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Evaluation Of The Effects Of Staining Solutions On Enamel After Orthodontic Bracket Debonding, Following Different Finishing Procedures-An In-Vitro Study

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ABSTRACT
OBJECTIVE: *To evaluate the effect of staining solutions on the enamel after orthodontic bracket debonding followed by different finishing procedures.*
MATERIAL AND METHOD: *Metal brackets were bonded to extracted human premolars (n=90). After 24 hours of photoaging, brackets were removed and samples were randomly divided into three groups, Group I (Tungsten carbide), Group II (Sof-Lex discs), and Group III (Tungsten carbide with Enhance finishing and polishing system). To evaluate stain susceptibility, teeth were immersed in turmeric solution, coffee solution, and artificial saliva. Color assessment of all the teeth was performed using a Spectrophotometer at baseline before bonding, after the finishing procedure, and after the staining procedure. The Statistical analysis was carried out to compare the effects of different resin removal techniques and staining methods.*
RESULT: *Kruskal Wallis ANOVA test revealed that there is a statically significant difference between the mean ranks in color change (ΔE) among the three groups. Pairwise comparison using Dunn's test showed that there is no significant difference between Tungsten carbide and Sof-Lex discs, whereas the difference between combination of Enhanced finishing system and Tungsten carbide with the other groups were significant. Pairwise comparison using Dunn's test showed that turmeric caused a significant change in ΔE compared to artificial saliva among the tungsten carbide and Sof-Lex disc group. Maximum color change is noticed with turmeric followed by coffee and artificial saliva.*
CONCLUSION: *The turmeric solution displayed a definite discoloration of teeth after debonding. However, when the combination of 30-fluted tungsten carbide bur and Enhance finishing and polishing system were used, resulted in less amount of enamel staining.*
Clinical significance: *Patient's diet, oral hygiene, bonding and debonding procedures affect tooth color during orthodontic treatment. Hence, it is mandatory for orthodontic patients to undergo routine oral prophylaxis.*

KEYWORDS: *Enamel staining, orthodontic debonding, finishing, spectrophotometer*

INTRODUCTION:

It is well established that orthodontic bracket bonding and debonding lead to an altered enamel surface. This effect may be because of enamel loss due to etching, enamel alterations due to white spot lesions, enamel microcracks or abrasions induced by adhesive removal procedures, or/and penetration of resin tags into the enamel structure at a depth reaching 50μm [1,2]. The various adhesive removal procedures following debonding include single step and multistep system comprising of tungsten carbide, diamond burs, sandpaper discs, and aluminium oxide discs and 30-fluted tungsten carbide bur provides a better finish to the enamel surface as compared to 12 fluted carbide bur. During orthodontic treatment, cracks develop into the adhesive resin which leads to crevice corrosion. Metal ions such as chromium and nickel get migrated into adhesive resin at the site of corrosion and along with chlorine from the saliva leads to the formation of chromium and nickel chlorides which shows greenish-black discoloration of resin.[3]

A spectrophotometer is preferred over a colorimeter for color assessment since it can record the reflected light from the entire visible spectrum while a colorimeter can measure the reflected light from only three wavelengths which include blue, green, and red.
Studies have shown that penetration of residual resin tags into the enamel shows changes in enamel color [4-11]. It is determined that 50µm of resin tag length can be found into enamel which cannot be reversed by debonding and cleaning procedures. These color changes in the enamel, change the refractive index of the region and modifies the diffusely reflected light component. Besides this, there is an added problem of extrinsic staining of the residual resin from food colorants.
According to the author's knowledge, this is the first study of its kind to evaluate the effects of stain susceptibility of teeth with various food colorants after various finishing procedures. Keeping this perspective in mind this current study was carried out which evaluated the effect of different staining solutions after orthodontic bracket debonding using different finishing procedures. The objectives of the study were to compare the color change of enamel before bonding and after debonding of orthodontic brackets followed by residual resin removal with various finishing procedures and to evaluate stain susceptibility of teeth after finishing techniques.

MATERIALS AND METHODS

Ninety freshly extracted human premolars extracted for orthodontic reasons were collected. The research protocol was evaluated and approved by the Institutional Review Board and Ethical committee in 2018 (GDCH/IIEC/18-35). Teeth with white spot lesions, fractures, decay, microcracks and restorations were excluded from the study. Teeth were washed, cleaned thoroughly and stored in distilled water.

Sample preparation

The most of the root part of each tooth was removed with a diamond disc, and the crown part with the buccal surfaces exposed and facing upward was embedded in a self-cure acrylic resin (Figure 1) which was poured into ¾ inch plastic cylindrical mould of height 5mm. These samples were randomly divided into three groups, Group I (Tungsten carbide), Group II (Sof-Lex discs), and Group III (Tungsten carbide with Enhance finishing and polishing system). Each group was evaluated for stain susceptibility using turmeric solution, coffee solution, and artificial saliva as shown in Table I (Figure 2).

Table I. Allocation of teeth to different groups (Study groups)

Group I (Tungsten carbide)	**Group II (Sof-Lex disc)**	**Group III (Tungsten carbide with Enhance finishing and polishing system)**
I-A. Turmeric	II-A. Turmeric	III-A. Turmeric
I-B. Coffee	II-B. Coffee	III-B. Coffee
I-C. Artificial Saliva	II-C. Artificial Saliva	III-C. Artificial Saliva

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Figure 1

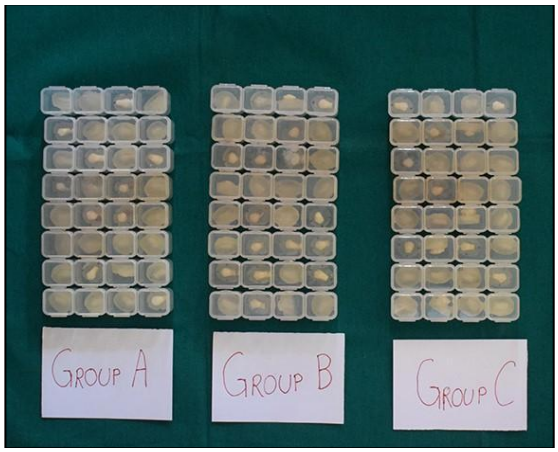

Figure 2

Color assessment at baseline

Following the sample preparation, the color assessment was performed at baseline using a UV visible Spectrophotometer (Figure 3). Markings were made on the acrylic to obtain a consistent and standardized orientation of the specimen for color measurement. These measurements were evaluated in accordance with the CIE (Commission Internationale de l'Eclairage) L*a*b* color system (lightness, red/ green, and blue/yellow respectively). The American Dental Association recommended Commission Internationale de L, Eclairage (CIELAB) color differential system where L*a*b* color space was plotted in a cube form (Figure 4). L* denotes lightness and the maximum value for L* could be 100 indicating a perfect reflecting diffuser and the minimum value for L* could be zero, representing black. There was no specific numerical limit for a* and b* axis. Red was represented by positive a* value and green by negative a* value. Positive b* value showed yellow and negative value represented blue color.

Figure 3

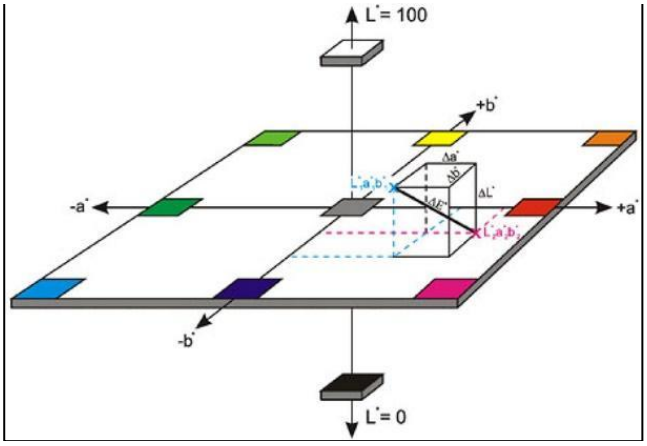

Figure 4

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Bonding

After baseline color measurements, all the teeth were bonded using a standard bonding procedure (figure 5). Etchant used was 37% orthophosphoric acid for 15 seconds and Transbond XT Adhesive Primer (3M Unitek, Monrovia, Calif) was used in conjunction with Transbond XT Adhesive Resin (3M Unitek) according to the manufacturer's instructions for bonding. Maxillary first premolar stainless-steel brackets with 0.022-inch slots (American Orthodontics, USA) were cured using a light emitting diode unit (LED.D, Guilin woodpecker medical instrument Co. Ltd) for 15 seconds. The bonded specimens were kept in distilled water at room temperature for 24 hours for adequate polymerization, followed by thermocycling with 500 cycles at 55°C and 5°C with a dwell time of 20 seconds in each bath, with a transfer time of 4 seconds.

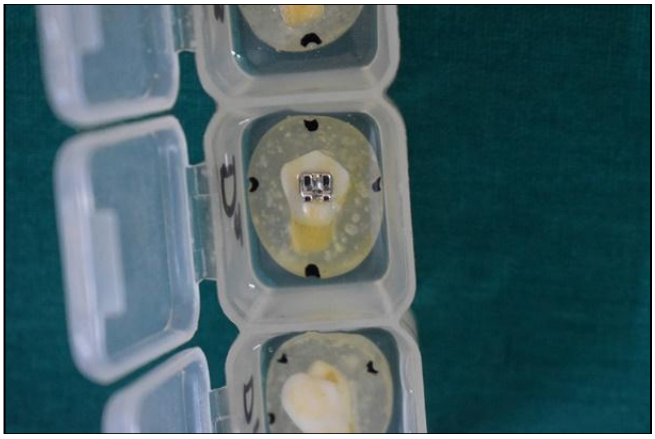

Figure 5

Debonding and Resin Removal

After thermocycling, the brackets were debonded using straight debonding plier (GDC 3000/83) and the teeth were subjected to the respective resin removal method, which was verified by visual inspection under loupe magnification.

In group I, the resin removal was done using 30-fluted tungsten carbide bur (FF 9642) (Figure 6) with an air rotor handpiece at high speed.

In group II, the resin removal was done using a sequence of four Sof-lex discs (coarse, medium, fine, super-fine) (3M) (Figure 7) with a micromotor handpiece. Sof-Lex discs are the aluminium oxide coated abrasives, available in different grits coarse (55 μm), medium (40 μm), fine (24 μm), and super fine (8 μm).

Figure 6

Figure 7

In group III, the resin removal was done using 30-fluted tungsten carbide bur (FF 9642) with an air rotor handpiece and further finishing was done using Enhance finishing and polishing system (DENTSPLY) with micromotor (Figure 8). This system is one of the recently introduced methods for final finishing and polishing of teeth after bracket removal. Enhance tips are made up of cured urethane dimethacrylate resin and aluminium oxide (40μm). In all the groups, the resin removal was done using light paintbrush

strokes in one direction. The 30-fluted tungsten carbide bur, Sof-lex discs and Enhance finishing tips were replaced after every five samples. Following finishing procedures, a color assessment of the teeth was carried out.

Figure 8

Staining procedure
To evaluate stain susceptibility, study groups were divided into three subgroups based on the type of staining solution: -Subgroup A: 0.1% Turmeric solution, B: Coffee solution, and C: Artificial saliva.

Preparation of solutions
In order to make 0.1% weight turmeric solution, 0.1g of turmeric powder was dissolved in 100ml of distilled water. The coffee solution was prepared by dissolving 1.5g of coffee powder (Nescafe Classic, Nestle) in 120ml of distilled water according to the manufacturer's instructions and artificial saliva was used which had a pH similar to human saliva.

Storage of specimens
Ten randomly selected specimens from each group were stored separately in ninety plastic tablet containers with respective solutions (at 37 ° C ± 1 ° C) for a period of 15 days. The staining solutions were freshly made and changed daily.

Color assessment was performed at baseline before bonding, after finishing and after staining procedure using spectrophotometer X- Rite i1 Pro, Software: X- Rite Profile maker Pro 5.0.10. The color comparison was performed in terms of L∗, a∗, and b∗ using the formula: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$
ΔE= Change in color, ΔL= Change in lightness, Δa= Change in red/ green, Δb=Change in blue/yellow.

Statistical analysis
All the data was entered into a Microsoft Excel sheet. Analysis was carried out using SPSS (Statistical Package For The Social Sciences) version 22 by IBM. Standard descriptive statistics means and standard deviations were calculated for all parameters. The change in colour after debonding and staining was assessed using Kruskal Wallis ANOVA test followed by Dunns Post Hoc test. A statistically significant level was predetermined at 0.05 for all tests.

Result:
This study aimed to compare the color change of enamel before bonding and after debonding of orthodontic brackets followed by residual resin removal with various finishing procedures and to evaluate stain susceptibility of teeth after finishing techniques.
In Table II, ranges of mean of each color coordinate of enamel surface at baseline for all the groups is: CIE L* 61.250-64.900; CIE a* -1.47 − -1.67; CIE b* 2.23–3.33. The L* value increases for all the groups

before and after debonding. The a* value becomes less negative for all the four groups. The b* values for all the experimental groups become more positive.

Table II: The mean and standard deviation of Commission Internationale de l'Eclairage L*, a*, b* and color change for individual groups before and after debonding

		Baseline				After debonding and finishing			
Group (n=30)		L	a	b	ΔE	L	A	b	ΔE
Group I	Mean	64.900	-1.47	3.33	29.50	68.600	-1.13	5.83	18.70
	SD	6.8247	.629	2.928	6.511	5.8933	.730	2.151	4.572
Group II	Mean	61.760	-1.50	2.23	28.77	68.953	-1.00	5.77	18.73
	SD	9.3272	.630	2.344	8.601	9.7160	.643	2.079	7.943
Group III	Mean	61.250	-1.67	3.33	25.63	69.727	-1.03	6.87	18.27
	SD	8.9942	.661	2.975	8.389	9.2838	.890	2.417	7.982

The mean change in ΔE (Table III) from baseline to after debonding is highest among the Tungsten carbide group (10.760) and least among combination of Enhanced finishing system and Tungsten carbide (7.387). Kruskal Wallis ANOVA test revealed that there is a statistically significant difference between the mean ranks in ΔE among the three groups.

Table III. Comparison of mean change in ΔE from baseline to after debonding using Kruskal Wallis ANOVA

	N	Mean	SD	Mean rank	df	*χ2*	P value
Group I	30	10.760	5.0587	51.38	2	13.863	0.001*
Group II	30	10.037	2.2273	54.03			
Group III	30	7.387	2.5208	31.08			

$p<0.05$

As seen in Table IV, the Pairwise comparison using Dunn's test showed that there is no significant difference between Tungsten carbide and Sof-Lex disks, whereas the difference between the combination of Enhanced finishing system and Tungsten carbide with the other groups were highly significant.

Table IV. Pairwise comparison using Tukey HSD

Groups compared	P value
Group I- Group II	0.694
Group I – Group III	0.003*
Group II – Group III	0.001*

*p <0.05

Table V: Comparison of mean change in ΔE from baseline for different stains in each group using Kruskal Wallis ANOVA

Group	Stains	N	Mean	SD	Mean rank	df	*χ2*	P value
Group I	Turmeric	10	6.10	1.19	21.80	2	10.53	0.005*

	Coffee	10	5.05	1.19	15.65			
	Artificial Saliva	10	4.03	1.21	9.05			
Group II	Turmeric	10	5.36	0.97	23.25	2	15.95	<0.001*
	Coffee	10	4.23	1.10	15.70			
	Artificial Saliva	10	3.05	0.67	7.55			
Group III	Turmeric	10	4.00	2.58	19.50	2	4.83	0.089
	Coffee	10	2.80	1.39	15.95			
	Artificial Saliva	10	2.23	1.14	11.05			

**p<0.05*

Kruskal Wallis ANOVA test done for change in ΔE from baseline to post-staining (Table V) showed that there is a statistically highly significant difference between the stains among Tungsten carbide and Sof-Lex disc groups. Whereas Enhanced finishing system and Tungsten carbide group had no significant change in ΔE when stained with different materials.

Pairwise comparison using Dunn's test (Table VI) showed that turmeric caused a highly significant change in ΔE compared to artificial saliva among the tungsten carbide and Sof-Lex disc group.

Table VI: Pairwise comparison using Dunn's test

Groups compared	P value	
	Tungsten carbide	Sof-Lex disc
Turmeric - Coffee	0.35	0.164
Turmeric - Artificial saliva	0.004*	<0.001*
Coffee - Artificial saliva	0.279	0.115

**p* <0.05

DISCUSSION:

The advent of the acid-etch technique has revolutionarised the orthodontic practice by facilitating direct bonding of orthodontic brackets. However, the process of bracket removal following the completion of active treatment poses a challenge as to restore the enamel surface to its pre-treatment condition. The present investigation demonstrated the effect of bonding, debonding, and various finishing techniques on stain susceptibility of enamel. When the combination of 30-fluted tungsten carbide bur and Enhanced finishing and polishing system were used showed the least color change of tooth enamel post debonding. It was evaluated that both turmeric and coffee cause staining of enamel. However, turmeric showed a significant color change of teeth.

Trakyali *et al*[12] set the clinical threshold value for color change at 3.7 units. However, the observer does not notice the color difference clinically below 3.7 units and above this value, the observer can notice the difference[13]. In the current study, the color differences were found to exceed the clinical threshold value indicating the susceptibility of enamel to various effects induced.

It was observed that the value of color change at baseline in all the experimental groups was increased after debonding. This might be due to increase in lightness and gradual increase in yellowness or redness whereas the value of color change decreased after finishing and gradually increased after staining. The lightness of the teeth decreased after finishing due to loss of surface enamel which changed the refractive index and thus altered the path of diffusely reflected light. Although the underlying dentin was yellowish in color, it was covered by a thick layer of enamel. This might also lead to a mild increase in yellowness of the teeth. On exposure to staining solutions, there was a further decrease in lightness and a significant increase in yellowness or redness of the teeth. As the color of turmeric was yellow, teeth immersed in turmeric showed an increase in yellowness (+b). The color of coffee was reddish-brown, hence teeth exposed to coffee presented with an increase in redness (+a). These findings were similar to the study carried out by Vatsala et al[14].

Since this was the first study of its kind, comparisons were done wherever possible. The two most characteristic concerns involving the debonding procedure include incomplete resin removal and iatrogenic enamel damage leading to surface roughness. The stain susceptibility of the dentition is affected by the presence of residual resin or increase in surface roughness, that bring about internal changes via physiochemical reaction of resin and external changes caused by superficial absorption of food pigments. Thus, surface staining is an inevitable consequence of improper debonding techniques.

The most commonly used finishing and polishing devices for resin removal include various single-step and multi-step systems comprising of tungsten carbide (12-fluted, 30-fluted), diamond bur and aluminium oxide coated abrasive discs like Sof-Lex discs, Super Snap discs. According to a study, diamond finishing bur has been found to be extremely injurious to the enamel surface producing deep grooves that correspond to the size of the abrasive diamond particles. [15] Ulusoy *et al* [9] found that 30-fluted tungsten carbide bur was better than 12-fluted bur as it causes less damage to the enamel surface. Though the use of 30-fluted tungsten carbide bur is time-consuming, it is the preferred method as it causes less damage to the enamel. Vidor et al[11] recommended a combination of tungsten carbide bur and Enhance finishing tips for residual resin removal, as it provided the least surface roughness and better smoothness of enamel comparable to intact enamel. It is observed that abrasive particles disengage from the Enhance tips when light pressure is applied and efficiently buff the surface. Polishing the surfaces with polishing paste gives a glossy surface that inhibits plaque accumulation and a surface that is aesthetically pleasing.

A highly statistically significant difference in color change was found in all three finishing techniques, indicating a definite color change of surface enamel irrespective of the finishing method used. However, the color difference after finishing was the highest in group II followed by group I. The least amount of color change was noticed in group III. Thus, the multistep method using 30-fluted tungsten carbide bur and Enhance finishing and polishing system was found to be the most efficient method for finishing.

Although there were no studies to compare the effect of various finishing techniques on enamel surface discoloration, a lot of literature[9,11,12] has evaluated the enamel surface roughness with various finishing techniques. Campbell et al[16] concluded that the use of a multi-step procedure involving 30-fluted tungsten carbide bur, Enhance finishing cups and points, and polishing paste for resin removal provided with the smoother enamel surface. Ulusoy[9] suggested the use of 30-fluted tungsten carbide bur for efficient resin removal. However, single-step use of 30-fluted tungsten carbide bur was shown to produce fine scratches which need to be eliminated with other polishing techniques. Vidor *et al*[11] recommended a combination of 30-fluted tungsten carbide bur and Enhance finishing and polishing system for resin removal after debonding as it posed less harm to the enamel while efficiently removing

the residual resin. The study concluded that the sequential use of multiple polishing tools was superior compared to the single-step procedure. Though these findings[9,11,12] cannot be directly correlated to the present study because they have carried out only surface roughness evaluation but the inferences are similar, as a decrease in surface roughness results in less enamel color change.

According to the study conducted by Vatsala *et al,*[14] there was no statistically significant difference amongst the various staining solutions (tea, turmeric, and coffee) when used for an incubation period of one week, hence the incubation period was doubled for this study. When various groups were compared after immersion in turmeric solution a definite discoloration has been found in all the samples which were immersed in turmeric solution. Thus, turmeric effectively stains all the groups. The highest turmeric staining was found in group II followed by group I. The minimum discoloration was associated with Group III owing to a better finishing technique. A statistically significant difference in color change was found in all the experimental groups immersed in turmeric solution.

The deep yellow staining of turmeric could be attributed to the presence of an organic pigment, curcumin. Curcumin is a polyphenol that is non-polar and hydrophobic in nature. Thus, the polarity of curcumin might not be the mechanism associated with the discoloration of this compound[17]. Instead, this colorant disperses into the resin as a separate phase and thus discolours the resin. This property was used by Aghili et al[18] who recommended the application of turmeric powder mixed in GC-MI plus paste for disclosing residual resin after debonding due to the staining ability of turmeric. So that only residual resin could be cleaned without damaging enamel. When various groups were compared after immersion in coffee solution a definite discoloration has been found in all the samples. Thus, coffee effectively stains all the groups. The highest coffee staining was found in Group II followed by Group I and least in Group III.

Sequential use of Sof-Lex discs is required to achieve a smooth and glossy enamel surface however, it is time-consuming and some abrasive remnants and metal traces from the mandrel remain on the enamel surface. Ulusoy[9] showed that sequential use of Sof-Lex discs led to a decrease in surface roughness, however, adhesive remnants remained on the enamel surface. As such, the use of Sof-Lex discs alone was not an effective method of finishing. In the present study, Group II showed maximum staining as compared to the other groups. The possible reason might be the presence of a thin residual adhesive layer on the enamel surface which showed maximum discoloration on exposure to the coffee solution. Beverages such as coffee and tea are highly polar in nature, therefore, they have a high potential to stain the resin matrix by adsorption or absorption.[19,20] Joo *et al*[21] have carried out the study to assess the stain susceptibility of the enamel with the methylene blue stain on surfaces finished with tungsten carbide burs and they were additionally polished with rubber cup and pumice. They concluded that the stain susceptibility of the surfaces which were highly glossed was less. It can be inferred that Group III which showed minimum staining both with turmeric and coffee had a maximally polished surface.

Jahanbin *et al*[22] stated that the enamel color was not affected by adhesive used for bonding. Moreover, components of the enamel were responsible for the uptake of exogenous stain, not the resin tags. The least total staining was observed in Group III which could be attributed to the smooth and glossy enamel surface being produced by this multistep system. This result was in concurrence with Vidor *et al*[11] and Campbell P M[15] who found a superior finish of enamel surface with this combination. Glossy enamel surface and increase in reflection of light were shown to reduce the total enamel color difference from baseline to staining. This system proved to be the most efficient in eliminating bulky residual resin remnants and restores the enamel surface closest to its pretreatment condition.

The color change in the different study groups could be associated not only with the surface roughness post-debonding but also with other factors. These include resin tags infiltration into the enamel [5] which changes the refractive index and thus alters the path of diffusely reflected light, and also internal discoloration of enamel caused by photoaging.[2, 23] Eliades et al[23] found out that photoaging of orthodontic resin accelerates the clinically detectable color change, which in turn contributes to enamel

discoloration, particularly after completion of orthodontic treatment. Haghighi etal[24] evaluated that bonding with chemically cured and light cured composites have similar effects on tooth color. Iosif etal[25] reported that bonding strength got affected after prolonged exposure of brackets to acidic drinks due to erosion propagation into both enamel-adhesive interface and bonding layer.

Although, there is no finishing method presently available to restore the perikymata intact on the enamel surface, the current study reveals that the combination of tungsten carbide bur and Enhanced finishing and polishing system can produce an enamel surface finish close to that of an intact enamel surface. The clinical significance of tungsten carbide bur is that it produces the finest scratch pattern compared to that of other instruments which can be eliminated with polishing methods.

CONCLUSION:

The result showed that the turmeric solution displayed a definite discoloration compared to the coffee solution and artificial saliva. However, when a combination of 30-fluted tungsten carbide bur and Enhance finishing and polishing system were used resulted in less amount of discoloration of enamel. Although enamel surface roughness was not evaluated at microscopic level after finishing procedures, residual resin after debonding of bracket was removed under loupe magnification by the same observer under same lighting condition until no remnants remain. Better finishing technique may reduce the susceptibility of enamel discoloration after orthodontic treatment. Also, awareness about various food colorants, dietary habits, good oral hygiene maintenance and routine dental check-ups should be implicated in the orthodontic patients.

Therefore, it was concluded that orthodontic treatment brought about various structural and superficial alterations of the enamel surface, which could be minimized using proper finishing and polishing methods with minimal enamel damage.

CITATIONS:

1) **Pandian A, Ranganathan S, Padmanabhan S**. Enamel Color Changes following Orthodontic Treatment. Indian Journal of Dental Research; Volume 28, Issue 3, May-June 2017
2) **Boncuka Y, Cehreli ZC, Ozsoy OP**. Effects of different orthodontic adhesives and resin removal techniques on enamel color alteration. Angle Orthod. 2014; 84:634–641.
3) **Gwinnett AJ.** Corrosion of resin-bonded orthodontic brackets. American Journal of Orthodontics Volume 82, Number 6 June 1982.
4) **Eliades T, Kakaboura A, Eliades G, Bradley TG.** Comparison of enamel color changes associated with orthodontic bonding using two different adhesives. European Journal of Orthodontics 23 (2001) 85-90
5) **Zaher AR, Abdalla EM, Motie MAA, Rehman NA, Kassem H, Athanasiou.** Enamel color changes after debonding using various bonding systems. Journal of Orthodontics 39:2012, 82-88.
6) **Coskuner HG, Atik E and Taner T.** Tooth color change due to different etching and debonding procedures. Angle Orthod. 2018; 88:779–784.
7) **Zachrisson BU, Arthun J**. Enamel surface appearance after various debonding techniques. Am J Orthod. 1979 Feb;75(2):121-7.
8) **Radlanski RJ**. A New Carbide Finishing Bur for Bracket Debonding. J Orofac Orthop/Fortschr Kieferorthop 2001; 62:296–304.
9) **Ulusoy C.** Comparison of finishing and polishing systems for residual resin removal after debonding. J Appl Oral Sci. 2009;17(3):209-215.
10) **Macieski K, Rocha R, Locks A, and Ribeiro GU.** Evaluation of remaining resin removal (three modes) on enamel surface after bracket debonding. Dental Press J. Orthod. vol.16 no.5 Maringá Sept./Oct. 2011
11) **Vidor MM, Felix RP, Marchiora EM, Hahn L**. Enamel surface evaluation after bracket debonding and different resin removal methods. Dental Press J Orthod. 2015 Mar-Apr;20(2):61-7.
12) **Trakyali G, Ozdemir F I, and Arun T**. Enamel color changes at debonding and after finishing procedures using five different adhesives. European Journal of Orthodontics 31(2009) 397-401.

13) **Mokrzycki W.S. and Tatol M**. Colour difference Delta E - A survey: Machine Graphics and Vision, 20(4):383-411, April 2011.
14) **Vatsala V, Kidiyoor H and Patil AK**. Comparison of Enamel Color Alterations Associated with Different Staining Agents Around Orthodontic Brackets: An In-vitro Study. Journal of Indian Orthodontic Society ¦ Volume 51 ¦ Issue 3 ¦ July-September 2017.
15) **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 Sep;108(3):284-93.
16) **Campbell PM.** Enamel surfaces after orthodontic bracket debonding. Angle Orthod. 1995;65(2):103-10.
17) **Yew HZ, Beerhall TL and Richards LC**. A laboratory investigation of colour changes in two contemporary resin composites on exposure to spices. Australian Dental Journal 2013; 58: 468–477.
18) **Aghili H, Golzarian M, Yassaei S, Ebrahiminik Z, Moradi Z**. Staining Ability of Turmerics-Persica Solution and Turmeric-GC-MI Plus Paste on Remnant Adhesive Resin after Bracket Debonding. Journal of Clinical and Diagnostic Research. 2018 Sep, Vol-12(9): ZC34-ZC36.
19) **Ye Cui, Zhao Z, Du X, Ye J, Wei X**. Comparison of enamel discoloration associated with bonding with three different orthodontic adhesives and cleaning-up with four different procedures. Journal of dentistry41s (2013) e35–e40.
20) **Usha C, Rao SR, and George GM**. A Comparative Evaluation of the Staining Capacity of Microhybrid and Nanohybrid Resin-based Composite to Indian Spices and Food Colorants: An In-vitro Study. Indian Journal of Dental Research, Volume 29, Issue 2, March-April 2018
21) **Joo HJ, Lee YK, Lee DY, Kim YJ, Lim YK**. Influence of orthodontic adhesives and clean-up procedures on the stain susceptibility of enamel after debonding. Angle Orthod. 2011; 81:334–340.
22) **Jahanbin A, Ameri H, Khaleghimoghaddam R.** Effect of adhesive types on enamel discolouration around orthodontic brackets. Aust Orthod J 2009; 25:19-23.
23) **Eliades T, Gioka C, Heim M, Eliades G, Makou M.** Color stability of orthodontic adhesive resins. Angle Orthod. 2004 Jun;74(3):391-3.
24) **Sadr Haghighi AH, Emami M, Fakhri E, Rezaei Y**. Effects of Orthodontic Adhesives on Dental Enamel Color Alteration Using Chemically Cured and Light-Cured Composites. *Front Dent.* 2020;17:13.
25) **Iosif C, Cuc, S,Prodan, D, Moldovan M, Petean I, Badea M E, Sava S, Tonea A and Chifor R.** Effects of Acidic Environments on Dental Structures after Bracket Debonding. Int. J. Mol. Sci. **2022**, 23, 15583.