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The Effect of Intra-Coronal Bleaching on The Shear Bond Strength of Orthodontic Self Ligating Brackets: An in Vitro Study

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Abstract

Introduction

A Smile is a curve that sets everything straight, the best medicine in the world without any side effect is a smiling face, ability to smile is a peculiarity of primate species including monkeys, apes, and humans. Facial esthetics plays a major role in creating a beautiful confident smile, improving our personality, enhancing our social skill, social acceptance and even in creating job opportunities[1]. Macro esthetics, mini esthetics and micro esthetics play a major role in creating good facial esthetics.

Discoloration of teeth is one of the major aesthetic concerns of dental patients[1]. Discolored teeth, especially in the anterior region can cause considerable cosmetic impairment[2]. This region comprises of central incisor,

lateral incisors and canine. When the pulp is injured, blood extravasations from ruptured vessels can invade the pulp chamber, and erythrocytes can penetrate the dentinal tubules. The erythrocytes undergo hemolysis and liberate hemoglobin, this releases iron[3]. The iron is combined with hydrogen sulfide to form iron sulfide, a black compound that gives teeth the dark discoloration[4].

Tooth discoloration may be classified as intrinsic or extrinsic. The main intrinsic factors for discoloration are pulp hemorrhage, decomposition of pulp, bacteria and its products, tetracycline, pulp necrosis, intra-canal medicaments, some endodontic filling materials, metallic restorations, and also by incorporation of chromogenic material into dentin and enamel during odontogenesis or after eruption[5]. Extrinsic factors for discoloration include soft drinks, food color, smocking and pan chewing etc.

Main treatment options for this condition include root canal treatment followed by veneer and crown, teeth whitening is an alternative therapeutic method. The discoloration of teeth with non-vital pulp requires an effective treatment with chemical bleaching agents[6]. This chemical bleaching can be achieved with both extra-coronal and intra-coronal bleaching techniques.

Based on clinical experience and research extra-coronal tooth bleaching is considered safe and effective and the most conservative method of improving the esthetics of discolored teeth[7,8]. However, several studies reported that extra-coronal bleaching has some disadvantages, including tooth sensitivity, gingival irritation and recurrent discoloration after bleaching.[9, 10] In addition, alterations in enamel surface morphology and reductions in bond strength of adhesives after bleaching have been reported.[11,12,13,14,20,21] These adverse effects are clinically critical when bonding resin composites, porcelain veneers, and orthodontic brackets to bleached enamel surfaces[15].

Intra-coronal bleaching is a conservative alternative to more invasive non-vital aesthetic treatments such as crowning or the placement of veneers on discolored teeth[5]. The bleaching agents most commonly used for internal tooth bleaching are carbamide peroxide, hydrogen peroxide, and sodium per-borate[16]. Over the years, various authors have demonstrated that intra-coronal bleaching agents produce changes in enamel structure and composition, which may affect the shear bond strength of orthodontic brackets[1].

Self-ligating brackets can be of two types. Active self-ligating brackets have a clip that works to press on the arch wire and a wire bracket interaction is observed. A passive self-ligating bracket has a door, which when closed, does not lead to any pressure on the arch wire[50].

One of the most significant differences from conventional dental braces is the absence of elastic ligature (bands or ties). Self-ligating braces typically are smaller and more aesthetic since a metal door is required to hold wires in place. They also tend to stand off the teeth further toward the lips and cheeks. Proponents of self-ligating brackets say that patients with self-ligating brackets have better oral hygiene than patients with conventional brackets. The hygiene is related to the use of Elastic Ligature which serves as another factor for having plaque being retained[51].

Since some adults who are interested in orthodontic treatment might have also had their root canal treated teeth bleached or might want bleaching, it seems important to determine whether this procedure would significantly influence the bonding strength of orthodontic bracket adhesives to the enamel surface[2]. So far, to our knowledge, no studies have investigated the effect of intra-coronal bleaching on the bond strength

values of metallic brackets[2]. In some instances fixation of brackets on crown may interfere with gingival status, proper cleaning of tooth, intrusion and extrusion movement of crown and may cause micro cracks on crown surface during bracket removal. Now a day's many adults who are interested in orthodontic treatments had bleached root canal treated tooth or might want bleaching ,so it is important to determine whether the intra coronal bleaching significantly influence the bond strength of orthodontic brackets and its adherence to enamel surface[36,37,38,39,40,41,42].

The purpose of this in-vitro study was to evaluate and compare the shear bond strength of orthodontic self-ligating metallic brackets on root canal treated teeth that are intra-coronally bleached with two agents and compare it with control group.

Materials and Methods

The inclusion criteria includes

1. Non carious tooth,
2. Tooth with intact buccal surface,
3. Immediately extracted tooth,
4. Permanent upper maxillary central incisors

The exclusion criteria includes (i)Hypo plastic tooth,(ii)Tooth with cracks,(iii)Tooth with irregular enamel,(iv) Malformed tooth,(v)Alcohol and formalin treated tooth,(vi)Previously bleached tooth,(vii)Tooth which are not fit for RCT.

90 freshly extracted teeth were collected from the surgery department. The tooth were scraped for removing tissue tags and then followed by washing under running tap water. Then the teeth were kept in 0.1 % (weight/volume) thymol till use to prevent bacterial growth. Cleaned buccal surface of teeth were polished using rubber cup with pumice and water.

Access cavity were prepared using 12 fluted round diamond bur with a high-speed hand piece under water cooling, followed by Bio mechanical preparation (BMP) using pro-taper file. Sodium-hypo chlorite and saline were used as irrigating agents, after the final irrigation, root canals were dried with sterile paper points. The canals were filled with Gutta percha points as obturator and endomethasone as sealer.

After removing GP up to a point 2mm apical to CEJ, GIC filling were given to avoid the leakage of bleaching agent to apex.The sample were randomly divided in to three groups of 30 teeth ,mounted on color coded Jig(Red, Blue and Green)

Group A (RED): RCT treated teeth sealed using composite without intra coronal bleaching .It was taken as the control group.

Group B (BLUE): RCT treated teeth followed by intra coronal bleaching with hydrogen peroxide which was sealed with temporary filling material for 1 week. After one week same procedure was repeated and permanently sealed using composite.

Group C (GREEN): RCT treated teeth followed by intra coronal bleaching with sodium per borate which was sealed with temporary filling material for 1 week. After one week same procedure was repeated and permanently sealed using composite.

The teeth were immersed in artificial saliva and allowed to stand for 2 weeks. After 2 weeks stainless steel Orthodontic self-ligating brackets were bonded on all the 90 teeth using Trans Bond XT (3M) composite resin.

Etching

The teeth were rinsed with tap water by using an air-water syringe for 20 seconds, Cleaned with a non-fluoridated oil-free pumice for 30 seconds, rinsed for an additional 20 seconds, and dried with oil free compressed air for 20 seconds. The etchant with 37% phosphoric acid was applied to the buccal surface for a

period of 30 seconds. The teeth were then rinsed for 15 seconds at warm air dried for 5 seconds.

Priming

A layer of Trans bond XT primer was applied with an applicator brush in a single gentle stroke directed cervico-coronally.

Bonding

Trans bond XT adhesive was spread on the base of 3M bracket placed on the mid buccal surface of the crown and a firm seating pressure was applied until bracket to tooth contact was achieved. Any excess material was removed from around the bracket base.

After this step the embedded specimen were secured in a jig attached to the base plate of a Universal Instron testing machine and force required to de-bond the brackets (N) were recorded and converted in to Mega Pascal (MPa) by dividing force required to de-bond the bracket (N) by surface area of bracket base (9.64mm2).

Results

A total of 90 maxillary central incisors were selected for the study with 30 each in Group A (control) Group B and group C.

Data distribution and normality was confirmed by visualising using Q-Q plot, box plot and by Kolmogorov-Smirnov test. The normality test gives a p value of 0.08, 0.20 and 0.157 in control, Hydrogen peroxide treated teeth and Sodium per-borate treated teeth respectively (Graph-1). In control group there are 3 outlier values but in other groups there are no outliers. The resultant test p value of more than 0.05 indicates the values are normally distributed. Thus the shear bond strength values in the test are fit for parametric test using one way ANOVA to compare the means.

One way ANOVA test was done to check if there is a statistically significant difference in the mean shear bond strength between different intra coronal bleaching agents used in the study (Table-1). There was a statistically significant difference between the groups as determined by one-way ANOVA with F statistics 62.95 with degree of freedom 2 (between the groups) and 87 (within the groups) at a significant p-value 0 .000.

A Tukey post hoc test revealed that the shear bond strength difference was significantly higher in control (7.77± 1.25M Pa) compared to Hydrogen peroxide (5.87±0 .62) and Sodium per-borate (5.87±0 .62) at a significant P-value of 0.000 (Table-2). The study also shows that the shear bond strength is significantly higher in Hydrogen Peroxide compared to Sodium per-borate (5.12 ±0.85) at a significant p value of 0.008 .The mean difference is highest between control and sodium per-borate with a difference of 2.65MPa (p=0.000*).The mean difference between control and hydrogen peroxide was 1.90 M Pa (p value=0.000*).The mean difference was least between hydrogen peroxide and Sodium per-borate with mean difference of 0.748 M Pa (p value=0.008*).

Shear bond strength in control was highest when compared to hydrogen peroxide and Sodium per-borate and it was statistically significant (P- value = 0.000) – Graph 2.

The mean shear bond strength of group A with 30 samples kept as control group was 7.77 Mpa with a standard deviation of +/-1.25(Table-3). The mean shear bond strength of group B with 30 samples exposed to hydrogen peroxide was 5.87 Mpa with standard deviation of +/-0.62 (Table-4).The mean shear bond strength of group C with 30 sample exposed to sodium per-borate was 5.12 Mpa with standard deviation of +/-0.85 (Table-5).

One way ANOVA test was done to check if there is a statistically significant difference in the mean shear bond strength between different intra coronal bleaching agents

used in the study. There was a statistically significant difference between the groups as determined by one-way ANOVA with F statistics 62.95 with degree of freedom 2 (between the groups) and 87 (within the groups) at a significant p-value 0 .000.

Discussion

Discoloration of teeth is one of the major aesthetic concerns of all dental patients[1]. Discoloration of teeth, especially in the anterior region can cause considerable cosmetic impairment[2]. When the pulp is injured, blood extravasations from ruptured vessels can invade the pulp chamber, and erythrocytes can penetrate the dentinal tubules. The erythrocytes undergo hemolysis and liberate hemoglobin, this releases iron[3]. The iron is combined with hydrogen sulfide to form iron sulfide, a black compound that gives teeth the dark discoloration[4].

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Main treatment options for this tooth discoloration due to pulp necrosis include root canal treatment followed by veneer and crown, teeth whitening is an alternative therapeutic method. The discoloration of teeth with non-vital pulp requires an effective treatment with chemical bleaching agents[6]. This chemical bleaching can be achieved with both extra-coronal and intra-coronal bleaching techniques

Based on clinical experience and research extra-coronal tooth bleaching is considered safe and effective and the most conservative method of improving the esthetics of discolored teeth[7,8]. However, several studies reported that extra-coronal bleaching has some disadvantages, including tooth sensitivity, gingival irritation and recurrent discoloration after bleaching[9,10]. In addition, alterations in enamel surface morphology and reductions in bond strength of adhesives after bleaching have been reported.[11,12,13,14,20,21] These adverse effects are clinically critical when bonding resin composites, porcelain veneers, and orthodontic brackets to bleached enamel surfaces.[15]

Intra-coronal bleaching is a conservative alternative to more invasive non-vital aesthetic treatments such as crowning or the placement of veneers on discolored teeth[5]. The bleaching agents most commonly used for internal tooth bleaching are carbamide peroxide, hydrogen peroxide, and sodium per-borate[16]. Over the years, various authors have demonstrated that intra-coronal bleaching agents produce changes in enamel structure and composition, which may affect the shear bond strength of orthodontic brackets[1].

Intra-coronal bleaching of a discolored non-vital tooth is a widely used method in dental practice. Conservation of tooth structure and achievement of good esthetics are the most important aspects of internal bleaching; the procedure itself is cheap and easy to perform, particularly in adult patients who demand a higher quality of esthetics and who consider orthodontic treatment as a solution. Therefore, during the orthodontic treatment of adults, the possibility of experiencing an intra-coronally bleached tooth is high.[52]

The diffusion of an intra-coronal bleaching agent into the dentin tubules directly affects the accomplishment of bleaching treatment. Although penetration of the

bleaching agent into tubules is expected, this leaching action of bleaching agents may result in reduction of the micro crystalline structure of the dentin and enamel surface.

Lewinstein et al. indicated that intra-coronal bleaching lowers the micro hardness of dentin and enamel by the loss of calcium and alterations in the organic substance; these factors might be significant causes of the reduced strength of enamel bonds.[53]

Although numerous studies have investigated extra-coronal bleaching and its effect on shear bond strength of orthodontic bracket, we have found only few studies that investigated the effect of intra-coronal bleaching treatment on the shear bond strength of orthodontic metallic bracket bonded with orthodontic adhesives to enamel.

Uysal et al reported that intra-coronal bleaching with sodium per-borate and hydrogen peroxide adversely affected the SBS of brackets bonded immediately after bleaching or 30 days after bleaching. They suggested that lower SBS could be due to changes in enamel structure resulting from increased porosity or reduction of the micro-hardness of dentin and enamel by the loss of calcium. In present study we observed that reduction in the shear bond strength of all intra coronally bleached teeth in agreement with result of Uysal et. Al.[2]

Amaral et al evaluated the in vitro effects of sodium per-borate and hydrogen peroxide intra-coronal bleaching on enamel and dentin bond strength; they concluded that all of the intra-coronal bleaching techniques tested reduced the bond strength of dentin and enamel. From the present study we found that shear bond strength of hydrogen peroxide group and sodium per-borate group is less compared to control group, so our finding match with the above study.[54]

No articles were found that investigate the effect of intra coronal bleaching on root canal treated teeth that are bonded with self-ligating brackets. Based on study by Maria Francesca Sfondrini et al, shear bond strength of the conventional brackets showed lower shear bond strength values than the self-ligating brackets bonded under same condition. The reason for increased shear bond strength of self- ligating bracket could be due to change in the bracket base area and difference in the bracket mesh design. From current study we found that shear bond strength of self- ligating bracket showed higher shear bond strength value than conventional bracket bonded under same condition, so the result is in agreement with result of Maria Francesca Sfondrini et al.[55]

Among the three groups, the lowest shear bond strengths to dentin and enamel were observed in groups that received intra-coronal bleaching with sodium per-borate. Amaral et al stated that this could be due to the pH of sodium per-borate. From studies it was observed that pH of fresh mix of sodium per borate and superoxol was around 10-11, which reduced with time. This alkaline pH cause more changes in the microcrystalline structure of enamel and dentin which result in more reduction in shear bone strength. Consistent with this finding, the sodium per-borate group also showed the weakest shear bond strength in the present study.[54]

Rotstein et al.found that intra-coronal bleaching with hydrogen peroxide reduced the level of calcium in tooth enamel, this reduction in calcium level affect the ability for micro mechanical bond between the enamel and the composite and thus cause reduction in shear bond strength .In present study also consistent with this finding we can observe reduction in shear bond strength. While bleaching with sodium per-borate did not affect calcium levels. [56]

Shinohara et al. compared the effects of per-borate and hydrogen peroxide intra-coronal bleaching on enamel and dentin bond strength; they found a statistically significant decrease in the bond strength of composite resin for enamel and dentin after non-vital bleaching with both agents. However, they found no statistically significant differences between these bleaching agents. But in present study the difference in shear bond strength of this two group found statistically significant. This discrepancy with the present report may be due to differences in study design. In current study it is observed that compared with sodium per-borate group the shear bond strength of hydrogen peroxide group is less, so if we are planning for intra coronal bleaching of non-vital teeth before bonding better to use hydrogen peroxide as agent.[57]

Some authorshave suggested that residual oxygen produced from bleaching agents inhibits resin polymerization and interferes with resin attachment. Most authors recommend delaying bonding of the brackets after bleaching for 2 to 4 weeks. To eliminate the effects of residual oxygen from the bleaching agent, in our study we delayed bonding of the brackets for 2 weeks and stored the specimens in artificial saliva.[58, 59]

Most authors have concluded that bleaching adversely affects the SBS of orthodontic brackets. In agreement with these studies, SBS values were significantly lower in all of the study groups than in the control group in the current study. Therefore, bleaching procedures should be delayed until the completion of orthodontic treatment. If intra-coronal bleaching is mandatory, Hydrogen peroxide should be used as the bleaching agent.[34, 60, 61]

Main Limitations of this study is that being an in-vitro study, results may differ from in-vivo conditions. Bond failure can occur in human mouth through a plethora of other causes like masticatory forces, acute thermal fluctuations and acute pH changes.

Graph 1**:** Test for normality

Graph 2: Comparison of control with hydrogen peroxide and sodium per-borate

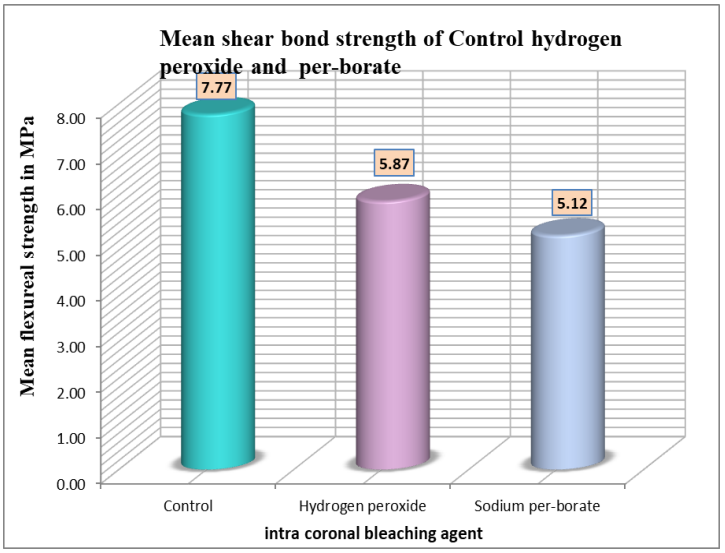

Table 1:One Way ANOVA Statistics

Category	Sum of squares	Degree of freedom	Mean square	F statistics	Significance
Between Groups	111.913	2	55.957	62.948	0.000***
Within Groups	77.337	87	.889		
Total	189.251	89			

*- significant p-value, less than 0.05

Table 2: Tukey Post Hoc test to identify significantly different groups

Sample 1	Mean shear bond strength and SD	Sample 2	Mean difference in shear bond strength	Significance (p=value)	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	7.77± 1.25	Hydrogen Peroxide	1.90093*	0.000*	1.3205	2.4814
		Sodium per-borate	2.64914*	0.000*	2.0687	3.2296
Hydrogen Peroxide	5.87±0 .62	Control	-1.90093*	0.000*	-2.4814	-1.3205
		Sodium per-borate	.74821*	0.008*	.1677	1.3287
Sodium per-borate	5.12 ±0.85	Control	-2.64914*	0.000*	-3.2296	-2.0687
		Hydrogen Peroxide	-.74821*	0.008*	-1.3287	-.1677

*-significant p-value, less than 0.05

Table 3: Mean Shear Bond Strength of control group

Material category	Sample size	Mean (MPa)	SD	Minimum (M Pa)	Maximum (M Pa)	95% Confidence interval
Control	30	7.77	1.25	5.75	10.12	7.30 - 8.24

Table 4: Mean Shear Bond Strength of hydrogen peroxide

Material category	Sample size	Mean (M Pa)	SD	Minimum (M Pa)	Maximum (M Pa)	95% Confidence interval
Hydrogen Peroxide	30	5.87	.62	4.86	6.94	5.64-6.10

Table 5:Mean Shear Bond Strength of sodium per-borate

Material category	Sample size	Mean (M Pa)	SD	Minimum (M Pa)	Maximum (M Pa)	95% Confidence interval
Sodium per-borate	30	5.12	.85	3.76	6.59	4.81-5.44

Conclusion

From this study we concluded that,

- Intra coronal bleaching of non-vital teeth with sodium per-borate and hydrogen peroxide affected the shear bond strength of self-ligating bracket that were bonded 2 weeks after bleaching.
- The mean shear bond strength of control, hydrogen peroxide and sodium per-borate group were 7.77 Mpa, 5.87 Mpa and 5.12 Mpa respectively.
- Among the two bleaching agents sodium per-borate group showed least shear bond strength.
- Bleaching procedures should be delayed until the completion of orthodontic treatment. If intra-coronal bleaching is mandatory, Hydrogen peroxide should be used as the bleaching agent.

Availability of data and materials

The data underlying this article are available in the article and its online material

List of abbreviations used

SPEED	Spring-Loaded, Precision, Edgewise, Energy and Delivery
MPa	Mega Pascal
SBS	Shear bond strength
SLB	Self-ligating bracket
CEJ	Cemento enamel junction
GP	Gutta percha point
LED	Light emitting diode

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