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COMPARISON OF THE CLEANUP OF REMNANT BONDING ADHESIVE FROM THE ENAMEL SURFACE AFTER DEBONDING USING CARBIDE BUR WITH AND WITHOUT ILLUMINATED LIGHT FROM PALATAL TOOTH SURFACE UNDER DRY AND WET CONDITIONS

[1*]Mushahid Hasan, [2]Pradeep Raghav, [3]Dr. Ashutosh Wadhawan, [4]C. Munish Reddy, [5]Amit Khera, [6]Dr. Prashant Sharma

[1]3rd Year Post Graduate Student, Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College, Meerut, Uttar Pradesh.
[2]Professor & Head, Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College, Meerut, Uttar Pradesh.
[3]Reader, Department of Orthodontics and Dentofacial Orthopedics, Subharti Dental College & Hospital.
[4]Professor, Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College, Meerut, Uttar Pradesh.
[5]Reader, Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College, Meerut, Uttar Pradesh.
[6]Senior Lecturer in Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College & Hospital.

***Corresponding Author: Dr. Mushahid Hasan, MDS**

3rd Year Post Graduate Student, Department of Orthodontics and Dentofacial Orthopaedics, Subharti Dental College, Meerut, Uttar Pradesh.

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ABSTRACT

Introduction: During fixed mechanotherapy, the bonded brackets can be removed by various methods which leave varying amounts of adhesive remnants on the enamel surface. Various techniques have been designed to achieve satisfactory composite removal with minimal iatrogenic damage to enamel surface. It include pliers and scalers, sandpaper discs, diamond burs stones, ultrasonic instruments and tungsten carbide burs. However, most of these studies rely on quality assurance of finishing procedures performed on the teeth, without estimating time required and the amount of adhesive remnant left after the finishing procedures. So, the main aim of this article was to compare the cleanup of bonding adhesive remnant from the surface of enamel after debonding using carbide bur with blue illuminated light on tooth surface under dry and wet conditions. **Methods:** An invitro experimental study consisted of four groups of 10 samples in each group. The metal brackets were pressed with the help of force gauge applying a horizontal pressure of 2 ounces using Transbond XT as an adhesive. Debonding of brackets was done using debonding plier in all the groups (Dry, Wet, Dry with Light and Wet with Light). After debonding, Surface reconditioning of enamel surface was performed using finishing tungsten carbide bur followed by polishing with soflex discs. Direct visual analysis analysis was done aftersive removal and after polishing. Enamel surface topography was evaluated using scanning electron microscope. **Results:** It was found that direct visual analysis and SEM (scanning electron microscope) analysis after adhesive removal, each group showed the presence of soft marks and few evident marks on the enamel surface. It also found that there was significant ($p < 0.05$) reduction of soft marks after polishing and evident marks were seen in dry condition with blue illuminated light. A statistically significant difference ($p < 0.05$) was seen in time analysis while comparing all the groups (D, W, DL and WL). **Conclusion:** When comparing both the conditions (dry and wet) with or without illuminated light; the dry condition with illuminated light provided better adhesive removal, also a significant reduction in the soft and evident marks were seen. Also, the application of auxiliary blue illuminated light reduces the chair side time during polishing.

KEYWORDS: Debonding, Adhesive Removal, Scannng Electron Microscope, Enamel Damage, Surface Roughness, Enamel Scars.

INTRODUCTION

The application of direct bonding of orthodontic brackets on enamel surface of a tooth has been a widely accepted clinical procedure for a little more than a decade. Early reports of debonding procedures recommended the removal of any adhesive remnants with a hand instrument followed by a fluted bur, and prophylaxis with zirconate, pumic, finishing of composite, paste.[1] During mechanical removal of adhesive remnant, a significant amount of enamel loss and irreversible enamel damage occur. Although the appearence of scars on the enamel surface after adhesive removal seems to be

inevitable, the damage can be minimized by choosing the right procedure.

Various techniques have been designed to achieve satisfactory adhesive removal with minimal iatrogenic damage to surface of enamel. Among them are pliers and scalers, sandpaper discs, diamond burs, stones, ultrasonic instruments, and tungsten carbide burs. However, most of these studies rely on quality assurance of finishing procedures performed on the teeth, without estimating the total time taken and the amount of adhesive left after the finishing procedures.[2]

The search for an effective and safe method of AR removal following debonding has attracted the interest of many researchers leading to the development of wide variety of instruments, methods for adhesive resin removal and modifications in procedures.[3] Some of the studies have suggested that enamel loss is less severe when adhesive is removed under dry conditions as compared to wet conditions due to decreased visibility but also there's decreased roughness on surface of enamel under wet condition.[4-7] As Kaneshima et.al[8] suggested that the visibility of composite can be increased with the use of illuminated light. Therefore, this study aimed to compare the cleanup of remnant bonding adhesive from the enamel surface after debonding using carbide bur with blue illuminated light on tooth surface under dry and wet conditions.

MATERIAL AND METHOD

An in vitro experimental study was conducted in the department of Orthodontics and Dentofacial Orthopaedics Dentistry, Subharti Dental College, Meerut. The samples were selected and examined according to the research criteria.

The inclusion and exclusion criteria were as follows

INCLUSION CRITERIA

1. Freshly extracted maxillary central incisors.
2. The same material is used to bond all the brackets (TransbondXT-3M).
3. All the brackets were bonded by applying the same compressive force.

EXCLUSION CRITERIA

1. Developmental defects on tooth structure
2. Fractured enamel surface
3. Fluorosis or enamel hypo calcification on labial surface

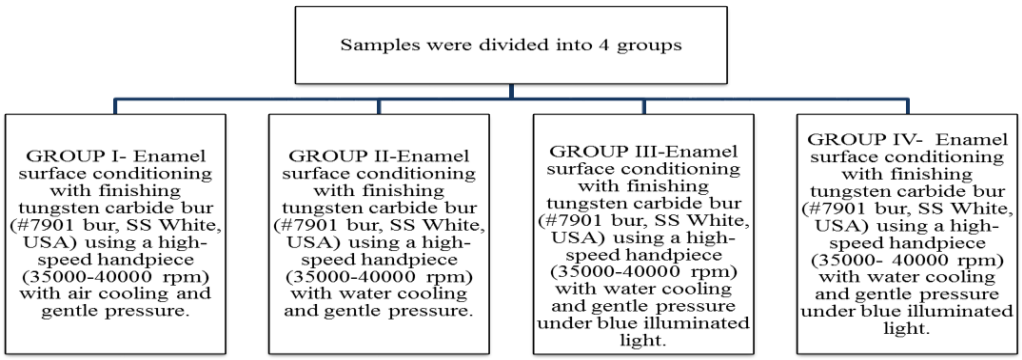
A total of 40 freshly extracted human maxillary central incisors were selected for the study. The teeth collected were cleaned and stored in distilled water at room temperature. Each tooth was mounted on a self-cured acrylic resin block in such a way that roots were completely embedded into the acrylic up to the cement-enamel junction level leaving the crown exposed. Each group was numbered for easy identification. The rubber cup and fluoride –free pumice were used to polish the buccal surface of all teeth. It was then sprayed with water and dried by compressesd oil-free airstream.

The buccal surfaces were etched with 37% orthophosphoric acid etching gel for 15 seconds, rinsed with copious water spray for another 45 seconds, and then dried with an oil free three way syringe. A thin layer of primer was applied using an applicator tip occluso-gingivally on the buccal surface. The adhesive was placed over the bracket base and the bracket was placed in the center of the teeth along the long axis of teeth using 2oz of compressive force. Excess material was removed using a scaler. Each sample was light-cured with iLED curing light at 1300 mW/cm2 for 20 seconds on both the mesial and the distal surface.

Debonding plier is used to debond each bracket by placing the beaks mesiodistally and then applying peeling type of force.[8,34-38] The adhesive was removed from tooth surface with tungsten carbide bur #7901[9,14,38] under these 4 conditions as follows, In dry condition, In wet condition (with irrigation using airotor handpiece), In dry condition under blue illuminated light, In wet condition (with irrigation using airotor handpiece) under blue illuminated light.

General considerations for adhesive removal from the tooth surface for all sample groups

- The burs used for adhesive removal were replaced after every sample.
- The same operator remove the adhesive remnants in all the groups.
- A second operator quantified the time required for removing the adhesive remnant from each sample and was taken as 30+/-5sec.
- The time taken for adhesive removal starts from placing the bur on the enamel surface till removal of adhesive remnant, verified using direct visual analysis, simulating a clinical situation.
- A specialized setup was made to standardize the distance at 5mm between the surface of tooth and blue illuminated light during removal of adhesive. (Figure. 1).

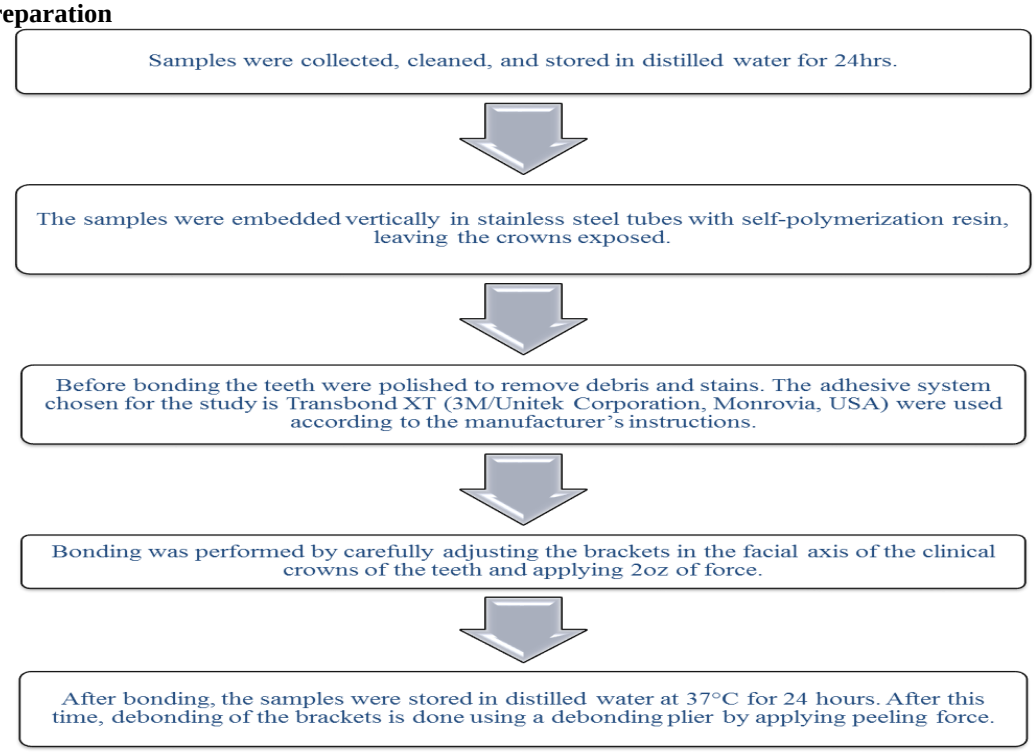


In cases of illuminated light with or without water cooling

The blue light is placed on the palatal surface of maxillary central incisors while removing the adhesive remnant from the buccal surfaces of the maxillary incisor using tungsten carbide bur (#7901 bur, SS White, USA).

The blue light used for illumination from the palatal surface is woodpecker's iLED curing light, having an intensity of 1300 mW/cm2. The intensity of light is checked for all age groups after every 5 samples with an intensity meter (woodpecker's intensity meter). This auxiliary illumination system, which emits blue light (wavelength – 410-480nm) reveals adhesive fluorescence.

Sample Preparation



Samples were randomly selected from each group and adhesive remnants were removed using a 12-fluted tungsten carbide bur #7901 followed by polishing using soflex discs in all four conditions i.e In dry condition, In wet condition (with irrigation using airotor handpiece, In dry condition under blue illuminated light, In wet condition (with irrigation using airotor handpiece) under blue illuminated light (Figure. 2).

Direct visual examination

After removing the AR (adhesive remnant), the specimens were coded to allow blind direct visual analysis. To simulate the routine clinical conditions as closely as possible this analysis was carried out by observing the enamel surface under a dental reflector light by naked eye, (Figure. 3).

The following criteria were used to make this assessment: a. Absence of removal marks; b. Presence of soft removal marks; c. Presence of more evident removal marks d. Presence of AR. To remove the bias this analysis was performed by five orthodontists.

In the event of a conflict between observers during the analysis a re-analysis of the analysis is performed.

Scanning electron microscope

SEM assessment was performed by randomly selecting 80% of the samples in each group after adhesive removal. The same parameters were used for direct visual analysis and were observed in the comparison of the images after adhesive removal and polishing.

Statistical analysis

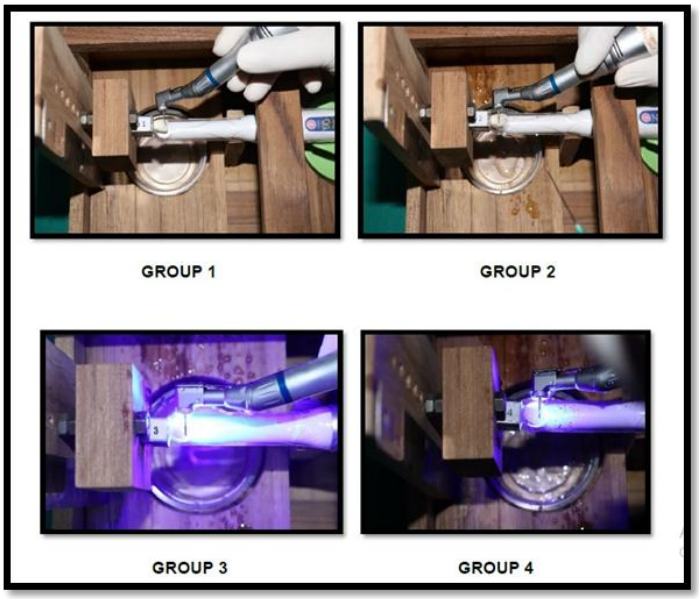
Data obtained was statistically tested in SPSS (Statistical Package for Social Sciences) software version 22.0 and Epi-info 3.0 using Microsoft Excel 2013 software. Fisher's exact test, and Mann-Whitney U test were used (direct visual and SEM assessments), as well as ANOVA and independent t-test (for determining AR removal time).

RESULTS

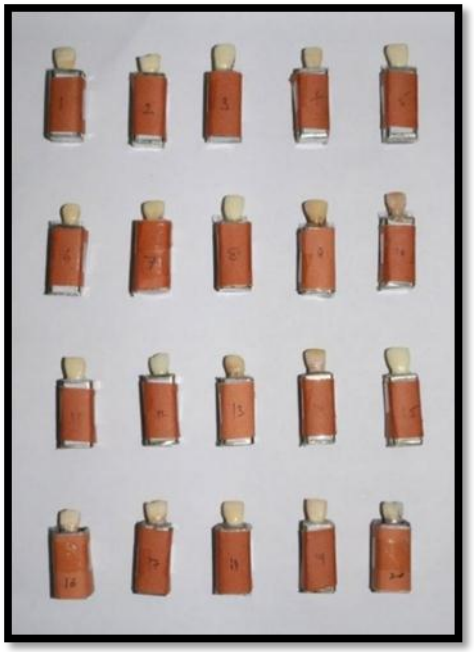
Table 1 shows fisher's extract test for comparison of direct visual analysis after adhesive removal and polishing under different conditions. All the groups i.e. (D, W, DL and WL) showed presence of predominantly soft marks on the enamel surface and some amount of evident marks. After polishing with soflex discs, a significant amount of reduction seen in soft and evident marks ($P < 0.05$) on surface of enamel.

A statistically significant reduction in soft marks were found in the dry condition with blue illuminated light (Table 2 shows analysis of variance F test; $P < 0.05$). Table 3 shows fisher's extract test for comparison of groups in SEM analysis after adhesive remnant removal and polishing. There was a significant ($P < 0.05$) reduction in amount of soft and evident marks after polishing with soflex disc. The groups DL and WL showed more reduction of marks as compared to groups D and W. Also a statistically significant ($P < 0.05$) difference in reduction of evident marks was seen in dry condition with blue illuminated light (Table 4). While comparing the time difference between all the four groups. There was statistically significant ($P < 0.05$) less time required for polishing under dry condition with blue illuminated light (Table 5). Also when we compared the groups with blue illuminated light (DL and WL) and without blue illuminated light (D and W), there was a statistically significant ($P < 0.05$) reduction in time seen during removal of adhesive and polishing.

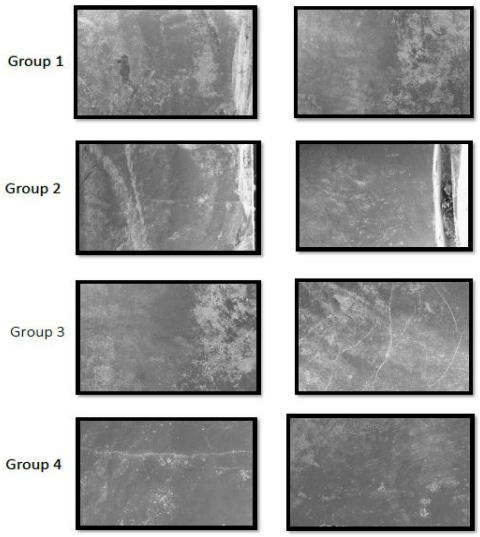
(Figure. 1)



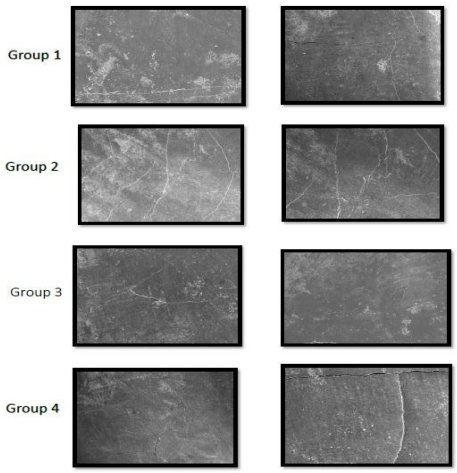
(Figure. 2)



(Figure. 3)



(Figure. 4)



(Figure. 5)

Table—1: Direct visual analysis after AR removal.

Score	Direct visual analysis after AR removal				Direct visual analysis after AR polishing			
	Removal Method				Removal Method			
	D	W	DL	WL	D	W	DL	WL
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Absence of Marks	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (40%)	2 (20%)	5 (50%)	3 (30%)
Presence of Soft Marks	7 (70%)	6 (60%)	8 (80%)	7 (70%)	4 (40%)	4 (40%)	3 (30%)	5 (50%)
Presence of Evident Marks	2 (20%)	3 (30%)	1 (10%)	2 (20%)	2 (20%)	3 (30%)	1 (10%)	1 (10%)
With Adhesive remnant	1 (10%)	1 (10%)	1 (10%)	1 (10%)	0 (0%)	1 (10%)	1 (10%)	1 (10%)
TOTAL	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)	10 (100%)
P- VALUE (FISHER'S EXACT TEST	P=.0032* P<.05 (SIG. ASSOCIATION)				P=.0024* P<.05 (SIG. ASSOCIATION)			

***SHOWS A SIGNIFICANT ASSOCIATION B/W REMOVAL METHODS & SCORES AT .05 LEVEL OF SIGNFICANCE. (P<.05)**

Table—2 (ANOVA) Analysis of variance – F - test for comparing the significant difference among direct visual analysis after AR and polishing.

SCORES	COMPARSION B/W DIRECT VISUAL ANALYSIS AFTER AR REMOVAL&DIRECT VISUAL ANALYSIS AFTER AR POLISHING			
	D	W	DL	WL
ABSENCE OF MARKS	.0001* P<.05 (SIG.)	.0000* P<.05 (SIG.)	.0002* P<.05 (SIG.)	.0000* P<.05 (SIG.)
Presence of SOFT MARKS	.0845** P>.05 (N.S.)	.0995** P>.05 (N.S.)	.0463* P<.05 (SIG.)	.1022** P>.05 (N.S.)
Presence of EVIDENT MARKS	1** P>.05 (N.S.)	1** P>.05 (N.S.)	1** P>.05 (N.S.)	.0943** P>.05 (N.S.)
WITH Adhesive remnant	.0000* P<.05 (SIG.)	1** P>.05 (N.S.)	1** P>.05 (N.S.)	1 ** P>.05 (N.S.)

Table—3: SEM analysis after AR removal.

Score	SEM analysis after AR removal				SEM analysis after AR polishing			
	Removal Method				Removal Method			
	D	W	3 (37.5%)	WL	D	W	DL	WL
	n (%)	n (%)	3 (37.5%)	n (%)	n (%)	n (%)	n (%)	n (%)
Absence of Marks	2 (25%)	1 (12.5%)	1 (12.5%)	2 (25%)	3 (37.5%)	2 (25%)	4 (50%)	1 (12.5%)
Presence of Soft Marks	3 (37.5%)	4 (50%)	1 (12.5%)	3 (37.5%)	2 (25%)	3 (37.5%)	3 (37.5%)	3 (37.5%)
Presence of Evident Marks	2 (25%)	1 (12.5%)	8 (100%)	2 (25%)	2 (25%)	2 (25%)	0 (0%)	3 (37.5%)
With Adhesive remnant	1 (12.5%)	2 (25%)		1 (12.5%)	1 (12.5%)	1 (12.5%)	1 (12.5%)	1 (12.5%)
TOTAL	8 (100%)	8 (100%)	8 (100%)	8 (100%)	8 (100%)	8 (100%)	8 (100%)	8 (100%)
P- VALUE (FISHER'S EXACT TEST	P=.0019* P<.05 (SIG. ASSOCIATION)				P=.0011* P<.05 (SIG. ASSOCIATION)			

***SHOWS A SIGNIFICANT ASSOCIATION B/W REMOVAL METHODS & SCORES AT .05 LEVEL OF SIGNFICANCE.(P<.05)**

Table—4 (ANOVA) Analysis of variance – F - test for comparing the significant difference among SEM after AR and SEM after polishing.

SCORES	COMPARSION B/W SEM ANALYSIS AFTER AR REMOVAL & SEM ANALYSIS AFTER POLISHING			
	D	W	DL	WL
ABSENCE OF MARKS	**.1011** P>.05 (N.S.)**	**.1042 ** P>.05 (N.S.)**	**.0987 ** P>.05 (N.S.)**	**.1042 ** P>.05 (N.S.)**
Presence of SOFT MARKS	**.1011** P>.05 (N.S.)**	**.0987 ** P>.05 (N.S.)**	**1 ** P>.05 (N.S.)**	**1** P>.05 (N.S.)**
Presence of EVIDENT MARKS	**1** P>.05 (N.S.)**	**.1042 ** P>.05 (N.S.)**	**.0001* P<.05 (SIG.)**	**.1011** P>.05 (N.S.)**
WITH Adhesive remnant	**1** P>.05 (N.S.)**	**.1042 ** P>.05 (N.S.)**	**1 ** P>.05 (N.S.)**	**1** P>.05 (N.S.)**

Table—5 - (ANOVA) Analysis of variance –F- test for comparing the significant difference among different removal methods in four groups.

S.NO.	AR REMOVAL TIME--REMOVAL METHOD	MEAN ± S.D.	D &W	D & DL	D & WL	W & DL	W & WL	DL & WL
1	D	28.30±5.6	.0021* P<.05 (SIG.)	.0013* P<.05 (SIG.)	.2365** P>.05 (N.S.)	.0014* P<.05 (SIG.)	.1011** P>.05 (N.S.)	.0031* P<.05 (SIG.)
2	W	29.80±4.80						
3	DL	26.7±3.70						
4	WL	28.60±4.90						

***SHOWS A SIGNIFICANT DIFFEFERNCE AT .05 LEVEL OF SIGNIFICANCE.(P<.05)**

DISCUSSION

The present study showed that statistically significant results were obtained on the enamel surface after removal of AR, verified both by direct visual analysis and SEM analysis. In comparison of different adhesive removal methods used (D, W, DL, WL), all methods showed satisfactory removal of the adhesive remnant.

Although after removal of AR in all the methods after direct visual analysis, it was found that there were presence of soft marks and few evident marks on the surface of enamel. While comparing the removal of AR after polishing, a similar trend in the reduction of soft & evident marks was seen. After polishing there was a statistically significant reduction in soft and evident marks was seen by doing polishing in blue illuminated light under dry condition, which suggests that blue illuminated light probably provides better visualization of adhesive remnant during polishing which might be aided in the reduction of soft and evident marks during polishing. A similar trend was observed in the SEM analysis also after AR removal and polishing (Figure. 4). Connie Lai et.al[48] also suggested that during orthodontic debonding UV light is more effective and efficient than white light in detection of fluorescent adhesive.

It was found in both direct visual and SEM analysis after polishing that there is a significant increase in number of samples with no removal marks and soft marks, thus indicated a reduction in evident marks on the enamel surface (Figure. 5). This put emphasis on the importance of polishing under blue emitted light, especially after removal of AR by multi-bladed tips at high speed. Another important clinical perspective alludes to the time taken during AR removal after debonding of orthodontic brackets. Regarding the patient, it will be less time consuming offering more comfort for pediatric and geriatric care, patients with TMJ dysfunction, patients who find difficulty in opening their mouth for long period of time.[8]

The present study verified that using a blue emitted light allowed a significantly quicker removal of AR in DL & WL relative to method D & W. In this study it was found that blue illuminated light hastens the procedure, and promotes a clinical time gain with greater technical agility and service efficiency, cost reduction. It is suggested that, for efficient removal of AR, blue illuminated light may be used in association with 12-bladed burs at high speed until visualizing a thin layer of AR, and then completing the removal with specific finishing and polishing tips at low speed. This method would allow fast, complete and safe removal of AR preserving the enamel surface of patient when applied clinically. Since in our study routinely used methods are used to remove the adhesive surface of tooth after conventional debonding i.e. finishing tungsten carbide bur followed by polishing with soflex discs were used. These methods are employed to remove adhesive and provide a smooth surface with minimal iatrogenic damage to the enamel.

Limitations of the study

- Limited number of sample size in the study. Samples included only central incisors.
- Results obtained were subjective during the direct visual analysis, due to which there may had been individual variation.
- SEM provided only the qualitative interpretation of the enamel surface, profilometry could have been performed to determine the quantitative loss of enamel with different tooth surface reconditioning methods.
- Practicality of putting blue illuminated light palatally during adhesive removal and polishing was difficult and require assistance.

Scope of further studies

- There is need for further investigation using these methods with the objective that if we use different categories of instrumentation that creates more roughness, will it be advantageous or will it have a detrimental effect on the enamel surface.
- Development of new instrument which include application of blue illuminated light palatally during the adhesive removal and polishing.

CONCLUSION

The following conclusions can be drawn from this study:

1. While comparing between the dry and wet condition with or without illuminated light; the dry condition with blue illuminated light provided better adhesive removal, also a significant reduction in the soft and evident marks were seen.
2. Polishing of the enamel surface should be done after AR to reduce soft and evident marks.
3. Also the auxiliary blue illuminated light can be used as an adjunct while polishing for better visualization of adhesive remnant and reduction of the chair side time for cleanup of enamel surface.

Therefore our study recommends use of 12 fluted tungsten carbide bur followed by polishing with soflex discs for cleanup of adhesive remnant under dry condition with blue illuminated light as a preferred method of reconditioning of the enamel surface. Further research is required for quantification of enamel loss with use of tungsten carbide bur and soflex discs.

List of abbreviation

SEM – scanning electron microscope
AR – adhesive remnant
D – dry
W – wet
DL – dry with illuminated light
WL - wet with illuminated light
TMJ – temporomandibular joint
UV – ultraviolet

REFERENCES

1. Howell S, Weekes WT. An electron microscopic evaluation of the enamel surface subsequent to various debonding procedures. Aust Dent J., 1990; 35(3): 245-52.
2. Hong YH, Lew K, Quantitative and qualitative assessment of enamel surface following five composite removal methods after bracket debonding. Eru J Orthod, 1995; 17(2).
3. Eliades T, Gioka C, Eliades G, Makou M. Enamel surface roughness following debonding using two resin grinding methods. Eur J Orthod, 2004; 26(3): 333-8.
4. Gwinnett AJ, Gorelick L. Microscopic evaluation of enamel after debonding: clinical application. Am J Orthod, 1977; 71(6): 651-65.
5. Retief DH, Denys FR. Finishing of enamel surfaces after debonding of orthodontic attachments. Angle Orthod, 1979; 49(1): 1-10.
6. Sandison RM. Tooth surface appearance after debonding. Br J Orthod, 1981; 8(4): 199-201.
7. Zachrisson BU, Arthun J. Enamel surface appearance after various debonding techniques. Am J Orthod, 1979; 75(2): 121-7.
8. Kaneshima EN, Berger SB, Fernandes T, Navarro M, Oltramari P. Using UV light for adhesive remnant removal after debonding of orthodontic accessories. Braz Oral Res., 2018; 32(47).
9. Bertrand D. Rouleau, Grayson W. Marshall, Robert O. Cooley, Enamel surface evaluations after clinical treatment and removal of orthodontic brackets. Am J OrthoD, 1982; 81(5): 423-26.
10. Oliver RG, Griffiths J. Different techniques of residual composite removal following debonding--time taken and surface enamel appearance. Br J Orthod, 1992; 19(2): 131-7.
11. M.R. Arcuri, R.L. Schneider, R.A. Strug, J.M. Clancy, Scanning electron microscope analysis of tooth enamel treated with rotary instruments and abrasives. J Prosthet Dent, 1993; 69(5): 483-90.
12. Zarrinnia K, Eid NM, Kehoe MJ. The effect of different debonding techniques on the enamel surface: an in vitro qualitative study. Am J Orthod Dentofacial Orthop, 1995; 108(3): 284-93.
13. Campbell PM. Enamel surfaces after orthodontic bracket debonding. Angle Orthod, 1995; 65(2): 103-10.
14. Radlanski RJ. A new carbide finishing bur for bracket debonding. J Orofac Orthop, 2001; 62(4): 296-304.
15. David VA, Staley RN, Bigelow HF, Jakobsen JR. Remnant amount and cleanup for 3 adhesives after debracketing Am J Orthod Dentofacial Orthop, 2002; 121(2): 291-6.
16. Kim SS, Park WK, Son WS, Ahn HS, Ro JH, Kim YD. Enamel surface evaluation after removal of orthodontic composite remnants by intraoral sandblasting: a 3-dimensional surface profilometry study. Am J Orthod Dentofacial Orthop, 2007; 132(1): 71-6.
17. Ulusoy C. Comparison of finishing and polishing systems for residual resin removal after debonding. J Appl Oral Sci., 2009; 17(3): 209-15.
18. Karan S, Kircelli BH, Tasdelen B. Enamel surface roughness after debonding. Angle Orthod, 2010; 80(6): 1081-8.
19. Ryf S et al. 2011 Enamel loss and adhesive remnants following bracket removal and various clean-up procedures *in vitro Eur J Orthod*, 2012; (34): 25–32.
20. Alessandri Bonetti G, Zanarini M, Incerti Parenti S, Lattuca M, Marchionni S, Gatto MR. Evaluation of enamel surfaces after bracket debonding: an in-vivo study with scanning electron microscopy. Am J Orthod Dentofacial Orthop, 2011; 140(5): 696-702.
21. Marchi Rodrigo De, Marchi Luciana Manzotti De, Terada Raquel Sano Suga, Terada Hélio Hissashi. Comparison between two methods for resin removing after bracket debonding. Dental Press J. Orthod, 2012; 17(6): 130-136.
22. Uma H L, Chandrelekha B, Mahajan A. Scanning electron miscroscopic evaluation of the enamel surface subsequent to various debonding procedures – an invitro study. AOSR, *2012*; 2(1): 17-22.
23. Ahrari F, Akbari M, Akbari J, Dabiri G. Enamel surface roughness after debonding of orthodontic brackets and various clean-up techniques. J Dent (Tehran), 2013; 10(1): 82-93.
24. Faria-Júnior ÉM, Guiraldo RD, Berger SB, Correr AB, Correr-Sobrinho L, Contreras EF, Lopes MB. In-vivo evaluation of the surface roughness and morphology of enamel after bracket removal and polishing by different techniques. Am J Orthod Dentofacial Orthop, 2015; 147(3): 324-9.
25. Vidor M, Felix RP, Marchioro EM, Hahn L. Enamel surface evaluation after bracket debonding and different resin removal methods Dental Press J Orthod, 2015; 20(2): 61–67.
26. Webb BJ, Koch J, Hagan JL, Ballard RW, Armbruster PC. Enamel Surface Roughness of Preferred Debonding and Polishing Protocols. J Orthod, 2016; 43(1): 39-46.

27. Khatria H, Mangla R, Garg H, Gambhir RS. Evaluation of enamel surface after orthodontic debonding and cleanup using different procedures: An *in vitro* study. J Dent Res Rev., 2016; 3: 88-93.
28. Erdur EA, Akın M, Cime L, İleri Z. Evaluation of Enamel Surface Roughness after Various Finishing Techniques for Debonding of Orthodontic Brackets. Turk J Orthod, 2016; 29(1): 1-5.
29. Cochrane NJ, Lo TWG, Adams GG, Schneider PM. Quantitative analysis of enamel on debonded orthodontic brackets. Am J Orthod Dentofacial Orthop, 2017; 152(3): 312-319.
30. Fan XC, Chen L, Huang XF. Effects of various debonding and adhesive clearance methods on enamel surface: an in vitro study. BMC Oral Health, 2017. 27; 17(1): 58.
31. Goel A, Singh A, Gupta T, Gambhir RS. Evaluation of surface roughness of enamel after various bonding and clean-up procedures on enamel bonded with three different bonding agents: An *in-vitro* study. J Clin Exp Dent., 2017; 9(5): 608-16.
32. Ribeiro AA, Almeida LF, Martins LP, Martins RP. Assessing adhesive remnant removal and enamel damage with ultraviolet light: An in-vitro study. Am J Orthod Dentofacial Orthop, 2017; 151(2): 292-296.
33. Yadav J, Raghav P, Reddy M, Ahuja NK. Evaluation of enamel loss with bonding and debonding: A study with profile projector. J Indian Orthod Soc., 2017; 51: 177-84.
34. Shah, P., Sharma, P., Goje, S.K. *et al.* Comparative evaluation of enamel surface roughness after debonding using four finishing and polishing systems for residual resin removal—an in vitro study. *Prog Orthod*, 2019: 20(18).
35. Yadav J, Khan M, Grover D, Nishi. Feasibilty of different methods after debonding of orthodontic bracket: an in vitro study IJDMS, 2019; 6(1): 186-89.
36. Bennett CG, Shen C, Waldron JM. The effects of debonding on the enamel surface. J Clin Orthod, 1984; 18(5): 330-4.
37. Piccoli L et al Comparison of two different debonding techniques in orthodontic treatment Ann Stomatol, 2017; 8(2): 71-78.
38. Vinay.P, Chandrashekhar B.S DEBONDING OF ORTHODONTIC BRACKETS- A CLINICAL TIP *Ann Essences Dent, 2011*; 3(1): 65-72.
39. Jaffer S, Oesterle LJ, Newman SM. Storage media effect on bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop, 2009; 136: 83-86.
40. Sachdeva K, Singla A, Mahajan V, Jaj HS, Saini. Effect of storage media on shear bond strength of orthodontic brackets. J Indian Orthod Soc., 2012; 46(4): 203-09.
41. MacColl GA, Rossouw PE, Titley KC, Yamin C. The relationship between bond strength and orthodontic bracket base surface area with conventional and microetched foil mesh bases. Am J Orthod. Dentofacial Orthop, 1998; 113: 276–281.
42. Bayram M, Yesilyurt C, Kusgöz A, Ulker M, Nur M. Shear bond strength of orthodontic brackets to aged resin composite surfaces: Effect of surface conditioning. Eur J Orthod, 2010; 33(4): 174-179.
43. Osorio R, Toledano M, Garcia-Godoy F. Bracket bonding with 15 or 60 second etching and adhesive remaining on enamel after debonding. Angle Orthod, 1999; 69(1): 45-48.
44. Nordenvall KJ, Brannstrom M, Malmgren O. Etching of deciduous teeth and young and old permanent teeth. A comparison between 15 and 60 seconds of etching. Am J Orthod, 1980; 78(4): 99–108.
45. Basharik ZM, Kamel MR, Shakib PA, Mirzaie M, Bijani A. Comparison of shear bond strength of stainless steel brackets bonded with three light-cured adhesives. Caspian J Dent Res., 2015; 4(2): 27-32.
46. Wang WN, Meng CL. A study of bond strength between light- and self-cured orthodontic resin. Am J Orthod Dentofacial Orthop, 1992; 101(5): 350–54.
47. Morais DR, Moresca AHK, Moro A, Moresca RC, Correr GM. Shear bond strength of brackets bonded with nanofilled flowable resins. Rev Sul Bras Odontol, 2015; 12(1): 8-13.
48. Lai C, Bush PJ, Warunek S, Covell DA, Jewari TA. An in vitro comparison of ultraviolet versus white light in the detection of adhesive remnants during orthodontic debonding. Angle Orthod, 2019; 89(3): 438-45.