height which is defined as the maximum peak valley height.
3. Rz (Mean Roughness depth) – It is the mean roughness depth with linking between highest peak and deepest valley of the sample.

Mean baseline roughness values of Ra, Rt, Rz was calculated.

The buccal surfaces of all the 80 teeth was polished with pumice slurry and rubber cup, rinsed with water, and dried with compressed air. The teeth were etched with 37% phosphoric acid for 30 seconds, rinsed and air-dried. Primer was applied on the tooth surface and light cured for 10 seconds. To avoid composite adhesion to the base of the metal bracket and enable its easy removal, Vaseline was applied to the mesh of the brackets. Light cure adhesive was applied on the bracket base and positioned on to the primed tooth surface (Figure 3). Ideal curing protocols of 40 seconds (10 seconds from each direction – mesial, distal occlusal and gingival). The brackets were debonded using a debonding plier by gently squeezing the mesial and distal wings of the bracket. The residual adhesive was then removed by using four different burs (Figure 4).

1. Group 1: Removal of Adhesive by means of Tungsten Carbide bur using a high speed hand piece (less than 1,00,000) rpm with water cooling (Figure 5).
2. Group 2: Removal of Adhesive by means of Pogo Polisher (DENTSPLY) using a low speed hand piece (10,000 – 20,000 rpm) with water cooling (Figure 5).
3. Group 3: Removal of Adhesive by means of Stainbuster (Abrasive Technology Inc.) bur using a low speed hand piece (10,000 – 20,000 rpm) with water cooling (Figure 5).
4. Group 4: Removal of Adhesive by means of Adhesive Residue Remover (Dentarum) bur using a low speed hand piece (10,000 – 20,000 rpm) with water cooling (Figure 5).

After resin removal, the surface roughness assessment for samples in each group was performed with a surface roughness tester and the values were tabulated. Mean post polishing roughness values of Ra, Rt, and Rz for each group were calculated.

6. Qualitative Observation

In each Group 3 samples were subjected to Scanning Electron Microscopic examination (SEM). Samples are mounted on aluminium stab by using conductive sticky pads and coated with palladium. Observations was performed at 20Kv under 200X magnification. Enamel Damage Index (EDI) score for each group was tabulated and subjected to statistical evaluation for assessing enamel surface damage.

The Modified Enamel Damage Index Scoring system includes 4 Scores.

Score 0: Smooth Enamel surface without presence of scratches. Perikymata may be seen on Enamel surface.

1. Score: Acceptable Enamel surface with fine scattered scratches involving 1- 10% of Enamel surface.
2. Score: Enamel surface with severe coarse scratches involving 11-50% of enamel surface.
3. Score: Enamel surface with severe coarse scratches and wide grooves involving more than 50% of enamel surface. These are visible to the naked eye.

7. Results

The statistical analysis was done using SPSS software version 26.0. The mean, standard deviation, ANOVA and Post hoc were calculated.

7.1. Quantitative analysis

In between the four different groups no statistical significant difference was found in baseline roughness with p values of 0.66 (Ra) (Table 1).

Post polishing Ra was compared using one way ANOVA test. It showed that the mean values of group 1 (1.314μm) was highest followed by group 2 (1.05μm), group 4 (0.83μm) and group 3 (0.702μm). The difference between the means was statistically significant with p value of 0.000 (Table 1).

Post hoc Turkey test was made to compare base line roughness and post polishing Ra between the groups. The mean difference obtained between Group 1 - Group 2 (P = 0.002), Group 1-Group 3(p=0.000), Group 1 - Group 4 (p=0.000), Group 2 - Group 3 (p=0.000), Group 2 - Group 4

Table 1: Comparison of mean difference in Ra

	Mean baseline roughness	Mean post polishing roughness	Mean difference
Group 1	0.86	1.314	-0.45
Group 2	0.87	1.05	-0.18
Group 3	0.82	0.702	0.12
Group 4	0.84	0.83	0.01
P value	0.66	0.000**	<0.05

Table 2: Post-hoc tests for Ra (Average Roughness) for baseline roughness and oost polishing roughness

Dependent variable	Comparison group	Compared with	Mean difference (unit-μm)	Std. error	p value
Baseline Ra	Group 1	Group 2	-0.01	0.012	0.66
		Group 3	0.04	0.012	0.014
	Group 2	Group 4	0.02	0.012	0.398
		Group 3	0.05	0.012	0.012
		Group 4	0.03	0.012	0.039
	Group 3	Group 4	-0.02	0.012	0.42
Post polishing Ra	Group 1	Group 2	0.26	0.068	0.002**
		Group 3	0.61	0. 068	0.000**
		Group 4	0.48	0. 068	0.000**
	Group 2	Group 3	0.34	0. 068	0.000**
		Group 4	0.22	0. 068	0.007**
	Group 3	Group 4	-0.12	0. 068	0.238
Difference Ra	Group 1	Group 2	-0.27	0.087	0.03**
		Group 3	-0.57	0.087	0.03**
		Group 4	-0.46	0.087	0.03**
	Group 2	Group 3	-0.3	0.087	0.03**
		Group 4	-0.19	0.087	0.03**
	Group 3	Group 4	0.11	0.087	0.238

**p <0.05 - considered as statistically significant

Table 3: Enamel damageindex scores

Groups	Samples	Enamel damage index
Group 1	Sample 1	3
	Sample 2	3
	Sample 3	3
Group 2	Sample 1	1
	Sample 2	1
	Sample 3	1
Group 3	Sample 1	0
	Sample 2	0
	Sample 3	0
Group 4	Sample 1	0
	Sample 2	0
	Sample 3	1

(p=0.007) is statistically significant. The difference between group 3 and Group 4 (p=0.238) is not significant (Table 2).

7.2. Qualitative analysis

In qualitative analysis enamel damage was identified through SEM (Scanning Electron Microscope) observations to calculate EDI (enamel damage index) (Figures 6, 7, 8, 9 and 10).

EDI score 0 was observed in Group 3 and also in Group 4 which showed that the enamel surface is smooth without presence of scratches. Score 1 was noted in all samples of Group 2 , one sample of Group 4 and Score 3 was noted in Group 1 (Table 4). All the EDI (Enamel Damage Index) scores are compared by using Pearson Chi Square Test which showed the significant difference between the Groups with p values of 0.002.

Table 4: Chi-Square test for enamel roughness evaluation (SEM)

Group score cross tabulation						
Groups		**Count**	**Score**			**Total**
		% within groups	0.00	1.00	2.00	3.00	
	Group 1	Total Count	0	0	0	3	3
		% within groups	0.0%	0.0%	0.0%	25%	25%
	Group 2	Total Count	0	3	0	0	3
		% within groups	0.0%	25%	0.0%	0.0%	25%
	Group 3	Total Count	3	0	0	0	3
		% within groups	25%			0.0%	25%
	Group 4	Total	2 1 0	0.0%	0.0%	0	3
			16.7%	8.3%	0.0%	0.0%	25%
Total		Count % within Score	5 41.7% 33.3%	4	0	3 25%	12
			00%				100%

(P=0.002**)p <0.05 - considered as statistically significant

8. Discussion

Bonding provides patient comfort, ease, and accuracy of bracket placement,[1,6] The bonding process includes acid etching and resin infiltration in the superficial layer of the enamel surface. After orthodontic treatment completion, the procedure of debonding is carried out. Debonding process causes damage to the enamel, by creating scratches, cracks, and grooves. It also removes the peripheral enamel layer which is rich in fluoride content,[1,2] Surface roughness created by debonding has disadvantages of discolored teeth, stain formation, plaque deposition, bacterial retention, enamel demineralization and damaging the esthetic form of teeth. To prevent the disadvantages caused by debonding, various methods of polishing are used.[2]

Gwinnett and Gorelick evaluated different methods of polishing enamel and concluded that polishing restores the enamel surface to its original quality.[3–6] Debonding can be done by various mechanical methods which are mentioned earlier.[2] The disadvantage of using debonding pliers, scalers and diamond finishing burs is that they cause deep gouges in the enamel.[3] Stainless steel burs are not effective in removing resin from the enamel surface and the bur needs to be frequently replaced because of bluntness.[7] The use of lasers to remove residual resin on the enamel surface produces surface irregularities, incomplete resin removal and damage to surrounding soft tissues.[8] To reduce the disadvantages various newer polishing methods are used.

The traditional method to remove residual resin on the enamel surface is by tungsten carbide bur.[9] 30-fluted TCB is used with high speed and water coolant for effective removal of residual resin and to produce a smooth enamel surface. Studies have shown the use of 30-flute tungsten carbide bur is the most effective method to remove highly filled residual resin from the enamel external surface in a short time after debonding.[3]

Studies done by Gwinett and Gorelick et al,[6] Zarrinnia et al.[10] and Neslihan et al.[11] have shown that 30 flute Tungsten carbide bur is the most effective method to remove residual resin at high speed but failed to produce acceptable enamel surfaces with coarse scratches, wide grooves, large pits, facets and marked enamel loss.

Pogo burs are single use diamond-impregnated polishing burs used with slow speed handpieces without water coolant. They produce enamel surfaces with fewer irregularities which are better than tungsten carbide bur.[1] The disadvantage is it requires more time than tungsten carbide bur. Patel et al. have shown that pogo burs produce the smoothest enamel surface when compared to other composite burs like one gloss system.[12]

A fiber-reinforced composite bur called Stainbuster bur produces a smooth enamel surface with fewer irregularities when compared to TC bur and Pogo bur because of its self-sharping feature. Studies[13] have shown that Stainbuster bur does not heat up when used with or without water spray, eliminates surface roughness, improves light reflection and reduces plaque accumulation and maturation. The disadvantage with this bur is that, Polishing with this bur is time consuming as it acts by grinding layer by layer to detach the residual resin.

Another bur for polishing enamel surfaces is Adhesive residual removal bur which is found to be safest and less destructive. It is a stiff rotary tool, made up of epoxy resin and glass.[5]

Study done by Olszowska et al.[5] showed that Adhesive Residual Remover bur produces finer surface when compared to tungsten carbide bur and Pogo bur.[5] In current study Tungsten carbide bur, Pogo bur, stainbuster bur and Adhesive residual remover bur are compared.

To assess changes in enamel surface roughness before and after debonding, contact profilometry was used to assess quantitative changes. Ra values are measured for all groups and compared.

When baseline surface roughness was compared between the enamel surfaces of teeth, in all the four Groups no statistically significant difference ($p < 0.05$) is found. This suggests that the surface roughness of natural enamel is

similar in all the teeth taken for the study.

Post-polishing Ra values of Group 1 showed a mean value of 1.314μm. Similar results were obtained in studies done by Trakyali et al.,[13] Yasmen et al.,[14] Harjoy et al.,[15] Degrazia et al.,[16] Ahrari et al.,[8] Goksu et al, and Alam et al, where mean values obtained were between 0.60 μm to 1.8 μm.

Some Studies[9,16,17] have shown that mean post-polishing roughness Ra values of enamel were obtained between 2.45 μm to 6.35 μm. The change in the mean post-polishing roughness Ra values can be attributed to the use of tungsten carbide burs with decreased number of flutes. Because when burs with fewer flutes are used, deeper and more aggressive cuts are formed on the enamel surface compared to burs with more number of flutes which give gentle and vibration-free polishing to produce smooth enamel surface because they have closer and shallow flutes.

Post-polishing Ra values of Group 2 showed a mean value of 1.05μm. Studies[2,18] have shown the mean roughness values ranging from 0.67 μm to 3.17 μm in accordance with this study.

Post-polishing Ra values of Group 3 showed a mean value of 0.702μm. Studies have shown mean roughness values ranging from 0.52 μm to 0.102 μm. Results obtained in the current study are similar to the studies done by Priyanka shah et al.,[2] Emire et al, Tuzcel et al.[19] and Trakyali et al.[13]

Post-polishing Ra values of Group 4 showed a mean value of 0.83μm, similar results were obtained by Olszowska et al.[5]

When mean post polishing roughness values of different groups are compared, it can be observed that the values of Group 3 were the lowest, suggesting that stainbuster produces the smoothest enamel surface after adhesive resin removal. When the difference Ra (Mean base line roughness - Mean post polishing roughness) mean values are compared it can be observed that the mean values of Group 3 was highest followed by group 4, group 2 and group 1. The difference between them is statistically significant.

Studies[2,18,20–22] showed that pogo bur produced a smoother enamel surface than tungsten carbide bur. Studies[17,20,23–25] comparing tungsten carbide bur and stainbuster bur shows that stainbuster bur produces the smoothest enamel surface. Priyanka shah et al conducted studies comparing stainbuster bur and pogo bur and they concluded that stainbuster bur produces the smoothest enamel surface when compared to pogo bur.[2]

In contrast to this study, Sara Bernardi[25] et al. have reported that tungsten carbide bur produces more smooth enamel finish than pogo bur. This difference can be accredited to the mechanotherapy followed, in which polishing with Tungsten carbide bur is done under magnifying loupe whereas polishing with Pogo bur is done under the naked eye.

When post-polishing mean difference Ra values are compared between the groups the difference obtained between Group 1 - Group 2, Group 1 - Group 3, Group 1 - Group 4, Group 2 - Group 3 and Group 2 - Group 4 are statistically significant ($P < 0.05$), but the difference between Group 3 - Group 4 is not statistically significant ($P > 0.05$), suggesting that the difference in enamel smoothness produced when Stainbuster bur and Adhesive residual remover bur are used is not significant.

The qualitative analysis of enamel is done by Scanning Electron Microscope (SEM) to produce highly magnified images. First, the samples are mounted on aluminium stab using conductive sticky pads and then samples are coated with palladium metal to improve the image quality. Then the samples are examined under a scanning electron microscope to know the surface quality of the enamel.

In samples of Group 1 EDI score of 3 is obtained. This shows that the use of tungsten carbide bur produces an enamel surface with wide grooves and coarse scratches. Similar results are obtained in the studies conducted by, Nelihen et al,[11] Elodie et al,[9] Ulusoy et al,[4] Harjoyet al,[15] Vidor et al,[26] Karan et al,[27] Padmalatha et al,[1] Olszowska et al.[5]

In samples of Group 2 an EDI score of 1 is obtained. This shows that the use of PoGo bur produces an acceptable enamel surface with fine scratches. Studies have shown similar results obtained.[1,4,5,17,27]

In samples of Group 3 an EDI score of 0 is obtained. This shows that the use of Stainbuster bur produces a smooth enamel surface without any scratches. Priyanka Shah et al,[2] Padmalatha et al,[1] and Karen et al[17] also showed similar results in their study.

In a sample of Group 4 EDI score of 0 and 1 is obtained. This shows that smooth enamel surfaces with fine scratches are produced.

SEM analysis shows that the smoothest enamel surface is produced by Stainbuster bur followed by Adhesive residual remover bur, Pogo bur and Tungsten carbide bur. Even though Stainbuster bur and adhesive residual remover bur produce smoother enamel surfaces the enamel surface smoothness produced by a Stainbuster bur is smoother than the natural enamel. Qualitative Analysis showed that the surface produced by the stain-buster bur is a smooth enamel surface without any scratches (EDI-0) compared to the Adhesive removal bur where fine scattered scratches can be seen in a few samples (EDI 1 or 0).

9. Limitations of the study

9.1. In current study, some limitations are there

1. It is an in vitro study, were in vivo conditions like presence of saliva, temperature, PH of oral cavity& oral hygiene are not considered.

2. In this study sample size is limited for SEM analysis. If large sample is used, enamel surface quality can be measured precisely.
3. In this study contact profilometry is used. With the use of latest methods like Atomic Force Microscopy, Focal Laser Microscopy, it is possible to clearly determine how much enamel has been lost.

10. Conclusion

Finishing of enamel surface followed by removal of bonded attachments is necessary. There are several techniques used to remove residual adhesive resin with minimal enamel loss, but all techniques used to remove residual resin causes certain degree of impairment to the enamel.

10.1. This study concluded that

1. Among all the four burs when quantitative analysis is done with surface profilometry, smooth enamel surface was created by Stainbuster bur, which is close to natural enamel surface followed by Adhesive residual remover bur, Pogo bur and Tungsten carbide bur in relation to post polishing average roughness (Ra).
2. On quantitative analysis with scanning electron microscope, least enamel scarring was created by Stainbuster bur followed by Adhesive residual remover bur, Pogo bur and Tungsten carbide bur.
3. Although Tungsten carbide bur took the shortest time to remove residual resin it produces enamel surface with wide groove and coarse scratches.
4. Stain buster bur and Adhesive residual removal bur can be used as an alternative for adhesive resin removal followed by debonding as it produces a fine enamel surface without any scratches & surface roughness smoother than natural enamel.

11. Source of Funding

None.

12. Conflict of Interest

None.

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