(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume4, Issue 1, Page No: 170-178
January-February 2021

A comparative evaluation of rise in temperature of pulp chamber using different bleaching agents during light activation - An in vitro study

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Type of Publication: Original Research Paper
Conflicts of Interest: Nil

ABSTRACT

Background: Temperature elevations of pulp chamber 5.6°C or greater causes pulpal damage and may result in necrosis, depending on pulp health and its physiological response capacity. In light-activated bleaching procedures there is a great concern about the heat generated by the light sources which may cause pulp necrosis.

Aims: To evaluate the rise in temperature of pulp chamber using three different bleaching agents during light activation.

Methods and Material: Sixty sound extracted permanent incisors were selected and randomly divided into two groups i.e. Control group (n=15) and Study group (n=45). Samples in study group were subdivided into three groups, each with fifteen teeth according to the use of bleaching agents, whereas Control group without the use of any bleaching agents. The temperature rise of the pulp chamber was measured using a thermocouple device (HTC^{TM,} DT-302-1 Thermometer type – K). The base line for intra-pulpal room temperature was recorded as room temperature. Rise in intra-pulpal temperature was recorded after each application of bleaching agents.

Statistical analysis used: Data obtained were analyzed using Mann-Whitney U, Kruskal-Wallis, Friedman and Wilcoxon signed rank test at ($P< 0.05$).

Results: A statistical significant difference of intra-pulpal temperature was seen in Group III (Philips dash) followed by Group I (Pola-office) and Group II (Pola-office plus) respectively.

Conclusions: Activation of LED with different bleaching gels used in this study did not exceed the critical threshold of 5.6 °C and were found to be safer for pulpal health.

Keywords: Activation, LED light, peroxide, Pulp temperature

INTRODUCTION

Tooth discoloration is becoming a greater concern as more emphasis is placed on esthetics. With the growing awareness of esthetic options, there is greater demand for solutions to such unsightly problems as food staining, fluorosis, and tetracycline staining.[1] Tooth discoloration varies in etiology, location, severity, appearance and affinity to tooth structure. It can be classified as extrinsic, intrinsic or combination of both, according to its location and etiology.[2]

Bleaching or teeth whitening is the most conservative dental treatment for discoloured teeth compared to the other teeth-whitening procedures such as resin-bonded composites, porcelain veneers and crowns.[3]

In earlier description (1884) use of hydrogen peroxide was reported by Harlan. Superoxol (30% hydrogen peroxide) had been mentioned by Abbot in 1918. Prinz in 1924 recommended using heated solution consisting of sodium perborate and

Superoxol for cleaning the pulp cavity. Some authors proposed using light, heat or electric currents to accelerate the bleaching reaction by activating the bleaching agent.[4]

The spectrum of treatment ranges from invasive options such as crowns, veneers and placement of direct restorations to minimally invasive therapies such as macroabrasion, microabrasion and bleaching to merely prophylaxis. From the number of services listed to enhance the appearance of the discolored teeth, bleaching is an extremely promising option. It is in fact both the clinicians and patients answer to a safe conservative approach to tackle discolorations, hence gaining wider acceptance.[5]

Procedures for bleaching teeth are divided into two broad categories: in-office bleaching, which is administered by a dentist using higher concentrations of whitening agents and at-home bleaching which the patient administers using lower concentrations of whitening agents in special trays.[6] The advantages of in-office bleaching include professional control over the contact of whitening agents with soft tissues, cervical area can be bleached, shorter treatment times, quicker results and more effective treatments.[7]

Various chemical agents like Hydrogen peroxide, sodium perborate and carbamide peroxide are generally used for bleaching. These materials are found effective for bleaching teeth but side effects of bleaching procedures include changes in tooth structure, microleakage of restorations, external root resorption and pulpal irritation.[8, 9]

The use of light to enhance the effects of the bleaching gel is recent and a study have pointed out that this procedure can accelerate dental bleaching process but most recent publications indicated that the benefit of the additional use of light is limited. A concentrated light source is applied to the tooth surface to increase the reaction rate and accelerate the decomposition of hydrogen peroxide to oxygen and perhydroxyl free radicals, which are thought to bleach the teeth.[10,11]

Different types of light-curing units such as Light-curing units, including blue halogen lights, light-emitting diode (LED) laser systems, blue plasma arc lamps, argon lasers, diode lasers, Nd-YAG lasers, Er:YAG lasers and CO^2 lasers have been used to catalyze the bleaching process by intensifying the oxidation-reduction reaction and accelerating the release of hydroxyl (OH–) radicals, which are thought to bleach the teeth.[12]

A solid-state light-emitting diode (LED) technology was proposed in 1995 for the polymerization of light-cured dental materials to overcome the shortcomings of halogen visible light-curing units.[13] LEDs use junctions of doped semiconductors to generate light, instead of the hot filaments used in halogen bulbs.[14] LEDs have a lifetime of over 10,000 hrs and undergo little degradation of output over this time. LEDs require no filters to produce blue light are resistant to shock and vibration and take little power to operate.[15] Light curing with high-energy output causes significantly higher pulp chamber temperature changes as compared to conventional halogen curing light.[16]

In light-activated bleaching procedures, there is great concern about the heat generated by the light source, which may cause pulp necrosis. Hence, the study was aimed to compare and evaluate the effect of different bleaching agents on temperature difference of pulp chamber induced by light activation and to determine the temperature difference from room temperature in permanent maxillary and mandibular incisors.

MATERIALS AND METHODS

The present study was carried out in the Department of Pediatric and Preventive Dentistry, Darshan Dental College and Hospital, Udaipur. The study was undertaken to evaluate the rise in temperature of pulp chamber using three different bleaching agents during light activation. Before starting the study, Ethical committee clearance was obtained from the institution (Darshan Dental College and Hospital).

Sample selection

This in vitro study was conducted on 60 extracted sound human permanent maxillary or mandibular extracted incisors. Restored teeth, fractured teeth, endodontically treated tooth, carious teeth and teeth with calcified canal were excluded from the study. The sample size required for the study was calculated based on the difference between three group means derived from previous studies and was estimated to be 15 per group.

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Bleaching materials used:

The following three bleaching materials where used for this study:

1. Pola office (35 % hydrogen peroxide, SDI limited, Australia)
2. Pola office plus (37.5 % hydrogen peroxide, SDI limited, Australia)
3. Philips dash (30 % hydrogen peroxide, Discus Dental, LLC, Ontario, USA)

Preparation of test sample

The study samples were collected and stored in 10% formalin solution until use. Before tooth sectioning all the samples were washed under running water and air dried. The root portions of the teeth were sectioned with a double-faced diamond saw approximately 2 mm below the cementoenamel junction in a buccolingual direction and perpendicular to the long axis of the teeth. (Figure 1) The sectioned samples were stored in deionized water until enlargement of the pulp chamber. Then the root cavities of the crowns were enlarged with #12, 14 and 16 Batt burs and # 1~6 Gates Glidden burs (Mani, INC, Tochigi, Japan) to facilitate the correct positioning of the thermocouple into the pulp chamber. During preparation, cavities were irrigated with 10 mL of 1% sodium hypochlorite solution. Thereafter, specimens were immersed in the same solution for 24 hrs to remove the remnant pulpal tissue. After this, specimens were rinsed for 1 hour in running water and allow to dry at room temperature for 6 hrs. Study group (n=45) were assigned to apply bleaching agent while control group (n=15) not to receive the bleaching agent. Three study groups (n=15) were formed according to materials used in this study. Group I – Pola office (35 % hydrogen peroxide, SDI limited, Australia), Group II – Pola office plus (37.5 % hydrogen peroxide, SDI limited, Australia) and Group III – Philips dash (30 % hydrogen peroxide, Discus Dental, LLC, Ontario, USA).

Evaluation of Intra-pulpal temperature

Specimens were positioned in an acrylic apparatus with an opening for inserting the wire into the cavity and a mark to determine the correct distance of the light source. The temperature rise was measured in the pulp chamber using a thermocouple wire (HTC^{TM,} DT-302-1 Thermometer type – K). A thermal conducting paste was injected into the pulp chamber to promote good thermal contact. The thermocouple wire was located in to the pulp chamber with the buccal wall contact and the specimen was properly fixed. Bleaching agent was prepared according to the manufacturer's instructions and three applications of each bleaching agent were performed on each specimen at room temperature (25ºC) on the buccal surface of the specimen to produce a uniform layer of approximately 1 mm thickness. The gel was removed and a fresh mix of gel placed for each subsequent temperature reading. During application, light source was positioned perpendicular to the buccal surface at a distance of 5 mm for 30 sec. The base line for intra-pulpal room temperature was recorded as Room temperature. Rise in intra-pulpal temperature was recorded after each application of bleaching agents. Data was submitted for statistical analysis for interpretation of result. (Figure 2, 3, 4)

STATISTICAL ANALYSIS

Obtained data were entered into Microsoft Excel spreadsheet and analyzed by SPSS (21.0 version). Shapiro Wilk test was used to check whether all variables were following normal distribution. Data were not normally distributed thus statistical analysis was performed using non-parametric tests of significance. Mann-whitney U test was used for comparing two groups, Kruskal-wallis test was used for comparing more than two groups, Friedman test was used for comparing more than 2 groups at different time interval and Wilcoxon signed rank test was used for repeated measures within-subjects. Level of statistical significance was set at p-value less than 0.05.

RESULTS

The comparison of mean (± SD) room temperature between Intergroup and intragroup temperature before light activation, temperature after 1st, 2nd & 3rd application of bleaching agent and light activation are shown in Table 1.

Graph 1 shows intragroup comparison of change in temperature from room temperature to different study intervals in control group. Significant differences were seen in the mean intra-pulpal temperature changes till 3rd light application (P<0.05) in control group at all study interval. When mean temperature

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difference was compared with different light application using Wilcoxon signed rank test, it was found to be statistically significant (P<0.0001).

Graph 2 shows intragroup comparison of change in temperature from room temperature to different study intervals in Group I. The intra-pulpal mean temperature showed significant difference till 3rd light application (P<0.05) in group I at all study interval. When mean temperature difference was compared with different bleaching agents and light application using Wilcoxon signed rank test, it was found to be statistically significant (P<0.0001).

Graph 3 shows intragroup comparison of change in temperature from room temperature to different study intervals in Group II. The intra-pulpal mean temperature showed significant difference till 3rd light application (P<0.05) in group I at all study interval. When mean temperature difference was compared with different bleaching agents and light application using Wilcoxon signed rank test, it was found to be statistically significant (P<0.0001).

Graph 4 shows intragroup comparison of change in temperature from room temperature to different study intervals in Group III. Significant differences were seen in the mean temperature from room temperature to temperature changes till 3rd light application (P<0.05) in group III in all study interval. When mean temperature difference were compared with different bleaching agents and light application using Wilcoxon signed rank test, it was found to be statistically significant (P<0.0001).

The maximum rise in temperature of pulp chamber was noted in Group III - Philips dash (30 % hydrogen peroxide, Discus Dental, LLC, Ontario, USA) followed by Group I - Pola office (35 % hydrogen peroxide, SDI limited, Australia) and Group II - Pola office plus (37.5 % hydrogen peroxide, SDI limited, Australia) respectively.

DISCUSSION

Dental bleaching has become progressively outstanding treatment among esthetic procedures routinely performed by dentists. It is very important to identify that a smile with a healthy appearance significantly increases the patient's self-esteem and confidence and projects an image of health. In addition, studies have proved that the satisfaction with smile is very important in personal and professional life.[17]

In the present study, 30% Hydrogen peroxide, 35% Hydrogen peroxide and 37.5% Hydrogen peroxide were used for bleaching with light activation. In this way a standardized procedure was achieved and the desired comparison of the different bleaching methods could be easily performed. The bleaching procedure was repeated three times independently of the kind of the activation that took place.

According to Auschill et al. in 2005[18] 3.15 cycles of 15 min are necessary to achieve the desired six Vita Shade Guide tab changes with in-office bleaching. Though four cycles of bleaching represent the usual maximum bleaching treatment that takes place in one session, the bleaching cycles should follow the recommendation given by the manufacturer for each session.[19]

Various studies concluded that the use of light can accelerate dental bleaching process as it enhances the effects of the bleaching gel. However, the benefit of the additional use of light is limited in recent publications.[10]

In the present study, light emitting diodes (LEDs) was used to evaluate the rise in temperature of pulp chamber using three different bleaching agents Michida et al. in 2009[20] found that light activation with LED promoted less temperature variation in the pulp chamber when compared to halogen light and Nd:YAG laser.

In this study, the time interval of 3 min was taken between three consecutive applications of bleaching agent.

According to Lizarelli. R et.al,[21] relaxation time is the time it takes for the tooth to return to its pre-irradiation temperature after the LED device has been turned off – is approximately 195 s (from 130 to 260 s), meaning that it is paramount to wait for a period of 3 min and 15 s between LED exposures. It is thus plausible that the use of an adequate bleaching gel for 90 s of exposition time is safe for pulpal tissue.

In the present study, thermal conducting paste was used for better heat conduction. A digital thermometer was used to measure the temperature. This method is easy to perform and reproduce and generate little variation between one reading to

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another and has been employed in several studies. [22, 23, 24]

In the present study, the maximum rise in temperature of pulp chamber was noted in Group III - Philips dash (30 % hydrogen peroxide) followed by Group I - Pola office (35 % hydrogen peroxide) and group II - Pola office plus (37.5 % hydrogen peroxide) respectively.

However**,** Baldissara, et al. (1997)[25] reported that an intra-pulpal temperature rise of 8.9°C to 14.7°C in humans does not induce pulpal pathology. The values of temperature rise obtained in this study are not critical for pulp health.

In the present study, the use of different bleaching agents with light activation significantly increased the temperature in the pulp chamber but no group achieved the critical temperature of 5.6°C. These findings are in agreement with those by Zanin et al. (2003)[26] who used LEDs for activating the bleaching gel with temperature rise of only 2ºC. It is important to be aware of the possible variations that may occur in the dental pulp. Even small temperature rises can cause an inflammatory process in the pulp tissue, which may be reversible or irreversible depending on the temperature reached and on the duration that the tooth was subjected to heating.

The light source used in this study helps the bleaching procedure to accelerate the decomposition of hydrogen peroxide, releasing oxidation radicals to break the dark colored molecules. However, the activation source that generate heat in the dental structure also cause expansion of the fluids inside the dentinal tubules and pulp. Dentin has a low thermal conductivity but in deeper preparations the potential for pulp damage is greater as the tubular surface area is increased.[27]

Within the limitations of in vitro investigation, it might be concluded that all bleaching agents (Pola-office, Pola-office plus, Philips dash) induced temperature changes in pulpal cavity. Although there were significant differences among the groups, the bleaching agents tested in this present study generated temperature rises within the safe range for the health of the vital pulp. It would have been pointed out that in vitro study models presented were not capable of reproducing the pulp blood flow which is capable of dissipating the heat applied. So, it should be considered that in vivo the temperature rise presents lower values than those found in present study.

The temperature values measured in this study can not be directly applied for temperature variations in vivo. The reason is that the method accomplished in this study does not consider the heat conduction within the tooth during in situ bleaching material activation due to the effect of blood circulation in the pulp chamber. A shortfall interfering with the results of this study is that this type of experiment cannot be conducted in vivo. Therefore, it is important to know the light sources being employed and their advantages in order to have a suitable perspective in esthetic dentistry.

CONCLUSION

The following conclusion can be drawn from our study:

1. Activation of LED showed minimal temperature rise in pulpal chamber, therefore causing less damage to the pulp tissue.
2. The use of an LED curing unit to activate hydrogen peroxide bleaching gel may be safer for pulpal health.
3. The study also suggests that use of a bleaching gel with LED light activation did not exceed the critical threshold of 5.6°C.
4. The maximum rise in temperature of pulp chamber was noted in Group III (Philips dash) followed by Group I (Pola-office) and group II (Pola-office plus).

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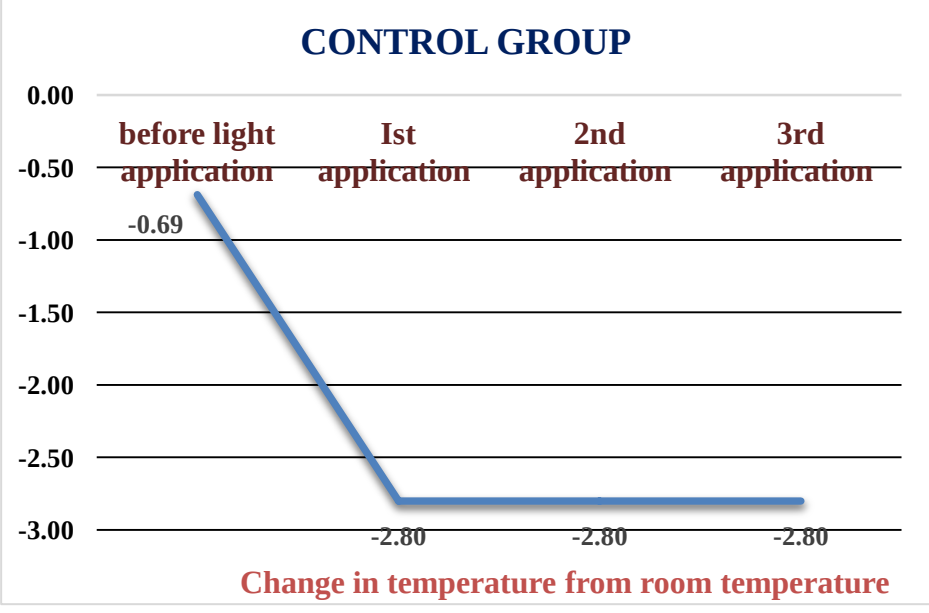
Table 1: Intergroup and intragroup comparison of mean room temperature, temperature before light activation, temperature after application of bleaching agent and light activation

GROUPS		Room temperature ^{0}C	Before light application ^{0}C	1st application ^{0}C	2nd application ^{0}C	3rd application ^{0}C
Control Group	Mean	27.6000	28.287	30.400	30.400	30.400
	SD	0.00000	0.1598	0.5542	0.5542	0.5542
Group I - Pola office	Mean	27.3000	27.827	29.607	29.520	29.553
	SD	0.00000	0.5338	0.8754	0.8621	0.8601
Group II - Pola office plus	Mean	27.5000	27.987	29.293	29.540	29.667
	SD	0.00000	0.2748	0.8964	0.9956	1.2004
Group III - Philips dash	Mean	27.1000	28.533	29.540	29.840	29.993
	SD	0.00000	2.5692	0.6356	0.6812	0.3474
p value		0.0001*	0.0001*	0.001*	0.005*	0.004*
Post hoc pairwise comparison		Control Group>Group II>Group I>Group III	Group III>Control Group>Group I>Group II>Group I	Control Group>Group I, Group II, Group III	Control Group>Group I, Group II, Group III	Control Group>Group I, Group II, Group III

Graph 1 : Intragroup comparison of change in temperature from room temperature to different study intervals in control group.



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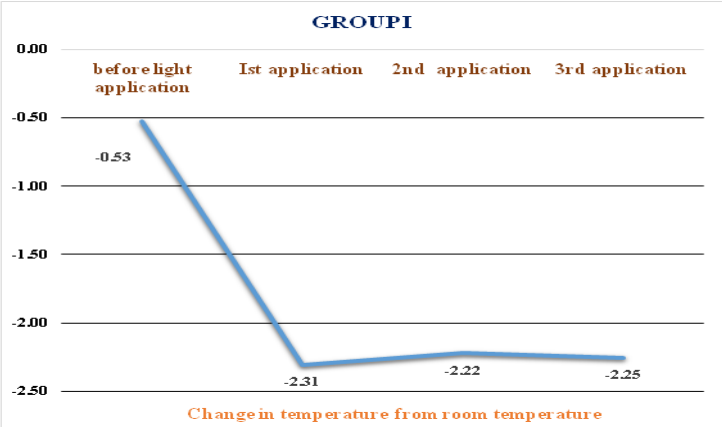
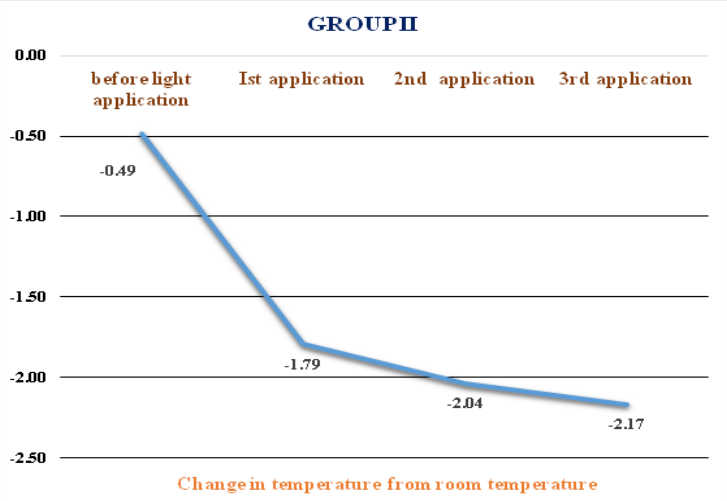
Graph 2: Intragroup comparison of change in temperature from room temperature to different study intervals in Group I.



Graph 3: Intragroup comparison of change in temperature from room temperature to different study intervals in Group II.



Graph 4: Intragroup comparison of change in temperature from room temperature to different study intervals in Group III.

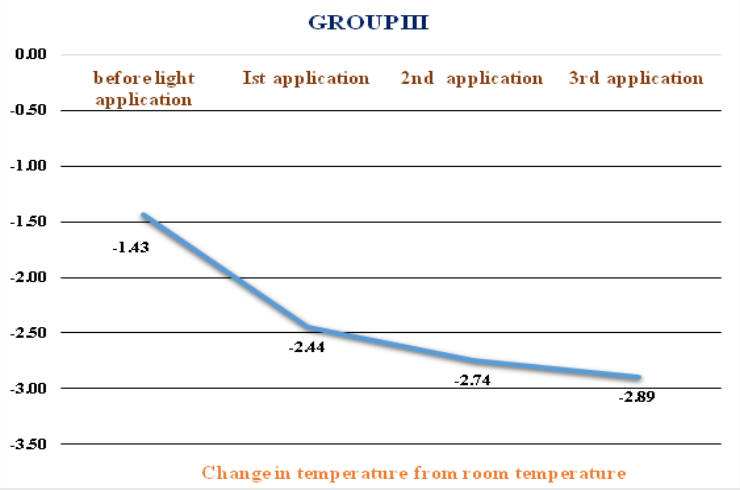


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Figure 1: Tooth sectioning was done 2mm below CEJ & perpendicular to long axis of the tooth

Figure 2: Temperature measurement without application of light

Figure 3: Application of bleaching agent

Figure 4: Application of LED light and Temperature measurement after applying bleaching agent

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