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Bond strength of composite resin to bleached enamel after surface treatment with laser activated sodium ascorbate: An *in vitro* study

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Abstract
Objective: Photo biomodulation therapy has proven benefits in various dental treatments. The current systematic review aims to explore the role of laser photo biomodulation in modulating post-operative pain followed by endodontic treatment.
Methods: In this systematic review, randomised controlled clinical trials on low-level laser therapy/ photo-biomodulation in endodontic therapy were analysed. Database search was performed in PubMed/ Medline, Web of Science, Scopus and Cochrane Library, followed by literature search in Google Scholar.
Results: A total of 16 studies were included as per the set criteria. The included studies utilised diode laser (808-970nm), Indium gallium aluminium and Nd: YAG laser. All the included studies evaluated post endodontic pain after root canal therapy, direct pulp capping, endodontic surgery. Majority of the included studies showed significant benefits of photobiomodulation in post-operative pain management in endodontic therapy.
Limitations: Heterogeneity of the laser parameters and lack of power calculations for sampling among the included studies precludes solid recommendation of use of photobiomodulation therapy for post-endodontic pain management.
Conclusion: Although photobiomodulation therapy has proven potential benefits being a possible adjunct in post- operative pain management in endodontic therapy, it requires robust standardized randomized control trials to confirm the results of the systematic review.

Keywords: Photobiomodulation, low-level laser therapy, root canal treatment, post-operative pain

Introduction
Esthetic procedures are one of the emerging procedures in dentistry nowadays and patients seek for a faster treatment along with beautiful smile. One of the most sought after esthetic treatment is considered to be vital tooth bleaching and has been well accepted treatment modality for discolored tooth [1, 2].
Two major types of vital tooth bleaching can be in office bleaching or at home bleaching. In office bleaching will be under dentists control and has a several advantage over at home bleaching which might include immediate color change after first appointment because of use of high concentration of bleaching material which might help to motivate the patient [3-5].
A lot of different bleaching agents has been used with varying concentrations such as hydrogen peroxide (30% - 40%), carbamide peroxide (35% - 37%) which have shown a better esthetic results. Hydrogen peroxide is the most routinely used bleaching agent. Hydrogen peroxide is a very unsteady molecule which diffuses through the organic matrix of enamel and dentin and releases free radicals and interaction between organic matrix and free radicals can unfavorably affect bond strength to enamel and dentin [6-8].
Bleaching treatment is usually recommended for discoloured tooth and also prior to adhesive esthetic restoration procedures. although, if the adhesive restorations are placed instantly on the bleached tooth it has been shown to diminish the bond strength to enamel in presence of free radicals which might take 7-14days to lessen and normalize the bond strength [9, 10].

To increase the immediate bond strength various antioxidants have been used. There are two mechanisms which have been considered to provide a protective effect. It may donate a hydrogen ion to free radical and might itself become a radical or may transform into radical cation by providing an electron to free radical. Sodium ascorbate (SA) is one of the most commonly used antioxidant [11, 12].
Lasers like Er:YAG and Diode laser find multiple application in restorative dentistry [13]. It is believed that use of lasers could influence post bleaching bonding, by stimulating substrate heating and bring about change in enamel and dentin morphology thus might be capable of eradicating the residual free radicals and neutralizing the negative effects of bleaching agents on bond strength allowing restorations to be replaced immediately [14-16].
Thus, the aim of the study was to check the bond strength of composite resin to bleached enamel after surface treatment with laser activated sodium ascorbate.

Materials and Methods

Inclusion criteria

Extracted human anterior teeth under patients consent.

Exclusion criteria

1. Carious teeth
2. Cracked teeth
3. Eroded teeth
4. Hypocalcified teeth

Armamentarium

1. Distilled water
2. 30% H202
3. 10% Sodium Ascorbate
4. Er: YAG Laser
5. Diode Laser

In this study, 55 extracted human anterior teeth were used. Organic debris were eliminated using a periodontal scaler, and prophylaxis was performed using pumice slurry and a rubber cup. After cleaning, the samples were transferred to 4 °C distilled water until the experiments. Teeth were embedded in acrylic molds till cementoenamel junction. The teeth were randomly assigned into 5 groups with each group containing 11 samples.

Group 1: Bleaching + Sodium Ascorbate
Group 2: Er:YAG laser assisted bleaching + Sodium Ascorbate.
Group 3: Diode laser assisted bleaching + Sodium Ascorbate.
Group 4: Er:YAG laser assisted bleaching + Sodium Ascorbate with Er:YAG laser activation.
Group 5: Diode laser assisted bleaching + Sodium Ascorbate with Diode laser activation.

Preparation of 10% Sodium Ascorbate

The solution was prepared by mixing 10g of powder of sodium ascorbate (Loba Chemie PVT. LTD) and 100 ml of distilled water.

Group 1

In this group 30% hydrogen peroxide bleaching agent was used. It was applied on the enamel surface for 15min, with an interval of 5 min between each application, totalizing 3 applications, as recommended by the manufacturer. Once bleaching was done 10% SA solution was applied on enamel surface for 10min and then was removed using suction.

Group 2

In this group bleaching was performed with the same procedure as group 1 followed by activation with 2940 nm Er:YAG laser with setting of 0.4 W, 40 mJ, 10Hz. Each tooth was irradiated for 3 times for 20 sec on each gel application in a sweeping motion and at a 2cm working distance in non contact mode. The gel was washed away with an air water spray after 5 min of contact period. Three gel applications and irradiation cycles will be performed for each tooth for a total of 15min. Once bleaching was done 10% SA solution was applied on enamel surface for 10min and then was removed using suction.

Group 3

In this group bleaching was performed with the same procedure as group 1 followed by activation with 980nm diode laser. Diode laser was operated on 1.5W in continuous wave with hand piece placed perpendicular to tooth surface. After placement of gel on enamel it was immediately activated by diode laser for 30sec then the gel on the enamel surface was stirred with microbrush and waited for 1 min to avoid possible overheating of dental structure. Procedures was repeated 3 times. After last irradiation the gel was left for 5 min on enamel. Later the gel was removed by suction and rinsed off the enamel surface with running water for 30 sec. The total treatment time for each tooth was 15 min. Once bleaching was done 10% SA solution was applied on enamel surface for 10min and then was removed using suction.

Group 4

In this group bleaching is done same as in group 2. After bleaching 10% SA solution was applied on enamel surface (1 mL/min) and activated with Er:YAG (λ of 2940 nm) laser irradiation. This equipment has a spot size of 0.8 mm. Irradiation was done using 40mJ and 10 Hz for 20sec.

Group 5

In this group bleaching is done same as in group 3. After bleaching 10% SA solution was applied on enamel surface (1 mL/min) and activated with the diode laser (λ of 980 nm) irradiation using 1.5 W, for 20sec in non contact mode.

Restorative procedure

Once bleaching of all the samples was done it was restored immediately with composite. 37% phosphoric acid was applied on the surface for 15 s, followed by rinsing with distilled water and drying with absorbent paper. Then, bonding agent was applied and photo polymerized according to the manufacturers instructions. The enamel surfaces were restored with composite resin using circular molds of 3mm diameter and 4mm height. The composite resin was included in three increments, polymerized using an LED light source, with a light intensity of 800 mW/cm.

Debonding test

The specimens were positioned in a universal test machine with a load cell of 10 kN. The force application was performed using a rectangular stainless steel tip, at a constant speed of 0.5 mm/min until the displacement of the restoration. Shear bond strength was calculated by dividing fracture load by bonding area.

Results

Data was subjected to Normalcy test (Shapiro Wilk test). Data showed normal distribution. Hence parametric tests (ANOVA with Post-hoc Bonferroni) were applied.

The Shapiro–Wilk test is more appropriate method for small sample sizes (<50 samples) although it can also be handling on larger sample size while Kolmogorov–Smirnov test is used for n ≥50. For both of the above tests, null hypothesis states that data are taken from normal distributed population. If the p value of the Shapiro-Wilk Test is greater than 0.05, the data is normal. If it is below 0.05, the data significantly deviate from a normal distribution.

Table 2 shows comparison of the mean shear bond strength based on using ANOVA. Mean shear bond strength was highest in Group 1 in which bleaching was done without laser activation. Among the Er:YAG and diode laser assisted bleaching Er:YAG laser activation has shown better shear bond strength. When activation of sodium ascorbate was done with Er:YAG and diode laser the shear bond strength was reduced when compared to other groups.

Table 1: Shows tests of normality

Tests of Normality						
Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	p value	Statistic	df	p value
Group 1	.180	11	.200*	.911	11	.253
Group 2	.181	11	.200*	.819	11	.107
Group 3	.203	11	.200*	.865	11	.067
Group 4	.157	11	.200*	.912	11	.256
Group 5	.226	11	.121	.843	11	.305
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Table 2: Comparison of the mean shear bond strength based on using ANOVA

Groups	N	Minimum	Maximum	Mean	S. D	p value
Group 1	11	4.10	10.60	8.182	2.087	0.001*
Group 2	11	4.10	7.90	6.877	1.076	
Group 3	11	4.30	7.90	6.482	1.372	
Group 4	11	5.50	7.60	6.827	0.700	
Group 5	11	4.20	6.40	5.618	0.801	

*Significant

Table 3: Inter group comparison of shear bond strength using post-hoc Bonferroni

	Mean diff	p value
Group 1 Vs Group 2	1.305	0.231
Group 1 Vs Group 3	1.700	0.036*
Group 1 Vs Group 4	1.355	0.186
Group 1 Vs Group 5	2.560	0.001*
Group 2 Vs Group 3	0.395	1.000
Group 2 Vs Group 4	0.050	1.000
Group 2 Vs Group 5	1.259	0.281
Group 3 Vs Group 4	-0.345	1.000
Group 3 Vs Group 5	0.864	1.000
Group 4 Vs Group 5	1.209	0.347

*Significant

Discussion

In many cases it is important to restore the tooth with adhesive system after bleaching. However, restoring immediately after bleaching has been a challenge because of decrease in immediate bond strength after bleaching procedure due to formation of free radicals post bleaching thus delaying the treatment procedure. Use of Antioxidants has reduced the free radicals on the tooth surface thus improving the immediate bond strength between tooth and restoration.

In this study we have checked the bond strength of composite resin to bleached enamel after surface treatment with laser activated sodium ascorbate.

According to our study, Diode laser activated bleaching lead to significantly decreased shear bond strength values when compared to Er:YAG and control group. This can be accounted to poor penetration of resin to diode irradiated enamel surface. Similar findings has been obtained by study conducted by Mirhashemi *et al*. compared the bond strength of resin based composite adhesive to enamel after bleaching with or without diode laser treatment and the study concluded that diode laser diminished the bond strength of the resin onto bleached enamel surfaces [17].

Though the immediate shear bond strength values obtained in Er:YAG laser assisted group was imperceptibly less than that of the control group it was not statistically significant. In contrary to the findings in this study some studies advocate the use of Er:YAG laser on tooth surface to enhance the adhesion to composite resin with the use of acid etching[18]. The better shear bond strength values obtained in other few studies could be because of deferment in restoration process by 14 days [3, 6, 9].

According to the results in this study, Er:YAG laser activation resulted in a slightly better shear bond strength than diode laser though it was not statistically significant. The temperature rise during bleaching with Er:YAG laser is confines within the gel unlike in the case of diode laser which is weakly absorbed by the gel [6]. So this might have caused increase in enamel surface temperature with diode laser activation leading to changes in surface morphology resulting in reduced shear bond strength.

According to Braz R *et al* Sodium ascorbate is majorly used as an antioxidant in biological systems, being considered a good alternative treatment owing to its capacity for interacting with residual oxygen in teeth post-whitening, by accelerating removal of residual oxygen, and by reverting the reduction in the bonding stress action after dental whitening. It considered as biocompatible antioxidant agent, safe for oral use.

Laser activation of Sodium ascorbate demonstrates lesser Shear bond strength than other groups in this study. Diode laser activation resulted in least shear bond strength. According to Lee and Kader *et al* Ascorbic acid is not stable at high temperature [19]. Increase in temperature due to laser activation would have caused degradation of Sodium Ascorbate resulting in its deactivation.

In vitro studies cannot be exactly correlated with clinical scenario further *in vivo* studies are required to confirm the Shear bond strength. This study was conducted to evaluate whether laser activation can improve the action of Sodium Ascorbate on bleached enamel.

Conclusion

Diode laser activation significantly reduced the immediate Shear bond strength on enamel with composite restoration. Laser activation of Sodium Ascorbate did not improve the shear bond strength after assisted bleaching. In the present study the parameters used with laser was fixed. In future further studies should be considered with variable parameters of Er:YAG and diode laser on activation of sodium ascorbate.

Conflict of Interest: Not available

Financial Support: Not available

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