Critical Appraisal

PULPAL TEMPERATURE CHANGES DURING POWER BLEACHING PROCEDURES

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Bleaching procedures are commonly used to enhance patient esthetics, either as a treatment means by itself or as part of a comprehensive multidisciplinary treatment plan. These three articles, two of which are outside the normally perused dental scientific literature, present different variations and results involved with in vitro pulpal temperature research. Interestingly, two of the articles include diode lasers, which have been suggested in other works to possibly reduce tissue inflammation.

COMPARISON OF TEMPERATURE INCREASE IN IN VITRO HUMAN TOOTH PULP BY DIFFERENT LIGHT SOURCES IN THE DENTAL WHITENING PROCESS

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Lasers in Medical Science 2009 (24:179–85)

ABSTRACT

Objective: This work evaluated the increase in dental pulp temperature during simulated bleaching procedures when using different light sources.

Materials and Methods: The apical third of the root nine intact teeth (three each of incisors, canines, and premolars) was removed by sectioning, followed by removal of pulp tissue. A K-type thermocouple was placed into the pulp chamber and temperature readings were observed with a digital thermometer to nearest 0.1°C. A commercially available, 35% hydrogen peroxide dental bleaching agent was placed 1-mm thick on the labial surfaces of the teeth. The bleaching agent was irradiated at a 1-mm distance using five different light sources:

Light source type	Wavelength (nm)	Power density (mW/cm^2)
Halogen	430–480	530
Blue LED	470	500
Green LED	530	300
Blue LED + infrared diode laser	LED 470; diode laser 795	LED 500; diode laser 20
Green LED + infrared diode laser	LED 530; diode laser 795	LED 300; diode laser 20

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Each specimen was irradiated three times for 1 minute followed by a 30-second rest interval. Pulpal temperatures were measured after each minute of light exposure, at the end of each 30-second rest interval, and the final temperature was recorded 3 minutes after the final irradiation. Each specimen was tested eight times using each light source. Means and standard deviations were determined and differences compared between tooth types and light sources.

Results: For all of the tooth types, the blue light-emitting diode (LED) plus the infrared diode laser caused the highest temperature rise above baseline, with values of 3.17 ± 2.18°C, 2.29 ± 1.47°C, and 1.83 ± 1.30°C for the incisor, canine, and premolar groups, respectively. The next highest temperature rise was caused by the blue LED with values of 2.71 ± 1.83°C, 2.04 ± 1.08°C, and 1.08 ± 0.72°C for the same respective teeth. The halogen light provided the third highest temperature rise 1.46 ± 0.83°C, 1.25 ± 0.72°C, and 1.67 ± 0.93°C for the same respective groups. The green LED, with and without the infrared diode laser, had the lowest temperature change with no increase more than 0.58°C over baseline.

Conclusions: The authors concluded that the blue LED light units can generate higher pulpal temperature increases than halogen light-curing units.

COMMENTARY

This study evaluated pulp temperature changes compared with baseline during light-activated bleaching procedures and is one of the few to include different tooth types. This investigation reported that incisor teeth are more susceptible to pulp temperature increases compared with cuspids and premolars; however, temperature increases for any of the tooth types and light sources did not exceed suggested temperature thresholds that concern pulp health. Nevertheless, it should be pointed out that the irradiance of the halogen and LED unit were appreciably less than the output of many current light-curing units.

This report was plagued with high standard deviations with covariance being over 100% in some instances. This may be due to the authors apparently testing the teeth in ambient, dry conditions, along with no description of any material placed in the specimen pulp chamber to facilitate heat transfer to the thermocouple. Furthermore, this study is one of the minority opinions that reports that LED units generate higher pulpal temperatures than halogen.

This also was interesting in that the authors described the possible therapeutic benefit of diode laser use, especially in the role of reducing pulp inflammation during the bleaching procedure. Although diode lasers have been reported to provide some benefit in soft tissue inflammation reduction, diode laser use in dental applications currently appear to be inconclusive. Also, diode laser studies usually involve direct interaction with soft tissue; it is not known if this same effect can be transmitted through intact enamel to dentin tubules and/or pulp soft tissue.

SUGGESTED READING

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A THERMAL INVESTIGATION OF DENTAL BLEACHING IN VITRO

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Photomedicine and Laser Surgery 2008 (26:489–93)

ABSTRACT

Objective: The purpose of this study was to investigate both the pulpal and external cervical surface temperatures generated when subjected to dental bleaching using two different 35% peroxide bleaching gels as well as two different methods of light activation.

Materials and Methods: Forty human mandibular permanent incisors were cleaned and subjected to a process of accelerated staining by thermocycling the teeth 1,000 cycles between 5 and 55°C in a mixture consisting of black tea, dry red wine, cola, pipe tobacco, and artificial saliva. Pulp chambers were accessed and a K-type thermocouple was inserted. A diluted black stain was placed into the pulp chamber to enhance thermal conductivity from tooth material to the thermocouple with radiographic confirmation of thermocouple placement. The teeth were pumiced to remove superficial enamel stains and were divided into four groups ($N = 10$).

Two commercially available 35% hydrogen peroxide gels were used, one with an initial red dye and with the other a green tint. Also, two different light sources were applied: a halogen light (400 mW/cm^2; wavelength 400–500 nm) and an LED light (350 mW/cm^2; wavelength 460–480 nm). Specimens were analyzed in a 37°C thermal bath with the root section to be analyzed above the water surface. The bleaching gels were prepared following manufacturer instructions, applied to the facial surface in 1-mm-thick layers, and allowed to set undisturbed for 1 minute before light activation. Light sources were placed in an optical mount 5 mm from the tooth surface, and activated according to the bleaching gel manufacturer's recommendations: halogen light 40 seconds and 3 minutes for the LED. Temperatures were recorded in real time using the placed thermocouples and infrared thermographic imaging for the selected root surface. Temperature increases above baseline levels were recorded.

Results: No significant temperature differences were found between bleach products either within the pulp chamber or root surface for each light group. However, halogen light-activated products generated significantly higher temperatures than the same products irradiated with the LED light. Accordingly, simulated pulp temperatures were approximately 4.5°C above baseline with the halogen light as compared with 1.5°C with the LED light. For root surfaces, halogen light-induced temperature increases were between 6.5–7.5°C, whereas LED unit temperature rise was between 2.8–3.0°C.

Conclusions: The halogen-based light source generated significantly higher pulpal and adjacent root surface temperatures than the LED light source. Even though generated temperatures did not exceed suggested safe values, more care in the usage of halogen light sources was advised.

COMMENTARY

This study used mandibular incisors following the rationale that smaller teeth are more susceptible to thermal changes, which has been suggested in earlier studies. Furthermore, this protocol included a staining protocol that simulated the accumulation of environmental dental stains. Additional value of this work is that it provided assessments of adjacent root surface temperatures in addition to pulp temperature change. This is indeed noteworthy as potential damage to periodontal structures requires consideration as well. Intraoral temperature and humidity conditions were simulated as well as a method to enhance thermal transfer between the tooth material and thermocouple in the pulp chamber. The halogen light source was found to generate higher temperatures; however, all temperatures were below reported thresholds to possibly cause pulpal damage. However, this study, like the first one reviewed, used light sources whose irradiances are below units currently on the market.

IN VITRO STUDY OF THE PULP CHAMBER TEMPERATURE RISE DURING LIGHT-ACTIVATED BLEACHING

T.G. Carrasco, L.D. Carrasco-Guerisoli, I.C. Fröner
Journal of Applied Oral Science 2008 (16:355–9)

ABSTRACT

Objective: This study evaluated in vitro the pulp chamber temperature increases caused by the light-activated dental bleaching technique using different light sources.

Materials and Methods: Seventy-eight human mandibular incisors were sectioned approximately 2 mm below the cementoenamel junction with the crown-root cavities enlarged to facilitate placement of a thermocouple into the pulp chamber. Half of the specimens received a commercial 35% hydrogen peroxide gel on the facial surface, whereas the other half did not experience any bleaching gel placement. These two groups (bleach/no bleach) were further subdivided into three groups ($N = 13$) according to the light source to be used: a combination therapeutic diode laser (40 mW, 790 nm) + LED light (470 nm), an LED light, and a conventional halogen light. The light sources were positioned perpendicular to and 5 mm from the labial surfaces with each light activated for 30 seconds. Temperature rise compared with initial baseline values were recorded with means established.

Results: Significant differences in mean temperature values were identified, depending on the light unit. When the bleaching agent was not applied, the halogen light caused the highest temperature rise (2.38 ± 0.66°C). The LED unit produced the lowest temperature increase (0.29 ± 0.13°C), which was similar to the LED + diode laser system (0.35 ± 0.15°C).

When the bleaching agent was used, there were also significant differences found among the groups, with the halogen light inducing significantly higher temperature increases (1.41 ± 0.64°C) than the LED + diode laser system (0.33 ± 0.12°C) and LED unit (0.44 ± 0.11°C). LED and LED + diode laser systems did not differ significantly either with or without bleaching agent application.

Conclusions: Halogen light unit use, either with or without bleaching agents, promoted higher pulp chamber temperature increases than an LED unit and LED + diode laser system. Even so, all pulpal temperatures remained within the safe limits suggested for pulpal health.

COMMENTARY

As in the preceding work, this study used mandibular incisors. Similar to the first study, a combination LED light and diode laser were used, along with an LED unit and a halogen light. Unfortunately, this study was hampered in that only power values were reported without further data that would allow deduction of approximate irradiance used with the specimens. Also, measurements were taken at ambient humidity and temperature conditions, so any relevance to intraoral conditions cannot be inferred. When the light units were used with bleaching gel, this study reported approximately one-fourth the pulp chamber temperature rise of that found with the previous study for halogen and one-third for an LED light. Interestingly, temperature rise for the halogen was very similar to that reported in the first reviewed study, which also used ambient testing conditions.

THE BOTTOM LINE

When you use any light source with in-office bleaching procedures, you will generate heat. Count on it. And this heat has to go somewhere, primarily absorbed by dental tissues. Whatever light source you choose, several factors interplay with the amount of heat generated—tooth type, tooth size, time of light exposure, and irradiance of the light unit, to name a few. The literature is clear that the bleaching gel itself reduces the amount of heat that the pulp tissue might receive. As a rule, halogen-based light-curing units generate more thermal energy than LED units. The three reports reviewed in this commentary used different methodologies but all suggest that light-assisted bleaching does not generate sufficient heat to cause serious pulpal inflammation. However, these reports used halogen and LED units that are underpowered compared with LED units currently marketed.

What is there to take home from these studies? Know the irradiance of your light unit and pay strict attention to times used. Most of all, use the best thermocouple ever designed—the patient! Inquire specifically for symptoms involving postoperative sensitivity and/or pain at the appointments—and let the patient's feedback adjust your exposure time or power setting at subsequent appointments.

A further point to ponder: These three in vitro studies suggest that power bleaching, as a treatment means in and of itself, does not appear to generate thermal changes that exceed the values generally reported to cause irreversible pulpal damage. We all welcome that information. However, what about power bleaching procedures within a comprehensive treatment plan (e.g., orthodontics, periodontal procedures, tooth preparation) where the dental tissues might encounter sequential inflammation induced from the different treatment challenges? Hmmm. . . . Retrospective studies, if at all possible, might shed some light on this.

FURTHER SUGGESTED READING

Lin M, Xu F, Lu TJ, Bai BF. A review of heat transfer in human tooth—Experimental characterization and mathematical modeling. Dent Mater 2010;26:501–13.

DISCLAIMER

The opinions expressed in this Critical Appraisal are those of the author only: Any information contained within does not reflect endorsement or the official opinion of the United States Air Force, United States Department of Defense, or the United States Government.

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