COMPARATIVE EVALUATION OF THE EFFECT OF SODIUM ASCORBATE ON THE SHEAR BOND STRENGTH OF COMPOSITE RESIN AFTER LASER ASSISTED BLEACHING USING TWO DIFFERENT WAVELENGTHS – AN IN-VITRO STUDY.

By

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Dissertation

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(BRANCH – IV)

Under the Guidance of

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DEPARTMENT OF CONSERVATIVE DENTISTRY AND ENDODONTICS

KLE VISHWANATH KATTI INSTITUTE OF DENTAL SCIENCES

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This dissertation is

dedicated to

Almighty god,

My Parents,

&

My Family Members

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Date*:* ***Dr. Priyanka Kore***

Place *: Belagavi.*

LIST OF ABBREVIATIONS

nm	Nanometre
Xn	Xenon
KTP	Potassium Titanyl Phosphate
LED	Light emitting diode
w	Watt
OH	Hydroxyl ions
g	gram
mm	Millimetre
%	Percentage
i.e	That is
hr	hour
W/V	Weight by volume
cm	centimetre
UTM	Universal Testing Machine
Fig.	Figure
<	Less than

ABSTRACT

Introduction: In dental esthetics we strive towards mimicking and customising a restorative treatment which will harmonize with nature. The most common drive for improvement in the smile is due to the discoloration of the teeth. Tracing back, bleaching has been used successfully since its inception. Though there is enormous advancement in the procedures and materials incorporated for the bleaching techniques, the lengthy procedural time and supplemental appointments required are still a daunting problem. To cut through the same, activation of the bleaching agents to allow for a quicker treatment was postulated. Different light sources like halogen curing lights, Plasma arc lamp, Xn–halogen light and Lasers have been used for activation of the bleaching gel.Out of these, diode lasers have gained popularity due to their cost-efficiency and ease of use. Also, bleaching has shown to have a compromised bonding to composite restoration. Antioxidants like sodium ascorbate have been used to reverse the bond strength and have shown promising results.

Methodology: Sixty four extracted teeth were used for the study. 37.5% hydrogen peroxide bleaching gel was applied to the labial surface of the teeth. The specimens were divided into 2 groups, group 1 and group 2. Group 1 was irradiated with 445nm wavelength diode laser and group 2 was irradiated with 970 nm wavelength diode laser. The groups were further divided into subgroups based on the application of antioxidant as 1A, 1B, 2A, 2B. The specimens were then etched ,bonded and composite restoration of 5mm thickness was placed. The specimens were tested for shear bond strength using a universal testing machine. The intergroup comparison was done using two way ANOVA and the intragroup analysis was done using Tukey's multiple post hoc test.

Results: The shear bond strength was the highest when 445nm diode laser was used and 10% sodium ascorbate gel was applied as antioxidant

Conclusion: The bonding of composite resin is better when 445nm wavelength of diode laser is used for activation of the bleaching agent. Also, 10% sodium ascorbate gel provides for effective bonding to the bleached enamel.

Key words: Diode laser, sodium ascorbate, Bleaching.

TABLE OF CONTENTS

Sr.No.	Particulars	Page No.
1	INTRODUCTION	1-2
2	AIM & OBJECTIVES	3
3	RESEARCH HYPOTHESIS	4
4	REVIEW OF LITERATURE	5-8
5	MATERIALS AND METHOD	9-23
6	RESULTS	24-32
8	DISCUSSION	33-40
9	CONCLUSION	41
10	SUMMARY	42-44
11	BIBLIOGRAPHY	45-51
12	ANNEXURES	52-54

LIST OF TABLES

Table No.	Particulars	Page No.
1	Shear bond strength values for the subgroup in which 445nm wavelength is used	**24**
2	Shear bond strength values for the subgroup in which 445nm wavelength used followed by application of sodium ascorbate gel	**25**
3	Shear bond strength values for the subgroup in which 970 nm wavelength is used	**26**
4	Shear bond strength values for the subgroup in which 970 nm wavelength used followed by application of sodium ascorbate gel	**27**
5	Summary of Shear Bond Strength (MPa) in two main groups (1 and 2) and two sub groups (A and B)	**28**
6	Comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa) by two way ANOVA	**28**
7	Comparison of two main groups (1 and 2) with mean shear bond strength (MPa)	**29**
8	Comparison of two sub groups (A and B) with mean shear bond strength (MPa)	**30**
9	Pair wise comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa) by Tukeys multiple posthoc procedures	**31**

LIST OF FIGURES

Fig No.	Particulars	Page No.
1	Materials and armamentarium	17
2	Extracted human central incisor teeth	17
3	Sectioning of the tooth 2mm below the coronal portion	18
4	Application of 37.5% Hydrogen peroxide gel	18
5	Irradiation with diode laser	19
6	Power and wavelength settings for group A	19
7	Power and wavelength settings for group B	19
8	Application of 10% sodium ascorbate gel	20
9	Application of 37% phosphoric acid	20
10	Application of the bonding agent	21
11	Incremental layering of composite resin	21
12	Curing of the composite resin	22
13	Universal testing machine	22
14	Shear bond strength testing using universal testing machine	23
15	Comparison of two main groups (1 and 2) with mean she strength (MPa)	29
16	Comparison of two sub groups (A and B) with mean shear bond (MPa)	30
17	Comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa)	32

LIST OF ANNEXURES

Annexure No.	Particulars	Page No.
I	Ethical Approval Certificate	**52**
II	Biostatistics Certificate	**53**
III	Plagiarism Certificate	**54**

INTRODUCTION

Smiling is one of the most important facial expressions, a non verbal parameter of communication correlating joy and esthetics.[1]Each mind perceives beauty differently, and hence it is aptly quoted 'Beauty is in the mind of the beholder' but yet ironically, esthetics is science!!!!!!

Esthetics encompasses beauty in everything we see. Over a period of years, there has been a gradual percolation of it into dentistry. Today it has evolved from the choice of the class to the choice of the mass making it the spine support of dentistry.[2]

In dental esthetics we strive towards mimicking and customising a restorative treatment which will harmonize with nature. This ensures that the reestablished new smile not only highlights the esthetic features, but also adapts to the patient's life style, job, and social position.[3]

Current aesthetic dentistry emphasizes the implementation of philosophy to preserve the remaining tooth structure to achieve the most esthetic outcome. Amalgamation of the enhanced restorative techniques, precision oriented technology, evolving material science and evidence backed knowledge ensures and enables us to obtain healthy, functional and esthetic smiles.[4]

The most common drive for improvement in the smile is due to the discoloration of the teeth. The modalities of treatment for combating discoloration vary over a large spectrum with regards to its intervention.[1] The American Academy of cosmetic dentistry reported a notable 90% patients who opted for bleaching as a treatment choice.[5]

Tracing back, bleaching has been used successfully since its inception. Though there is enormous advancement in the procedures and materials incorporated for the bleaching techniques, the lengthy procedural time and supplemental

appointments required are still a daunting problem.[2] To cut through the same, activation of the bleaching agents to allow for a quicker treatment was postulated.

Comprehensive research in view of this threw light on the use of different types of sources for activation of the bleaching agent like halogen curing lights, Plasma arc lamp, Xn–halogen light and Lasers.[6] Evolution in the technology today have made lasers a knight in shining armour with explicit advantages of being user friendly and predictable.[7]

Different types of lasers have been time tested for the activation of the bleaching gel, of which the KTP lasers have emerged to give promising results. However, considering the cost-efficiency and an added advantage of being used as a soft tissue as well as hard tissue laser, diode lasers have gained popularity.[8]

The wavelengths used for bleaching include 970nm, 790 nm, 467nm, 445nm, 915nm, 940nm and 415nm of which the 445nm and 970 nm have shown efficacious results. These wavelengths have been researched individually for the efficacy of bleaching but have not been compared in respect to the effect they have on the bonding of composite restoration to the bleached tooth.[9]

Also, bleaching has shown to have a compromised bonding to composite restoration. Antioxidants like sodium ascorbate have been used to reverse the bond strength and have shown promising results.[10]

Till date, there has been no study documenting the use of an antioxidant on the bleached tooth after laser-assisted bleaching with two different wavelengths and the effect of the same on the bonding of composite restoration.

AIM & OBJECTIVES

AIM

- To evaluate and compare the effect of 10% sodium ascorbate on the shear bond strength of composite resin after laser assisted bleaching using two different wavelengths – 445 nm and 970 nm.

OBJECTIVES

- To evaluate the effect of sodium ascorbate on the shear bond strength of composite resin after laser assisted bleaching using 445 nm wavelength
- To evaluate the effect of sodium ascorbate on the shear bond strength of composite resin after laser assisted bleaching using 970 nm wavelength
- To compare the shear bond strength of composite resin after application of sodium ascorbate using 445 nm and 970 nm wavelength laser assisted bleaching.

HYPOTHESIS

NULL HYPOTHESIS

There is no difference in the shear bond strength of composite resin with the application of sodium ascorbate after laser assisted bleaching using two different wavelengths – 445nm and 970nm

ALTERNATE HYPOTHESIS

There is a difference in the shear bond strength of composite resin with the application of sodium ascorbate after laser assisted bleaching using two different wavelengths – 445 nm and 970 nm

.

REVIEW OF LITERATURE

1. An invitro investigation was performed to check the effectiveness of bleaching on activation using diode lasers and LED. laser and LED when compared regarding the change in the shade when advocated to different bleaching agents. The diode laser turned out to be on a higher side as compare to the LED in chroma as well as luminosity.[11]
2. An invitro study done to evaluate the temperature rise on the surface and the pulp after using diode lasers in association of bleaching concluded that, bleaching gels catalysed by diode lasers in Power bleaching turn out as potent insulating material, thereby curbing greater increase in temperatures inside the pulp chamber. Also, diode lasers used to activate bleaching gels are harmless to the pulp to any power setting below 2W.[12]
3. An invitro investigation was done to analyze for the microhardness of enamel after laser assisted bleaching using diode lasers of wavelengths810nm and 980 nm. It was concluded that the 980nm wavelength caused a greater decrease in the microhardness of the tooth. The demineralization was attributed to lesser concentrations of calcium and phosphorous and greater concentrations of sodium and chloride ions in the bleaching gels.[13]
4. An-in vitro study was done using three different antioxidants, sodium ascorbate, alpha tocopherol and hesperidin. The study described that laser assisted bleaching revealed and unaltered bond strength values. This was due to accelerated elimination of residual free oxygen radicals as a result of temperature rise caused by laser application. As backed up by evidence, ascorbic acid reinstitutes the hampered bonding as it modifies the redox

potential of the oxidized bonding substrate that provides for polymerization of adhesive resin via avoidance of its premature termination. Molecular structure of ascorbic acid contains 4 OH groups that can donate hydrogen to an oxidizing system. Also, it was summarized that this number of hydroxyl groups is quiet sufficient to regain back the original bond strength post teeth bleaching.[14]

5. The bond strength of composite to bleached enamel after application of sodium ascorbate was evaluated in an in vitro investigation. A one-week impediment in bonding post bleaching brings about reversal of diminished bond strength, according to the findings. Treatment of the bleached enamel surface with 10% sodium ascorbate, on the other hand, reverses the reduced bond strength and may be a better option than postponed bonding, especially if the restoration is to be finished immediately post bleaching.[15]
6. An in vitro study looked at the potency of light-emitting diode and diode laser for enhancing teeth whitening treatment. It was discovered that using a bleaching gel with light activation brought about speedy and thorough bleaching as compared to using a bleaching gel only.[16]
7. The shear bond strength of composite resin to the tooth following laser triggered bleaching with various activation sources was tested in an in vitro investigation. It was established that hydrogen peroxide activation reduces the bond strength of the composite resin to the tooth, necessitating a 1- 2 week waiting period for complete bond reversal.[17]
8. The efficacy, benefits, and adverse effects of activated bleaching techniques were studied in a systematic review. Heat- and light-activated bleaching procedures were likely to produce pulp irritation. If heat or light activation is

used, it is strongly recommended that you follow the guidelines prescribed by the manufacturer and keep the heat activation time to a minimum to avoid pulpal reactions.[18]

9. The effect of laser-activated bleaching with 445 nm and 915 nm diode lasers on enamel micro-hardness was evaluated in an invitro study published in the journal of Photodiagnosis and Photodynamic Therapy. As inferred by the findings, diode laser of wavelength 445nm reduces the microhardness of enamel less than 915nm laser after laser assisted tooth whitening.[19]
10. The temperature changes in the pulp chamber during bleaching treatments were measured using diode lasers with wavelengths of 445 nm and 970 nm and varied powers. It measured temperature changes using diode lasers with wavelengths of 970 nm at 1.5 W, 970 nm at 2 W, 445 nm at 1 W, and 445 nm at 1.5 W. The study indicated that temperature rise following diode laser bleaching at wavelengths of 970 nm and 445 nm is within acceptable standards, and these wavelengths alongwith the parameters employed of this investigation can be used as safe clinical bleaching procedures.[20]
11. An in vitro study looked at how far the bleaching gel penetrated the tooth, giving insight into the pulpal damage. The most penetration was seen with the traditional in-office bleaching process (2.232 0.39g), while the least was noticed with diode (1w) laser-assisted bleaching (0.31 0.28g). As a result, diode laser activated bleaching is safer than traditional in-office bleaching.[21]
12. Aftereffects on the enamel and pulp and the potency in laboratory settings and in patients, were established in a comprehensive systematic study. It summarised that diode lasers have been employed for laser assisted bleaching in a variety of wavelengths and power settings. The effectiveness of bleaching

is also dependent on the bleaching gel, the wavelength of the laser used for irradiation, and the laser's power settings.[22]

13. An in vitro study looked at the binding strength of bleached enamel using sodium ascorbate solution and gel form. It was discovered that both the two different viscosities of sodium ascorbate can greatly improve the bonding of resin composite to enamel following bleaching. sodium ascorbate (10%) and sodium ascorbate (20%) have similar effectiveness.[23]
14. The efficiency of laser induced bleaching utilising diode laser, Nd: YAG laser, and the conventional approach was evaluated in an invivo investigation on sixty patients. The laser devices delivered good bleaching efficacy, but increased the intrapulpal temperature according to the study.[24]
15. An elaborate systematic review and meta-analysis was done on the sensitivity of the bleached tooth after laser assisted bleaching. It was put forward that, laser assisted bleaching could be a precursor to the sensitivity of the teeth after vital bleaching. However, a consensus couldn’t be achieved with the available evidence and hence further researched is expected in this course.[25]

MATERIALS AND METHODS

The study was conducted in the Department of Conservative Dentistry and Endodontics, KAHER'S Vishwanath Katti Institute of Dental Sciences, Belagavi

Specimens were evaluated under the Universal testing machine at Praj Metallurgical laboratory, Pune.

Extracted human maxillary central incisor teeth were collected from Department of Oral and Maxillofacial Surgery, KAHER'S Vishwanath Katti Institute of Dental Sciences, Belagavi

10 % sodium ascorbate gel was formulated in the KLE College of Pharmacy Belagavi.

Inclusion criteria

- Teeth with intact crown with no caries, any previous restoration.
- Teeth which have not been root canal treated previously.
- Teeth which do not have any visible cracks or fractures of the crown portion.
- Teeth without anomalies like fusion, dens in dente and enamel hypoplasia
- Teeth without any discoloration like fluorosis or tetracycline stains.

Exclusion criteria

- As observed under 10x magnification of stereomicroscope, teeth with cracks or fractures.

MATERIALS

- Human maxillary central incisor teeth
- 0.1% thymol, 0.9% saline (Baxter NS Sodium Chloride IP 0.9% W/V)
- 10% sodium ascorbate gel
- Acrylic resin(Dental Products of India)
- 37.5 % Hydrogen peroxide gel (Pola Office plus SDI)
- 37% phosphoric acid etchant gel (Ivoclar Vivadent)
- Universal bonding agent (3M ESPE)
- Composite resin (3M ESPE)

ARMAMENTARIUM:

- Micromotor (NSK)
- Diamond disks
- Universal testing machine
- diode laser (Siro blue diode laser, Dentsply Sirona)
- Microbrush (Dentext)
- Curing Light (Woodpecker)

SAMPLE SIZE ESTIMATION

Standard deviation in the Ist group S1 = 2.5

Standard deviation in the IInd group S2 = 1.6

Mean difference between Ist and IInd sample = 2.2

Alpha Error(%) = 1 (Zalpha=2.58)

Power(%)= 95 (Zbeta=1.642)

sided = 2

Using the following formula, sample size was calculated as,

$$N = \frac{2S^2 [Z_{(1-\alpha/2)} + Z_{(1-\beta)}]^2}{d^2}$$

Number needed (n) = 32 in each group

SAMPLING PROCEDURE

The specimens were segregated with strict random allocation into groups and the sampling technique employed for the same was Multistage sampling technique.

STATISTICAL TEST

The results were analyzed statistically using,

- Two way ANOVA test for Intergroup analysis
- Tukey's multiple Post Hoc test for Intragroup analysis

DETAILS OF THE PROCEDURES CONDUCTED DURING THE RESEARCH:

Sixty four extracted human permanent maxillary central incisors were incorporated in the study strictly abiding to the inclusion and exclusion criteria. The included teeth were then observed for any cracks or fractures under a stereomicroscope with 10X magnification.

All teeth used for the study were disinfected in 0.1% thymol solution, cleared of calculus and soft tissue and stored in 0.9% saline solution till use.

Sectioning of the teeth was done at the level of 2mm below the cemento-enamel junction with the help of a diamond disk under continuous water cooling. The coronal portions of the teeth were embedded in self-cured acrylic resin blocks with the help of metal moulds (2 centimetres×3 centimetres) with the labial surface facing upwards. Enamel was wet ground using sandpaper disks to achieve flat uniform surface.

After flattening of the labial enamel, the bleaching gel (Pola Office plus SDI) consisting of 37.5% hydrogen peroxide was applied in uniform thickness following the guidelines prescribed by the manufacturer for a time period of 8 minutes

The allocation of samples were done into 2 groups as follows :

Group 1 – Teeth which were exposed to a wavelength of 445nm of diode laser (DENTSPLY SIRONA)

Group 2 – Teeth which were exposed to a wavelength of 970 nm of diode laser (DENTSPLY SIRONA)

The teeth in the group 1 were irradiated with the wavelength of 445nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds. The teeth in the group 2 were irradiated with the wavelength of 970 nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds.

Sodium ascorbate gel, the antioxidant was formulated in the KLE Pharmacy College by dispersion of Carbopol 974P in water using ultrasonic water bath with a continuous stirring motion. Following the dispersion, ascorbic acid was introduced into the solution and complete dissolution of the same was achieved. To neutralize the ph and increase the viscosity of the gel, sodium hydroxide was incorporated into it. The gel was kept in small airtight bottles and it was used within 24 hours of its preparation.[26]

Group 1 and Group 2 were then divided into two subgroups A and B, depending on the application of 10% sodium ascorbate gel. 1 hr after the bleaching procedures, the specimens in the subgroup 1B and 2B were coated with 10% sodium ascorbate gel using a microbrush.

Subgroup 1A – Teeth were exposed to wavelength of 445 nm without application of sodium ascorbate.

Subgroup 1B – Teeth exposed to wavelength of 445 nm followed by application of sodium ascorbate.

Subgroup 2A - Teeth exposed to wavelength of 970 nm without application of sodium ascorbate.

Subgroup 2B - Teeth exposed to wavelength of 970 nm followed by application of sodium ascorbate.

The sodium ascorbate gel was kept for a period of 20 min. The specimens were washed under running water and gently dried.

All the specimens were etched for 15 sec using 37% phosphoric acid etchant gel rinsed under running water and gently dried. Two coats of universal adhesive (3M ESPE) were applied on the bleached enamel surfaces using disposable microbrushes. A mold of (5mm×5mm×5mm) was positioned in the middle region of labial surface and a 5mm thick layer of composite resin was built up with incremental layering technique, wherein each increment was cured for 20 seconds. After this, the specimens were incubated for 7 days and were stored in distilled water till they were tested.

The bond strength was tested using the Universal Testing Machine (UTM) with a cross-head speed of 0.5mm/min at Praj Metallurgical Laboratory,Pune. The specimen was secured with resin to a modified testing jig attached to the UTM. Each specimen was forced to failure and the force required for debonding was divided by the bonded area of the specimens to express the bond strength values in MPa.

Flowchart:

Sixty four extracted human maxillary central incisor teeth were selected. They were disinfected in 0.1% thymol solution, cleaned of calculus and soft tissues and stored in 0.9% saline till use

↓

Inclusion and exclusion criteria were strictly abided by during the teeth selection

↓

Roots of the central incisors were sectioned 2mm below cementoenamel junction. The crowns were embedded in self-cured acrylic resin blocks with the help of a mould (2 centimetres×3 centimetres) with the labial surface facing upwards.

↓

Enamel were wet ground using sandpaper disks to achieve a uniform flat surface.

↓

After flattening of the labial enamel, 37.5 % hydrogen peroxide (POLA Office plus) bleaching gel was applied in uniform thickness for 8 minutes according to the manufacturer's instructions

↓

The specimens were divided into 2 experimental groups having 32 specimens each
Group 1: Specimens were irradiated with a 445nm wavelength of diode laser for 30 seconds.
Group 2: Specimens were irradiated with a 970nm wavelength of diode laser for 30 seconds.

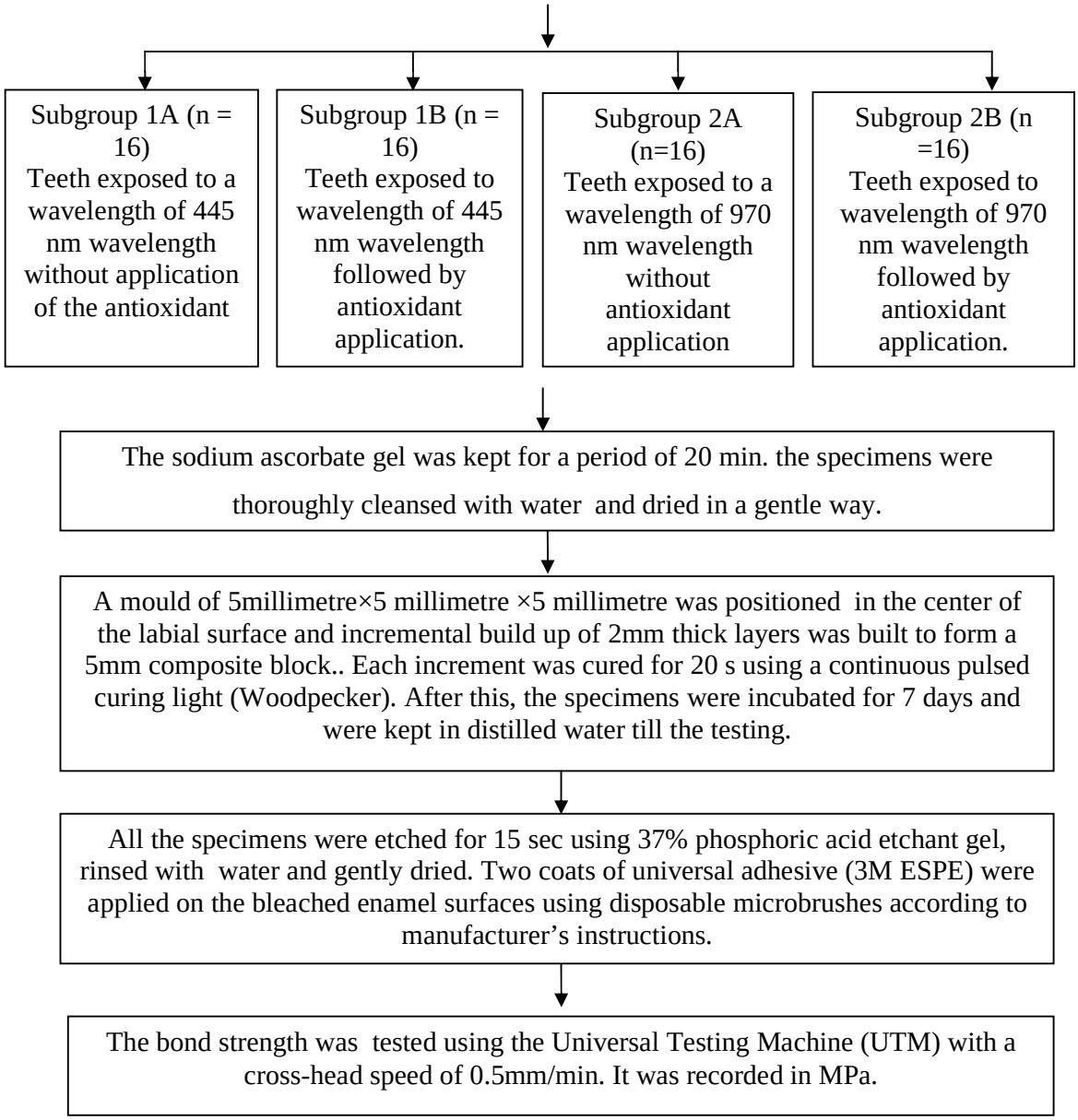
↓

The teeth in the group 1 were irradiated with the wavelength of 445nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds. The teeth in the group 2 were irradiated with the wavelength of 970 nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds.

↓

Group 1 and Group 2 were then divided into two subgroups A and B, depending on the application of 10% sodium ascorbate gel. 1 hr after the bleaching procedures, the specimens in the subgroup 1B and 2B were coated with 10% sodium ascorbate gel using a microbrush.

↓


Subgroup 1A (n = 16) Teeth exposed to a wavelength of 445 nm wavelength without application of the antioxidant
Subgroup 1B (n = 16) Teeth exposed to wavelength of 445 nm wavelength followed by antioxidant application.
Subgroup 2A (n=16) Teeth exposed to a wavelength of 970 nm wavelength without antioxidant application
Subgroup 2B (n =16) Teeth exposed to wavelength of 970 nm wavelength followed by antioxidant application.
The sodium ascorbate gel was kept for a period of 20 min. the specimens were thoroughly cleansed with water and dried in a gentle way.
A mould of 5millimetre×5 millimetre ×5 millimetre was positioned in the center of the labial surface and incremental build up of 2mm thick layers was built to form a 5mm composite block.. Each increment was cured for 20 s using a continuous pulsed curing light (Woodpecker). After this, the specimens were incubated for 7 days and were kept in distilled water till the testing.
All the specimens were etched for 15 sec using 37% phosphoric acid etchant gel, rinsed with water and gently dried. Two coats of universal adhesive (3M ESPE) were applied on the bleached enamel surfaces using disposable microbrushes according to manufacturer's instructions.
The bond strength was tested using the Universal Testing Machine (UTM) with a cross-head speed of 0.5mm/min. It was recorded in MPa.

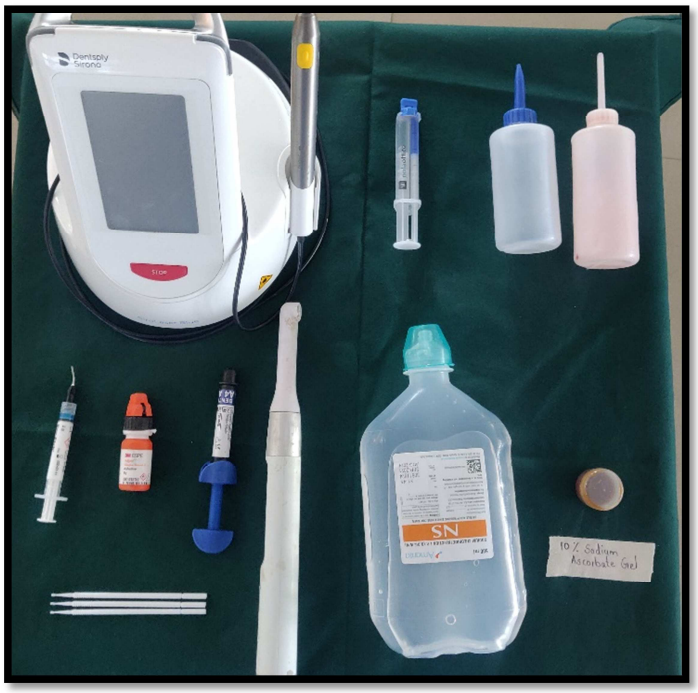


Fig 1. Materials and armamentarium

Fig. 2 Extracted human central incisor teeth

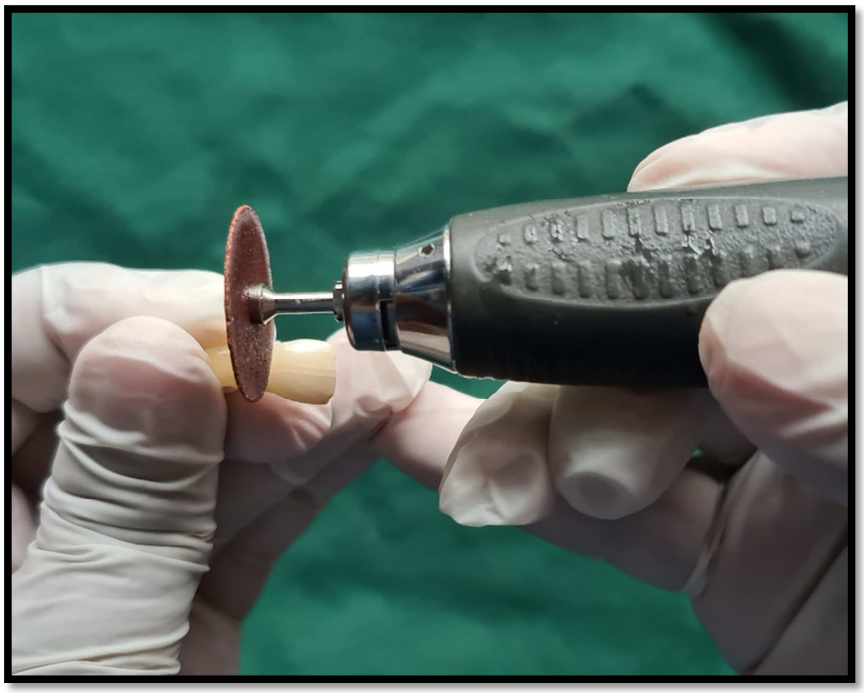


Fig. 3 Sectioning of the tooth 2mm below the CEJ

Fig 4 . Application of 37.5% Hydrogen peroxide gel

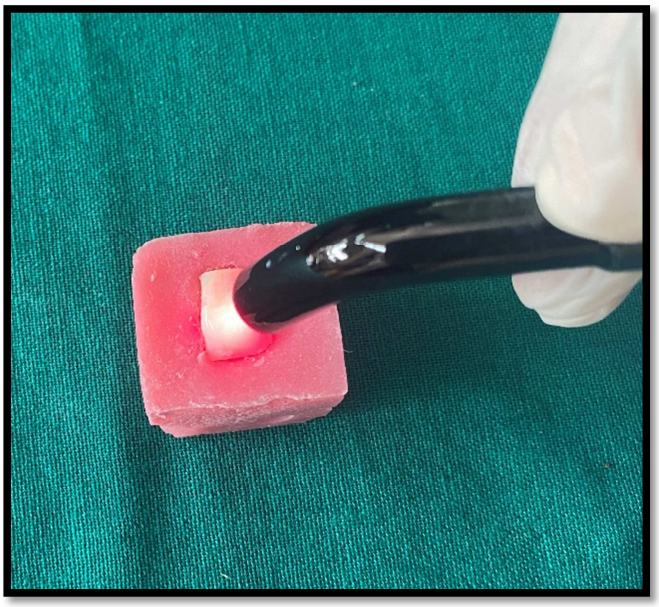


Fig.5. Irradiation with diode laser

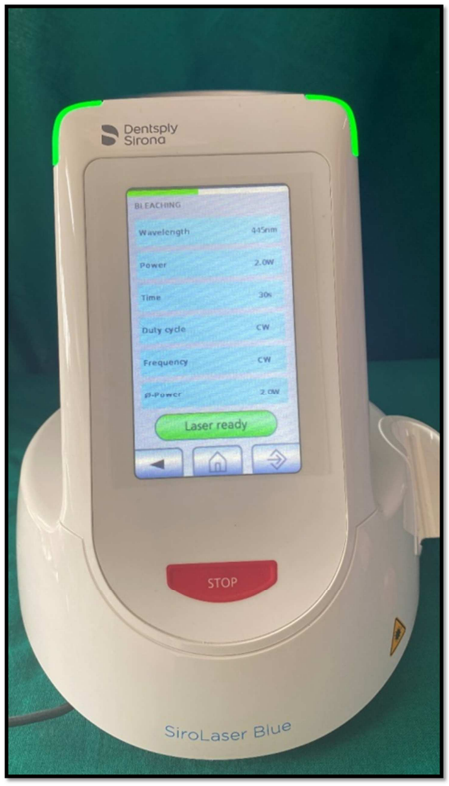


Fig 6. Power and wavelength settings for group A

Fig 7. Power and wavelength settings for group B

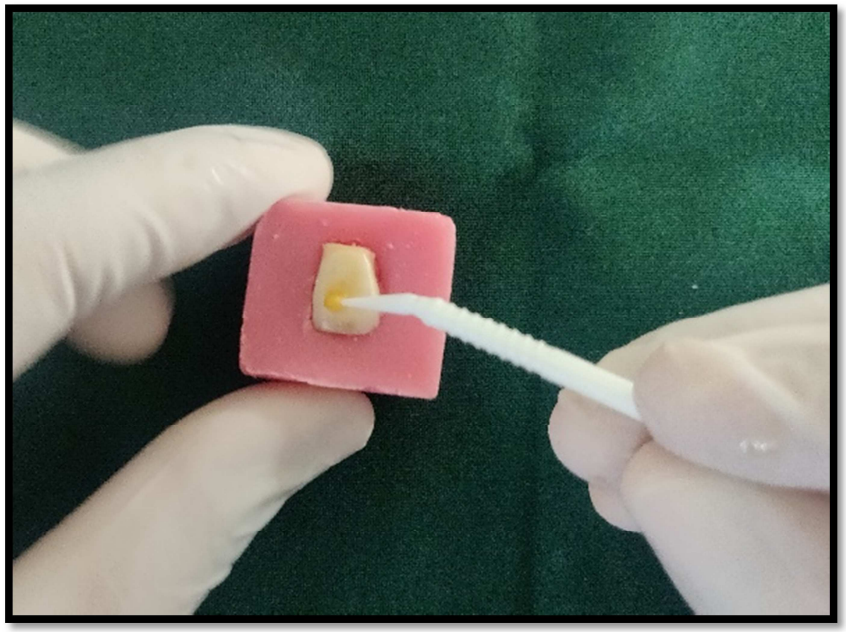


Fig 8 – Application of 10% sodium ascorbate gel

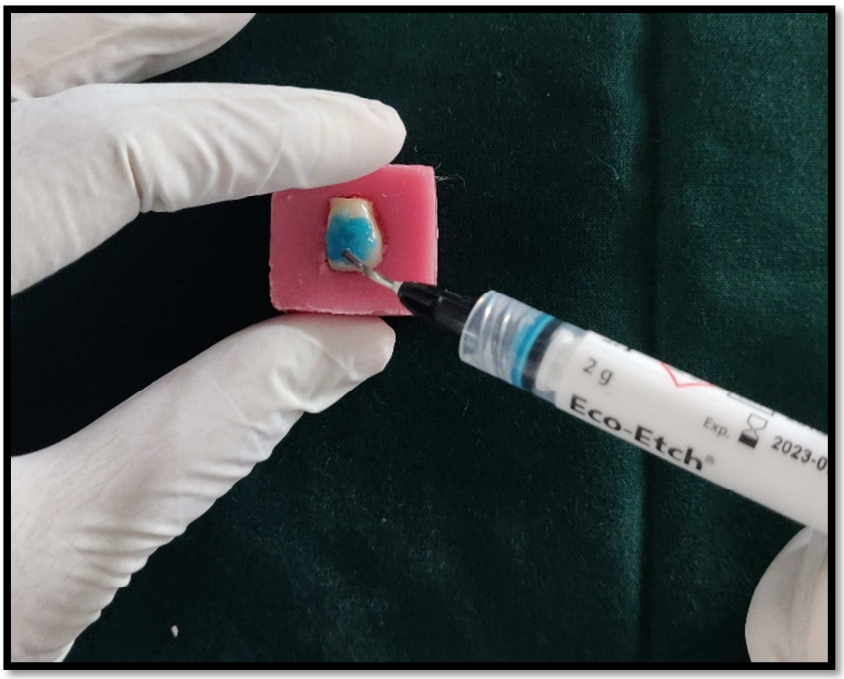


Fig 9 – Application of 37% phosphoric acid

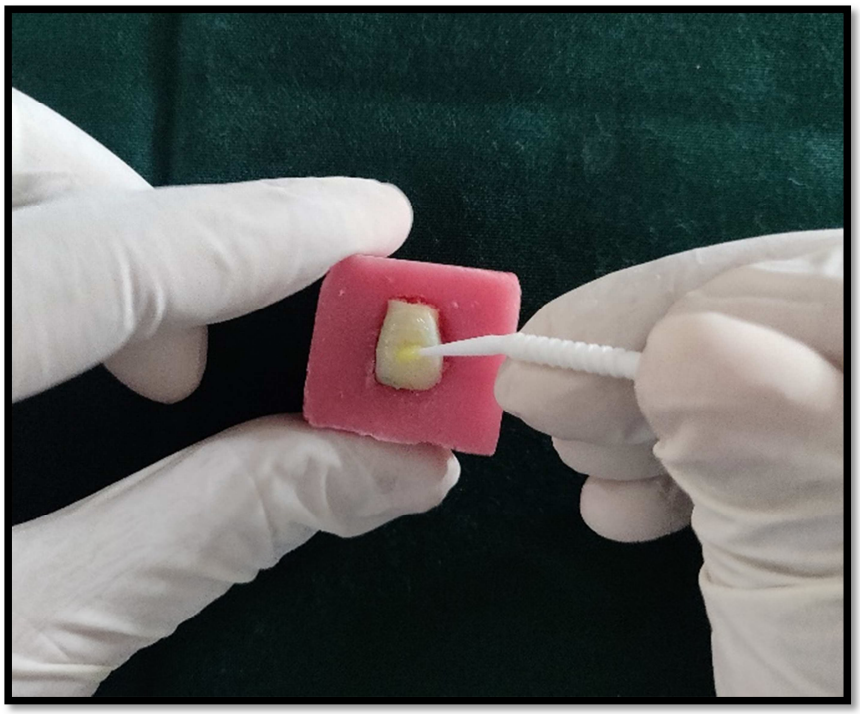


Fig. 10 – Application of the bonding agent

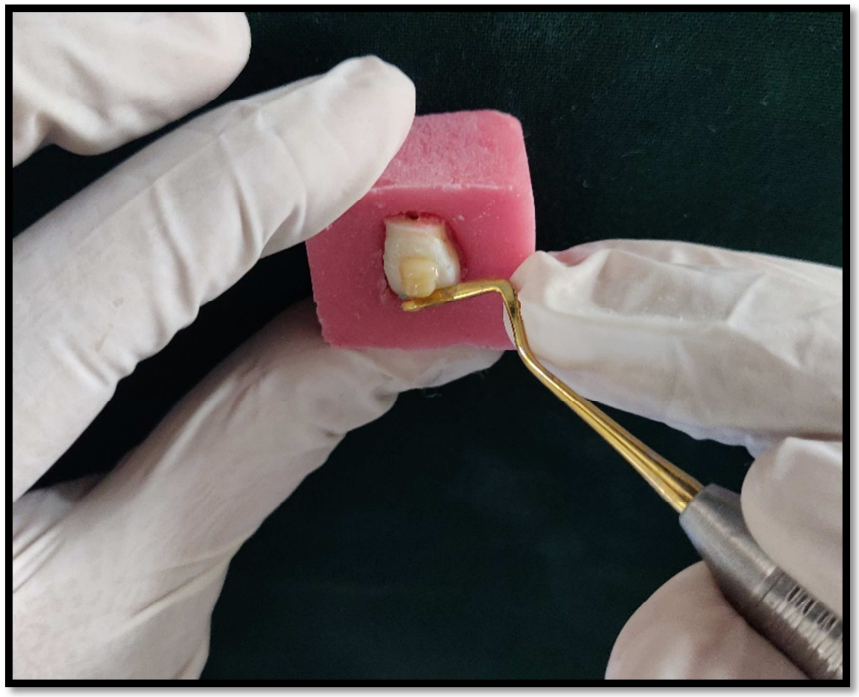


Fig.11 – Incremental layering of composite resin

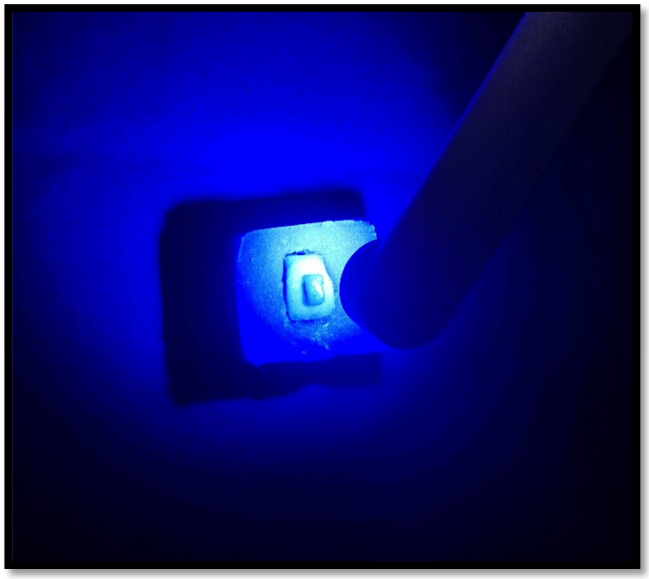


Fig 12 – Curing of the composite resin

Fig 13 – Universal testing machine

Fig 14 . Shear bond strength testing using UTM

RESULTS

Table 1 - Shear bond strength values for the subgroup in which 445nm wavelength is used

Sr. No.	Maximum Load (N)	Shear Bond Strength (MPa)
1	204.40	8.17
2	217.60	8.70
3	212.20	8.48
4	201.80	8.07
5	222.50	8.90
6	216.60	8.22
7	211.40	8.44
8	215.30	8.36
9	223.40	8.88
10	206.50	8.72
11	212.20	8.62
12	216.50	8.34
13	223.40	8.99
14	205.20	8.73
15	211.60	8.25
16	216.70	8.64

Table 2 – Shear bond strength values for the subgroup in which 445nm wavelength used followed by application of sodium ascorbate gel

Sr. No.	Maximum Load (N)	Shear Bond Strength (MPa)
1	294.40	11.776
2	267.70	10.708
3	282.10	11.284
4	251.80	10.072
5	278.40	11.136
6	266.60	10.006
7	270.20	11.243
8	272.50	11.117
9	233.40	11.232
10	286.60	10.532
11	261.30	10.432
12	258.20	11.222
13	270.60	11. 678
14	286.40	11.746
15	265.20	11.134
16	276.70	10.686

Table 3 - Shear bond strength values for the subgroup in which 970 nm wavelength is used

Sr. No.	Maximum Load (N)	Shear Bond Strength (MPa)
1	131.30	5.25
2	157.40	6.29
3	145.60	5.82
4	120.10	4.80
5	153.90	6.15
6	142.70	5.55
7	136.40	4.68
8	141.80	6.16
9	152.60	5.23
10	140.70	4.50
11	142.60	4.88
12	152.70	5.62
13	144.20	5.83
14	151.20	6.27
15	147.70	5.23
16	138.50	6.13

Table 4 – Shear bond strength values for the subgroup in which 970 nm wavelength used followed by application of sodium ascorbate gel

Sr. No.	Maximum Load (N)	Shear Bond Strength (MPa)
1	171.20	6.84
2	157.50	6.30
3	165.70	6.62
4	194.80	7.79
5	183.10	7.32
6	176.40	6.42
7	180.10	6.66
8	188.30	7.86
9	176.70	7.81
10	155.40	6.43
11	175.50	6.74
12	182.60	6.28
13	178.30	6.53
14	186.30	7.76
15	184.20	6.36
16	186.50	6.38

Table 5: Summary of Shear Bond Strength (MPa) in two main groups (1 and 2) and two sub groups (A and B)

Groups with sub groups	n	Mean	SD	SE	CV
Group 1 with sub group 1A	16	8.53	0.28	0.07	3.30
Group 1 with sub group 1B	16	11.00	0.55	0.14	4.97
Group 2 with sub group 2A	16	5.52	0.60	0.15	10.91
Group 2 with sub group 2B	16	6.88	0.61	0.15	8.81

Table 6: Comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa) by two way ANOVA

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	p-value
Main effects					
Groups	1	203.15	203.15	732.8893	0.0001*
Sub groups	1	58.53	58.53	211.1570	0.0001*
2-way interaction effects					
Groups x sub groups	1	4.94	4.94	17.8281	0.0001*
Error	60	16.63	0.28		
Total	63	283.25			

*$p<0.05$

Table 7: Comparison of two main groups (1 and 2) with mean shear bond strength (MPa)

Main groups	Group 1	Group 2
Mean	9.77	6.20
SD	1.32	0.91
Group 1	-	
Group 2	P=0.0001*	-

*p<0.05

Figure 15: Comparison of two main groups (1 and 2) with mean shear bond strength (MPa)

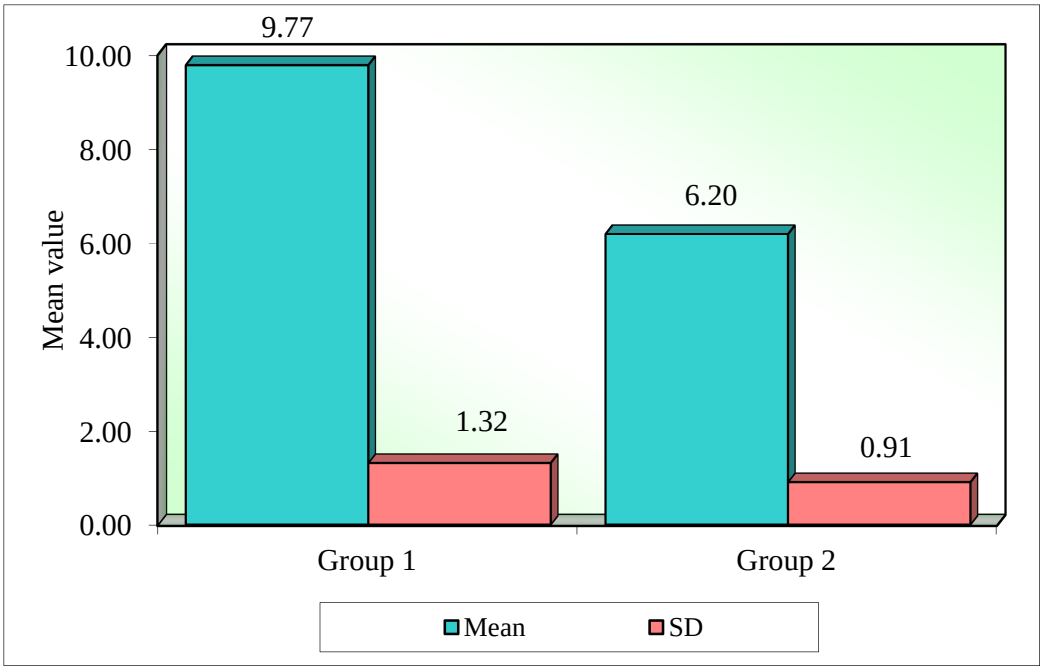


Table 8: Comparison of two sub groups (A and B) with mean shear bond strength (MPa)

Main groups	Sub group A	Sub group B
Mean	7.03	8.94
SD	1.60	2.17
Sub group A	-	
Sub group B	P=0.0002*	-

Figure 16: Comparison of two sub groups (A and B) with mean shear bond strength (MPa)

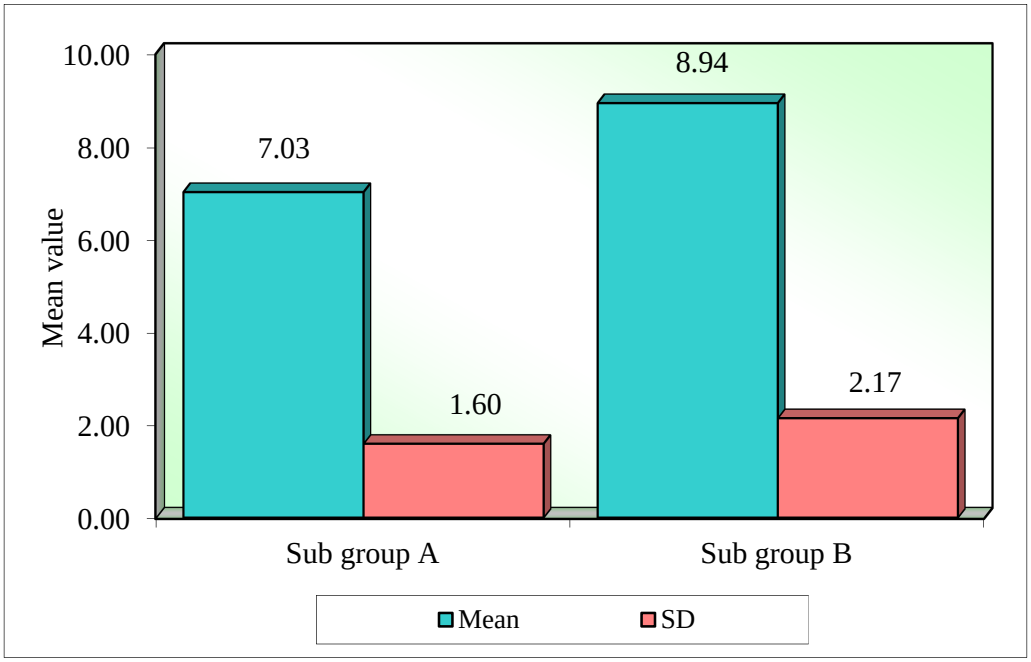
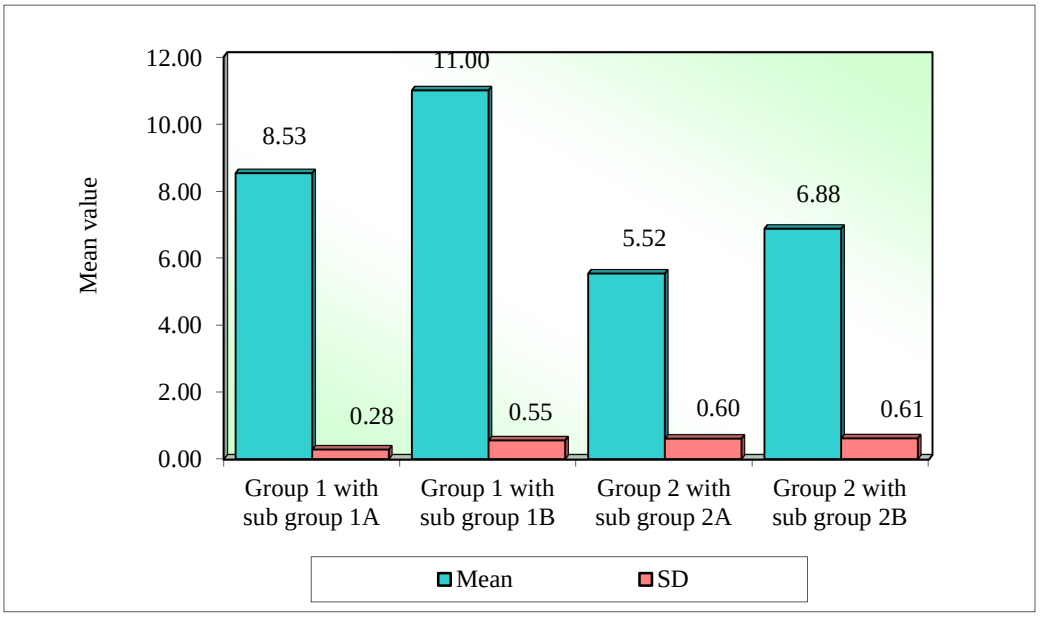


Table 9: Pair wise comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa) by Tukeys multiple posthoc procedures

Groups with sub groups	Group 1 with sub group 1A	Group 1 with sub group 1B	Group 2 with sub group 2A	Group 2 with sub group 2B
Mean	8.53	11.00	5.52	6.88
SD	0.28	0.55	0.60	0.61
Group 1 with sub group 1A	-			
Group 1 with sub group 1B	P=0.0002*	-		
Group 2 with sub group 2A	P=0.0002*	P=0.0001*	-	
Group 2 with sub group 2B	P=0.0002*	P=0.0002*	P=0.0002*	-

*$p<0.05$

Figure 17: Comparison of two main groups (1 and 2) and two sub groups (A and B) with mean shear bond strength (MPa)



According to the values obtained, the bond strength in group 1 i.e the group irradiated with 445nm diode laser was always on a higher side as compared to group 2 i.e group irradiated with 970 nm diode laser.

The highest bond strength values were seen with the group 1B in which the teeth were irradiated with 445nm wavelength light and sodium ascorbate gel was applied as an antioxidant.

Two way ANOVA was performed to study the interaction between the two groups, which suggested that statistically significant difference was seen between the group 1 and group 2 ($p<0.05$) and hence the null hypothesis was rejected.

Tukey's multiple post hoc test was carried out to check for the intragroup comparison and statistically significant difference was observed between the subgroups 1A,1B,2A,2B ($p<0.05$)

DISCUSSION

Beauty is the power, Smile is its sword!!!!!!!

The quest to have a beautiful smile has driven the esthetic dentistry to new horizons. Tooth discoloration has always been a factor of utmost concern for the patients in today's day and age. With the growing awareness of esthetic options, there is a great demand for various modalities in treating discolored teeth. Out of these treatment options, bleaching permits a successful esthetic outcome at minimal expense while conserving the tooth structure and hence a preferred treatment option.[27]

Bleaching can be successfully executed at home as well as in office settings. 10% carbamide peroxide used in home bleaching has been documented to have an equal efficiency as that of 37% hydrogen peroxide in whitening of the teeth. However, the lack of dexterity and the time constraints of the patient have driven them to inoffice bleaching .[28] Hydrogen peroxide bleaching agents have emerged as the most promising agents since the last 5 deciniums to be used for inoffice bleaching due to the rapidity in the results they provide.

Hydrogen peroxide, a low molecular weight substance, decomposes into oxygen and perhydroxyl free radicals. The latter is associated with high permeability and high diffusibility in the tooth structure. Perhydroxyl radicals attack the long chained, dark colored macromolecules of pigments and spilt them into smaller, less colored and more diffusible molecules which are removed from the structure producing the bleaching effect. Free radicals released from the hydrogen peroxide permeate into the enamel surface through interprismatic regions and may react not only with the pigmented organic molecules, but also with the organic enamel.

In-office bleaching uses different concentrations of a hydrogen peroxide (15–38% HP) formulation directly on the tooth surface. The concentration of the bleaching agent used is inversely proportional to the time required for the bleaching.[29] Depending on the degree of stains, longer application time or multiple appointments may be required to obtain optimum results.[30] A study by Bernardon concluded that the 10% carbamide peroxide home bleaching of 8 hrs provided with the same amount of shade change with 35 % hydrogen peroxide in office bleaching of 40 mins.[31] Therefore, in-office bleaching technique can bear the esthetic results with substantial reduced time period.

To reduce the time and obtain the required results, activation of the bleaching gel was postulated. The activation of the bleaching gel was carried out using different sources like heat, light and lasers.

In heat activated bleaching, the absorption of the heat energy caused rapid decomposition of the constituents to acquire the free radicals in short amount of time to provide better results. When heat was used for activation, the temperature rise of about 8.7 ℃ was observed in the pulp which is well above the threshold of 5.5°C and hence it could be detrimental to the pulpal health.[32]

Light sources like QTH and plasma arc lamps used for activation ,emit a wide wavelength range from ultraviolet (UV, wavelength < 380 nm), across the entire visible spectrum (VIS, = 380–750 nm) deep into the infrared (IR, > 750 nm).These sources worked on the principle where there was direct decomposition of the bleaching gel using the light energy or by decomposition through heating of the bleaching gel. The irradiation of the pulpal cells to the UV radiation and the infrared rays was deemed to be of critical threat to the pulpal cells. This concern of pulpal

damage gave way to research and experimentation to search for sources which had equal efficacy but also caused the least damage to the pulpal tissues.[33]

Tackling these shortcomings of the heat and light sources, the upgraded technology of lasers have been become the focal point in bleaching. Lasers basically work through three mecahnisms, Photothermal, photolytic and photochemical effects.[34] These mechanisms make use of heat, light and chemical energy respectively to fasten the bleaching action.An array of lasers have been researched extensively which include CO_2 (Luk et al.), Nd: YAG (Michida et al.), Er: YAG (Sari et al.), Diode lasers(Suleiman et al) and KTP (Zhang et al).

In the current scenario based on evidence, a variety of lasers have been researched but still there has been no consensus on which system is most clinically effective for bleaching.[35]

The KTP laser which is regarded to be one of the best lasers for bleaching works on the photochemical principle wherein, chromophores need to be incorporated to the bleaching gel in order to bring about the activation.[36] This inturn increases the treatment cost.

On the other hand, diode lasers can be used with the conventional bleaching agents and their cost-effectiveness and ergonomic design has facilitated clinicians to use them regularly in the operatory (Kato, Kohara, Sarkis, & Wetter, 2006).[37] In addition , diode lasers have shown a versatility in the wavelengths in regard to activation of the bleaching agents successfully. (CanKarabulut & Karabulut, 2010).[38]

Though there is no conclusion as to which source of activation is the best amongst heat, light and lasers research does claim superiority of lasers for various

reasons, such as shortening the operation time, reducing the risk of over-bleaching and postoperative sensitivity, providing a minimum increase in intrapulpal temperature, and thereby causing less damage to the pulp.[39] Frigo et al through his clinical investigations concluded that when laser was used using the photothermal action , satisfactory color change was acheived within half of the gel action time.[40] There was an increase in speed of decomposition by a factor of around 2.2 after activation of the bleaching gel with lasers.[32]

Valuing time and comfort of the patient without hampering the health of the pulpal tissue, incorporating the commonly used laser in clinical practice is the need of the hour.

With the upfront research using the different wavelengths of diode lasers, the post-operative sensitivity emerged as a grave concern. Post-operative sensitivity after laser assisted bleaching is observed in 8–66% of patients.[41] Bleaching is a technique that increases dentin permeability, increasing dental sensitivity especially when there is an increase in temperature. This rise in temperature is attributed to two reasons: 1. high concentration of hydrogen peroxide used and 2. Activation of the bleaching gel by heat, light or laser sources. The lower the heat generation of the whitening system, the lower is the sensitivity. In this sense the new techniques of bleaching should evolve to avoid the detrimental effect of temperature rise in the pulp chamber. The laser activation facilitates increased penetration of the peroxide towards the pulp. The elevation in the temperature in laser assisted bleaching depends on the wavelength of the laser light and the power of the laser used.[32] Hence, wavelengths which didn't elevate the pulpal temperature were extensively sought.

To obtain the most achievable esthetic result, composite resin restoration might be required post bleaching. In 1994, Dishman and colleagues reported that a high concentration of oxygen remains among the enamel prisms and in the dentin following dissociation of the bleaching agent.[42] The dentin and dentinal fluid can act as peroxide and oxygen free radical reservoir and could persist until removed by pulpal microcirculation or be released later through surface diffusion (Titley, *et al*).[43] In this perspective, this property could be deleterious during bonding of the composite resin, as higher levels of peroxide or oxygen may be present in the bonding surface, inhibiting the polymerization and, thus, reducing the bond strength. Initially, a waiting period of 1-3 weeks following the bleaching procedure was postulated to have the complete reversal of bond strength.[42] However, with the fast paced life and time concerns of patients, this seemed unfavourable.

To obtain immediate bonding post bleaching , a wide range of antioxidants like sodium ascorbate, Hesperidin, Lycopene have been time-tested.[44] There is no study which evaluates the effect of sodium ascorbate on the laser assisted bleached tooth. Therefore, the aim of this study was to evaluate the bond strength of composite resin after antioxidant application to a tooth after laser assisted bleaching in vitro.

The study was conducted in the department of Conservative dentistry and Endodontics at KAHER's Vishwanath Katti Institute of Dental Sciences, Belagavi.

37.5% hydrogen peroxide gel (Pola Office plus SDI) was used for bleaching. For effective bleaching results, the viscosity of the bleaching agent is of paramount importance. The carbopol is the thickening agent present in this bleaching agent. It serves two purposes, firstly it increases the viscosity of the bleaching agent to allow

for better retention and secondly, it increases the active oxygen-releasing time of the bleaching material by upto 4 times. (Rodrigues et al. 2007).[45]

SiroBlue Laser, a diode laser was used in the study which is equipped with a high-tech laser module, which provides three different forms of laser in a single device that is wavelengths of 445nm(blue) with peak power of 3W ,660 nm with peak power of 100 Mw and 970nm with peak power of 2W. According to the manufacturers, the wavelengths of 445nm and 970nm can be used for laser assisted bleaching and the 660nm is for photobiomodulation. It employs a special handpiece that expands the laser beam such that the laser is not used in point focus.[46]

The two wavelengths used in the study were 445nm and 970 nm wavelengths of diode laser. According to the De Moor, the temperature elevation after bleaching with the diode laser at the wavelengths 970 nm and 445 nm is in the safe range, and both wavelengths can be used as prudent in-office bleaching techniques. Also, there is a general recommendation of power for diode laser which should not exceed above 3 watts, to avoid overheating of the pulp chamber. Hence, a power of 2 W was used for both the wavelengths in this study.[47]

10% sodium ascorbate gel was used as an antioxidant in the study. Sodium ascorbate is a derivate of ascorbic acid with neutral pH. It is a potent antioxidant capable of quenching reactive free radicals in biological systems. Since vitamin C and its salts are non-toxic and widely used in food industry as antioxidants, it can be used on the dental hard tissue without creating any adverse biological effect or clinical hazards.[42]

Dabas et al studied the effect of different concentrations of sodium ascorbate hydrogels and concluded that the bond strength reversal was seen in equal efficiency with all the concentrations tested. Hence, 10% sodium ascorbate gel was used in this study.[26]

A study done Khoroushi et al. compared the bond strength obtained when etch and rinse and self-etch adhesive when used on bleached enamel, which concluded that the use of sodium ascorbate is more favourable used in conjunction with the etch and rinse adhesives. Attributing the decrease bond strength when self etch adhesives were used, as part of etching agent remained back causing hindrance to adequate bonding.[48] Hence, in this study the specimens were etched with 37% phosphoric acid and two coats of universal bonding agent was applied according to manufacturer's instructions to the bleached enamel.

The macro shear bond strength was tested in this study. This was because the finite element analysis demonstrated it to more accurately represent the bond strength values, especially for bonded samples. Also, Veneer restorations are the commonly implemented restorations to obtain high value esthetics post-bleaching. Shear forces more precisely reflect the forces generated on these restoration.[49]

According to the results of this study, the subgroup which was irradiated with 445nm laser light showed a better bond strength as compared to the 970nm subgroup irrespective of the application of 10% sodium ascorbate. Kaya et al in a study has concluded that bleaching induces morphological changes such as increase in porosity of enamel and loss of the minerals from the enamel surface. It was observed that due to the reduced mineral content, the resin tags formed with composite were less defined.[50] As validated by Saberi et al, the 445nm wavelength penetrated less into the

enamel and hence caused less mineral loss and porosity.[46] This could be the reason for better bonding obtained with the 445nm wavelength.

Specimens in the subgroups 1B and 2B showed better bond strength values as compared to subgroups 1A and 2A respectively. Sodium ascorbate, being a reducing agent, is capable of donating two high-energy electrons to scavenge the free radicals by the mechanism called passive detoxification. Molecular weight of the antioxidant also seems to have played a role. Hydrogen peroxide, being a low-molecular-weight substance, permeates into the dental hard tissues and breaks down into free radicals, so surface treatment done with any antioxidant to remove these free radicals should have low molecular weight for efficient scavenging action.[42] According to Lipinski's rule, molecular weight of the drug should be less than 500g/mol for its bioavailability. Sodium ascorbate has a molecular weight of 198.11 g/mol and is water soluble. This enabled sodium ascorbate to penetrate better and provide an effective bonding.[51]

Further in-vivo studies need to be considered to check the potential for bonding after diode laser assisted bleaching with 445nm and 970 nm as the in-vitro study does not completely simulate the conditions in the oral cavity.

Therefore, within the limitations of the study, it can be inferred that the 445 nm wavelength diode laser light can be successfully used for laser assisted bleaching with the least amount of changes of the tooth surface, minimal pulpal damage and an enhanced bonding of restoration to the bleached tooth after application of 10% sodium ascorbate gel.

CONCLUSION

Within the limitations of the study, the results imply application of 10 % sodium ascorbate gel to teeth irradiated with 445nm wavelength diode laser light permits the surface to have a favorable bonding to the tooth structure. Also, the pulpal damage occurring due to higher wavelength of 970 nm can be avoided with the use of 445 nm wavelength. Further, clinical studies need to be conducted with regard to diode laser activated bleaching and sodium ascorbate gel application needs to be evaluated in vivo.

SUMMARY

The study was conducted in the department of Conservative Dentistry and Endodontics at KAHER's Vishwanath Katti Institute of Dental Sciences, with the aim to evaluate and compare the shear bond strength of composite resin with application of sodium ascorbate after diode laser assisted bleaching using two different wavelengths - 445nm and 970nm

Sixty four extracted human permanent maxillary central incisors were included in the study strictly abiding to the inclusion and exclusion criteria.

Roots of all teeth were cut 2mm below the cemento-enamel junction with the help of a diamond disk under continuous water cooling. The crowns were mounted in self-cured acrylic resin blocks using metal moulds (2 cm×3cm) with the labial surface facing upwards. Enamel was wet ground using sandpaper to achieve flat uniform surface.

After flattening of the labial enamel the bleaching gel (Pola Office plus SDI) consisting of 37.5% hydrogen peroxide was applied in uniform thickness according to the manufacturer's instructions for a time period of 8 minutes.

The specimens were divided in two groups :

Group 1 – Teeth which were exposed to a wavelength of 445nm of diode laser (DENTSPLY SIRONA)

Group 2 – Teeth which were exposed to a wavelength of 970 nm of diode laser (DENTSPLY SIRONA)

The teeth in the group 1 were irradiated with the wavelength of 445nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds. The teeth in the group 2 were irradiated with the wavelength of 970 nm and power 2W of the diode laser (DENTSPLY SIRONA) for 30 seconds.

Group 1 and Group 2 were then divided into two subgroups A and B, depending on the application of 10% sodium ascorbate gel. 1 hr after the bleaching procedures, the specimens in the subgroup 1B and 2B were coated with 10% sodium ascorbate gel using a microbrush.

Subgroup 1A – Teeth were exposed to a wavelength of 445 nm wavelength without application of sodium ascorbate.

Subgroup 1B – Teeth exposed to wavelength of 445 nm wavelength followed by application of sodium ascorbate.

Subgroup 2A - Teeth exposed to a wavelength of 970 nm wavelength without application of sodium ascorbate.

Subgroup 2B - Teeth exposed to wavelength of 970 nm wavelength followed by application of sodium ascorbate.

The sodium ascorbate gel was kept for a period of 20 min. The specimens were washed under running water and gently dried.

All the specimens were etched for 15 sec using 37% phosphoric acid etchant gel rinsed under running water and gently dried. Two coats of universal adhesive (3M ESPE) were applied on the bleached enamel surfaces using disposable microbrushes.

A mold of (5mm×5mm×5mm) was placed in the center of the labial surface and a 5mm thick layer of composite resin was built up with incremental layering technique, wherein each increment was cured for 20 seconds.

The bond strength was tested using the Universal Testing Machine (UTM) with a cross-head speed of 0.5mm/min. Statistical analysis was performed using two way ANOVA for intergroup analysis and Mann Whitney U test for intragroup analysis.

The shear bond strength values were the highest in the group 1, in which teeth were irradiated with 445 nm wavelength irrespective of the application of the antioxidant. Within the group, the highest bond strength was seen in the subgroup 1B in which antioxidant was applied after irradiation with 445 nm wavelength. This could be attributed to lesser mineral loss and less porosity in the enamel of the specimens irradiated with 445nm wavelength diode laser. Within the limitations of the study, the results imply application of 10 % sodium ascorbate gel to teeth irradiated with 445nm wavelength diode laser light permits the surface to have a favorable bonding to the tooth structure. Also, the pulpal damage occurring due to higher wavelength of 970 nm can be avoided with the use of 445 nm wavelength. Further, clinical studies need to be conducted in regard to diode laser activated bleaching and sodium ascorbate gel application needs to be evaluated in vivo.

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ANNEXURE – I
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CERTIFICATE

This is to Certify that the synopsis titled

Comparative evaluation of the effect of sodium ascorbate on shear bond strength of composite resin after laser assisted bleaching : An invitro study *Submitted by*

Dr. Priyanka Kore *P. G. Student / Staff, Guided by* Dr. Sonal B. Joshi *from Department of* Conservative & Endodontics. *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 12/11/20

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ANNEXURE – II
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entitled..Comparative evaluation of the effect of Sodium ascorbate on the shear bond strength of composite resin after laser assisted bleaching using two different wavelengths - An invitro study.

has been done under my guidance and considered satisfactory.

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Date : 21/12/2021

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ANNEXURE – III
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PLAGIARISM CHECK REPORT

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The soft copy of Research Work / Manuscript by DR. PRIYANKA. KORE entitled

"COMPARATIVE EVALUATION OF EFFECT OF SODIUM ASCORBATE ON THE SHEAR BOND STRENGTH OF COMPOSITE RESIN AFTER LASER ASSISTED BLEACHING USING TWO DIFFERENT WAVELENGTHS – AN IN VITRO STUDY"

under the guidance of DR. ANIL. B. JOSHI has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of 1%, which is **within** / **not within** the acceptable limits of 10% as per the UGC guidelines.

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