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Original Article

Effect of Soft-start Curing Mode on Postoperative Hypersensitivity of Class I Posterior Composites Restorations

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ABSTRACT

Objectives: To evaluate the occurrence of postoperative hypersensitivity (POH) in Class I posterior composite restorations comparing the soft-start with the constant light curing modes.

Materials and Methods: Seventy patients with each having contra lateral class I occlusal caries lesions in premolars and molars teeth were participated. 140 class I cavity preparations were restored with Adper™ Single Bond 2 adhesive and Filtek™ Z250 XT resin composite (3M-ESPE). For each patient, one restoration was cured with soft-start mode and the contralateral restoration was cured with constant curing modes using Light Emitting Diode (LED) curing light. POH to various stimuli was evaluated at week 1, 4, and 13 post-treatment using Visual Analog Scale (VAS). Data were collected and analyzed by Chi-Square and Fischer Exact tests.

Results: No statistical significant differences were observed between the two curing modes (soft-start or constant) in occurrence of postoperative hypersensitivity (P>0.05). Out of 140 restorations that were placed, only two (1.4 %) restorations reported POH to cold stimuli at week 1 post-treatment, being in mild; VAS=3 for soft-start and moderate; VAS=5 for constant light curing mode. No POH was reported at week 4 and 13 for soft-start or constant curing modes.

Conclusion: Soft-start curing mode did not show any difference in occurrence of POH in class I posterior composite restorations when compared with constant curing mode.

Keywords: Class I, posterior composite, soft-start & constant curing mode, postoperative hypersensitivity

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INTRODUCTION

Postoperative Hypersensitivity (POH) is defined as pain in a tooth occurring a week or more following restoration placement in relation with mastication or with sensitivity to hot, cold, and sweet stimuli [(1)]. Mild degree of POH immediately following restorative procedure is expected and the patient should be informed in advance. However, once POH becomes constant for longer period of time, the restoration needs attention and its management remains a challenge to the clinician [(2, 3)].

Literature reported about 0-31% of patients experienced POH after placement of resin composite restorations in posterior teeth [(2-13)]. Excessive frictional heat generated during cavity preparation and dentine dehydration without the use of sufficient coolant, incomplete seal of dentinal tubules by adhesive bonding agent, infection caused by bacterial invasion can produce POH [(14)]. Operator skills, material properties, curing modes and cavity depth,[(2, 13, 15)] are found to be influencing the occurrence of POH particularly in class I and II restorations [(13)]. Posterior composite restorations are widely preferred nowadays because of the acceptable aesthetics, improved properties and the ability of directly bonding to tooth structure without removing healthy tooth structure [(16)]. However, polymerization volumetric shrinkage of the light-cured composites has remained a problem despite improvements in the materials and techniques [(17)].

The polymerization process involves methacrylate vinyl group that has its constrained, internal energy, which will subsequently be used to link together (polymerize) other such methacrylate groups present in the restorative material [17]. The key to starting the unlocking of this internal energy is by the help of a free radical generator. This free radical generator is activated by some external form of energy (heat, chemicals, or radiant energy) becoming a "free radical," initiating the polymerization [17, 18]. While this polymerization reaction is in process, there is shrinkage which results in stresses [17]. Polymerization shrinkage stress results in cracked enamel and marginal gap that fills with fluids due to microleakage. As the tooth is subjected to either hot or cold stimuli, contraction and expansion of the fluid in marginal gap leads to fluid movements within dentinal tubules resulting in POH [14, 18]. Polymerization contraction stress could also lead to marginal discoloration, secondary caries, pulpal inflammation and partial or total loss of the restoration [19, 20]. Thus, the clinician should note that it is the step of activating the internal energy that he/she can use to control when and how fast, and to what extent the polymerization reaction will proceed. It is the number of free radicals formed, the rate at which they are formed, and the rate at which they are annihilated that controls the subsequent polymerization reaction [17]. Factors such as component proportioning, temperature, and amount of radiant energy exposure are under the control of the clinician, and will all significantly influence the rate at which the polymerization process will proceed [20]. Several clinical methods have been suggested to reduce the polymerization shrinkage stresses. These include; 1) layering techniques or incremental placement of the composite material, [21] 2) application of stress absorbing layer as a cavity liner, such as low elastic modulus resin-based composite, flowable composite, [10, 22] and 3) modifying the light-activation protocols [23-25].

In this study, we focus on the factor of mode of radiant energy exposure. It has been documented that the method by which light energy is delivered to the composite is able to reduce the rate of stress developed during composite polymerization [16]. The "fast-curing" of high intensity lights can provide high degrees of conversion of the resin composite, and at the same time, produce high contraction stresses [23, 24, 26].

Therefore, several approaches have been proposed to initially reduce the conversion degree of resin material, by permitting a slower rate of polymerization process to allow stress relaxation to take place during the polymerization procedure, this is called the "soft start" method [20, 23, 25, 26]. This method can cause an improved flow of molecules in the material and decreases the polymerization shrinkage stress in a restoration [26]. Literature reported that the use of constant low intensity curing light or the use of a reduced light irradiance during the initial seconds, leads to improvement in marginal sealing and cavity wall adaptation, and significant reductions in microleakage and gap formation in composite restorations, [19] thus reducing the occurrence of POH. Various types of low irradiances light-curing protocols have been applied in clinical practice to reduce the polymerization contraction stress such as soft-start, stepped, ramped and pulse-delay light-curing protocols [24-26]. In the stepped and ramped, initial levels of light during an exposure were either a continuous low value for a short time, after which full output was applied, or the initial phase of the exposure applied a time-based, increase in intensity, until full value was reached, after which that value was held until the light shot off respectively [23]. The pulse-delay option included a distinct time delay (from 5 to 10 minutes) between initial application of a low intensity, short duration exposure (200 mW/cm2 for 3 seconds), and subsequent application of full light output for a longer time (500 mW/cm2 for 30 seconds) [24, 25].

These techniques allow stress release to occur by viscous flow before the stiffness (solid) stage without compromising the final polymer properties [27]. Therefore, it is anticipated that it produces less polymerization stress at the composite-tooth structure interface, [27] while maintains good quality mechanical properties of the composite restoration [28]. Consequently this would lead to good marginal seal and cavity adaptation, [19] which in turn results in less postoperative sensitivity [29]. So far there were very few clinical studies in the literature investigated the occurrence of POH compared different curing modes [30, 31].

Therefore, this clinical study aimed to evaluate the occurrence of POH in class I posterior composite restorations comparing the soft-start with the constant light curing modes.

MATERIALS AND METHODS

Study design:

A split mouth design is used where the same patient served as his or her own control. Soft-start light-curing mode was applied in the test group while constant light-curing mode was applied in the control group. Seventy adult patients at Alraja Dental Clinic in Benghazi City participated in the clinical study in a period from September 2016 to December 2017. After approval of the research by the director of the dental clinic, permissions from the patients were obtained after giving a brief explanation on the kind of investigation that was to be conducted. Inclusion criteria included male and female patients with an average age of 29±7 years old (range 20-50 years), having two contra lateral premolars or molars teeth with class I occlusal shallow- to mid-sized caries lesions with no history of sensitivity to cold or pain and no tenderness on percussion. Patients who were taking analgesics, or teeth with secondary caries, defective or fractured restoration, and old restorations that needed refilling were excluded from the study. In addition, teeth with deep carious lesions or severe destruction of the crown or not in occlusion were also excluded from the study. Of the 140 experimental teeth, molars teeth accounted for 84 (60%) and premolars teeth accounts for 56 (40%). 70 teeth were in the maxilla, and 70 in the mandible (Table 1). One tooth was restored at each clinical visit.

Cavity preparation and Restorative Procedure:

After clinical and radiographic assessment of the carious lesion local anaesthesia was given. A # SF-S11 diamond bur (Toboom Shanghai Precise Abrasive Tool Co., Ltd) in a high speed handpiece was used to access carious lesion at the occlusal surface of the tooth and remove the carious enamel and dentine with constant water-cooling. No bevels were placed on the enamel cavosurface margins of the preparations. After completing preparation; the cavity depth, width, and length were measured using a 1-mm marking periodontal probe (William probe) to the nearest millimetre and recorded. The cavity depth was measured from the enamel cavosurface margin to the deepest point in the preparation. The maximum and the narrowest dimensions were considered as length and width of the preparation at the enamel cavosurface margin [(1)]. For each patient, the dimensions of the two cavity preparations were approximately of similar size. A rubber dam was placed to isolate the operating field, then the enamel and dentine walls of the cavity preparation were acid etched with 37% phosphoric acid semi gel (Meta Biomed Co Ltd., Korea) for 30 and 15 seconds respectively. The prepared cavity was thoroughly rinsed off with water and then gently air dried with compressed air to remove excess water without desiccation. A layer of bonding system Adper™ Single Bond 2 Adhesive (3M ESPE) was applied with a microbrush and gently spread to ensure sufficient coverage of prepared tooth structure without pooling. A gentle stream of air was applied from an air syringe to remove excess material and solvent then light-cured for 10s. Nano-hybrid resin composite restorative material Filtek™ Z250 XT (3M ESPE) was placed in the cavity preparation with a flat-sided instrument using an incremental packing technique. Each increment of less than 2-mm thick was obliquely shaped inside the preparation and light-cured individually using either a soft-start in the test group or constant light-curing mode in the control group.

Curing of the composite restorations:

LED light curing unit (Mini LED, Satelec, France) was used throughout the study. For every patient, each increment of the composite restoration in the test group was cured for a total of 20 s using the soft-start curing mode in the way that; initial curing for 10 s from 0 to 1200 mW/cm^2 followed by 1200 mW/cm^2 for a further 10 s [(30)]. The contralateral restoration, control group was cured for 20 s using the constant curing mode at light intensity of 1200 mW/cm^2 at a distance of 0.5 mm from occlusal surface of the tooth. The selection of the teeth for the soft-start or constant modes was done randomly with the help of coin toss. Tooth on the right side received the composite restoration first. The coin toss decided if the right tooth light-cured with soft-start or constant curing mode, and consequently the contra lateral tooth received the alternate light-curing mode. After completing the restoration, rubber dam was removed and the restoration was checked for any high spots or heavy contacts. Occlusal adjustment was done in maximum intercuspation and eccentric movements using an articulating paper with the patient seated and the occlusal plane parallel to the ground. The identified high spots were carefully removed using extra fine grit diamond burs EX-17EF, FO-23EF (Toboom Shanghai Precise Abrasive Tool Co., Ltd) in a high-speed handpiece under air-water coolant, and then polished with polishing tips to eliminate any surfaces scratches (Enhance Dentsply Caulk). All clinical work on all patients was done by one clinician in order to control examiner variability.

Evaluation of Postoperative Hypersensitivity (POH):

Patients were recalled at 1-, 4-, and 13-week post-treatment to assess the occurrence of POH by verbally questioning the patient regarding sensitivity to cold, hot, sweet stimuli, mastication and clenching. Their answers about presence and degree of severity in sensitivity were measured using Visual Analogue Scale (VAS) [32, 33]. The VAS is presented as a 10 cm horizontal line anchored by two extremes ‘’ no pain’’ (score 0) and ‘pain as bad as it could be’ (score 10). Patients were asked to choose the mark that represented their degree of pain, which was assigned to be one of four categorical score: None; (0), Mild (1-3), Moderate (4-6) and Severe (7-10). All the readings (marks) stated by the patients were recorded and then the amount of pain was assessed. Data was collected, computerized and statistically analyzed using SPSS version 16, and differences in reported POH to various stimuli with respect to curing mode were analyzed using Chi-Square and Fischer Exact tests. The level of significance was set as P<0.05.

RESULTS

A total of 140 class I direct composite restorations were evaluated throughout the study periods.

70 restorations received soft-start light curing mode and the contra lateral 70 restorations received constant light curing mode. The mean age of patients was 29 ±7 (range 20-50) years old, 45 (64%) were Females and 25 (36%) were Males. For both; male and female patients, the high percentage of composite restorations were received by the age group of 20-29 years followed by 30-39 years and then the age group 40-50 years old. The mean and standard deviation for depth, width, and length of the cavity preparations were 3±0.25, 2±0.27, 5±1.23 mm respectively. The mean volume of the composite restorations was 33 mm^3. Detailed numbers and locations of teeth restored with soft-start and constant curing modes are described in table 1. The number and distributions of teeth are graphically illustrated in figure 1.

Statistical analysis revealed that there was no significant differences observed in occurrence of POH between the two curing modes at week 1 post treatment (P>0.05). Out of 140 posterior resin composite restorations placed with the two curing modes, only two restorations (1.4%) presented with mild and moderate POH to cold stimuli. Of those two restorations, one restoration (1/70, 1.4%) cured with soft-start light-curing mode, reported mild sensitivity (VAS=3), and the tooth involved was the upper right second molar (UR7) of a male patient. The other restoration (1/70, 1.4%) cured with constant light-curing mode, reported moderate sensitivity (VAS=5), and the tooth involved was the upper left first molar (UL6) of a female patient.

At week 4 post-treatment, the occurrence and severity of POH was totally eliminated, none of the patients reported POH for either of the treatment modalities. Also, no POH was reported at week 13 post-treatment either for soft-start or constant curing modes. In addition, there was no POH to hot, sweet, mastication and clinching as reported by patients through all the study period. No sever or spontaneous pain was reported from any of the restorations placed during the study for both curing modes as well.

Table 1: Frequency (%) of tooth type and location

	Soft start light-cure		**Constant light-cure**		
	Premolars	**Molars**	**Premolars**	**Molars**	**Total**
Maxilla	**17** (48.6%)	**18** (51.4%)	**17** (48.6%)	**18** (51.4%)	**70**
Mandible	**11** (31.4%)	**24** (68.6%)	**11** (31.4%)	**24** (68.6%)	**70**
Total	**28** (40.0%)	**42** (60.0%)	**28** (40.0%)	**42** (60.0%)	**140**
	70		**70**		

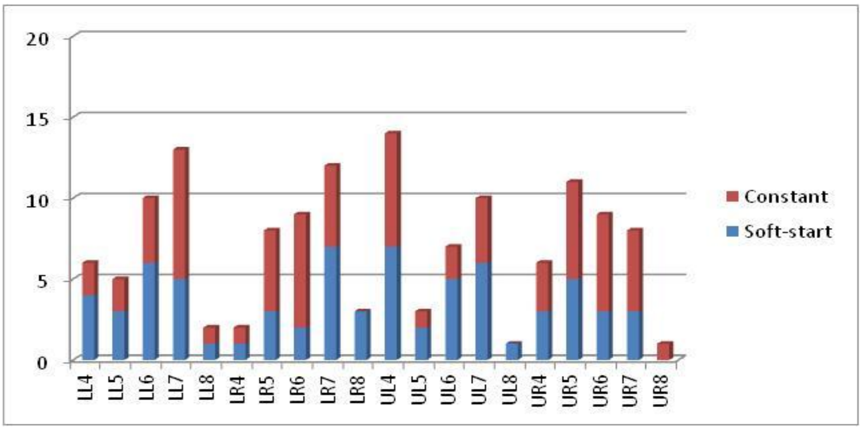

Figure 1: Number and distribution of teeth restored with soft-start or constant curing mode.

DISCUSSION

The current clinical study was conducted to evaluate the occurrence of POH in class I posterior composite restorations comparing two different protocols of light polymerization. It was done in an attempt to find out if the soft-start curing mode is a better treatment option than constant curing mode in eliminating or reducing occurrence of POH, so that a better curing technique may be applied for the patients to achieve the best clinical performance of posterior composite restorations. Though there are many variables in the clinical studies that can influence the outcomes such as material property, operator skills and experience, normal biological differences between patients for instance age, dietary habits, oral hygiene, occlusal loading [34]. Yet, the clinical trial remains the best method for evaluation and the final evidence for efficacy. It provides valuable information about the performance of different materials and techniques. Class I posterior composite restoration was selected for evaluation of POH because, among various clinical classes, class I and II posterior composite restorations are more susceptible to clinical failure, due to technique sensitivity of restorative procedures in posterior teeth, material properties, cavity size and stress developed from polymerization shrinkage that might cause enamel cracks, debonding of the composite restoration, pain and postoperative sensitivity [20].

Split-mouth design was selected in the current clinical trial. This design was introduced in dentistry by Ramfjord et al in 1968 compared the efficacy of two periodontal treatments by randomly allocating the treatment methods to half of each patient's dentition [35]. This design have the advantages of that, it may control variations within individuals and therefore potentially increases the power of the study [36]. Lesser number of patients was needed compared to the whole mouth design. Besides, since pain threshold and pain response varies among patients, splint-mouth design allows the use of contra lateral posterior teeth for each patient, therefore each patient acted as his/her own control. On the other hand, the enrollment of patients is hard sometimes because of the need of having symmetrical conditions or very similar extent of the disease in the mouth and this may bias the patients' selection into employing those with an advanced disease condition or deprived oral habits [3]. In the current clinical study, difficulty sometimes was experienced during patient selection due to the need to have two contra lateral premolars or molars teeth with a very similar degree of caries condition and extension.

The occurrence of POH following composite restorations was evaluated at particular intervals; 1, 4, and 13 week post-treatment using a 10-point VAS scale which is a numeric pain assessment scale for sensitivity to cold, hot, sweets, clenching, and mastication/chewing. The VAS is a frequently used method to measure pain intensity in clinical pain research, [32] and has been used to measure POH in previous study [1]. The VAS method is a simple, reliable and valid method and provides a high degree of resolution. It considers the most sensitive single-item method that makes VAS the optimal tool for describing pain intensity and hence to guide pain treatment [32, 33]. It has been claimed that POH could be attributed to the contraction stress on tooth structure resulted from polymerization shrinkage of resin composite [18]. If these generated stresses at the margins of restorations exceed the bond strength, microleakage occurs at the tooth restoration interface which causes ingress of cariogenic bacteria, post-operative hypersensitivity, and secondary caries [19]. Slower polymerization/curing of composite restoration causes an improved flow of molecules in the material during setting reaction and decreasing the contraction stress in a restoration, [26] and consequently decreases POH [37]. Recently, a variety of light curing protocols with various light intensity methods for the irradiation mode have been introduced with the expectation that they may reduce polymerization shrinkage stresses, and therefore, reduces POH. These methods utilize soft-start protocols such as step curing and ramp curing, or a pulse-delay curing procedure [24, 25]. Literature reported that soft-start curing mode produces less polymerization stresses, therefore, may result in lesser marginal gap formation and increased marginal integrity which leads to less incidence of POH [17, 37]. However, in the current study the two curing approaches had no effect on occurrence of POH of class I posterior composite restorations as reported by patients. Out of 70 restorations received soft-start curing-light only one restoration (1/70, 1.4%) reported mild sensitivity to cold with VAS score=3, and the involved tooth was the upper right second molar (UR7) of a male patient. The other restoration (1/70, 1.4%) received constant light-curing mode, reported moderate sensitivity with VAS score=5 and the tooth involved was the upper left second premolar (UL6) of a female patient. The cavity preparation dimensions for both teeth reported POH was approximately similar. Occurrence of POH was evaluated for variety of stimulus, however cold sensitivity was the only reported stimuli that caused POH. Our findings were in agreement with Chan et al study who conducted a double-blind, randomized clinical trial to compare two curing techniques: soft-start ((pulse-delay) and the plasma arc curing light in Class I and II composite restorations [16]. They concluded that class I and II restorations placed with a soft start technique did not show significant changes in postoperative sensitivity or decreased signs of marginal stress [16]. Other investigators concluded that restorations placed with the soft start curing technique did not show significant improvements in postoperative sensitivity when compared to the constant curing technique in class V composite restoration [26, 31, 38]. In addition, Ilie et al reported that soft-start curing protocol is suitable for shallow cavities even by curing with high intensity LED-curing units [39]. On the other hand, other researchers found that the step mode of the LED curing light reduced the incidence and severity of postoperative sensitivity following placement of posterior composite restorations compared to the fast mode of the same curing light [30]. Variation in the results between studies could be due to differences in cavity size, number of clinicians performing the clinical procedure, type of resin composite material and difference in restorative techniques, light-curing type and light intensity used at the beginning of the light curing procedure [26, 38].

The explanations for results obtained in the current study could be attributed to many reasons: First the selection of the caries teeth were performed carefully, as for each patient, both contra lateral teeth have shallow to mid-sized class I occlusal caries lesions. Care was taken to select both contra lateral teeth with similar dimensions of the cavity preparation especially regarding depth of the cavities, being within 3mm. Deep caries lesions were excluded from the study to eliminate the need for liners or bases which could affect standardization of the study. In addition to minimized the confusing effect of preoperative pulp disease on the occurrence and severity of postoperative sensitivity. Studies have established that larger and deeper cavities showed more POH compared with lesser depth cavities [2, 15] i.e. the larger the cavity and the volume of the restoration, the more the possibility of high stress leading to gaps, margin microleakage and pulpal stimulation through fluid flow down dentinal tubules during mastication and POH [1]. In addition, all class I cavity preparations were restored using the one dental adhesive and one resin composite restorative material. It seemed that adhesive material fully sealed dentinal layer and that prevents rapid outward flow of tubule fluids and greatly minimize or even eliminate the risk of POH. Moreover, all clinical work was carried out by one clinician to reduce the inconsistency among clinicians as regards to skills, capability, and experience in handling and manipulating materials and technique [14]. Additionally, the restorative procedures were undertaken in best clinical conditions under rubber dam isolation avoiding moisture and bacterial contamination. For all experimental teeth; extreme care was taken during removal of the caries tissues and preparation of cavity walls using an intermittent cutting and light pressure with the high speed handpiece and generous water spray to avoid dehydration of dental tissues. Also care was taken to insert resin composite using incremental packing technique to obtain best outcomes, where each increment of less than 2-mm thick was obliquely shaped inside the preparation in a way to contact only with part of the cavity floor and one side wall of the cavity [40]. Therefore the ratio between bonded to unbonded surface area would be reduced and, consequently, the stress level within the cavity would be less, this result in less POH. In addition, care was taken to insert an accurate amount of resin composite material in the cavity to avoid excessive finishing procedure of the restoration at the cavity margins to avoid trauma to the bonded interface, and therefore to eliminate POH. All these reasons could contribute to the low incidence of POH obtained in this study for both curing modes and no difference in incidence of POH was observed, as claimed by researchers who concluded that POH is largely dependent on the clinical technique employed and restorative procedure applied accompanied with the advanced adhesive technology available as well as the strict restorative protocol followed [3, 4].

In general, the reported postoperative hypersensitivity following posterior composite restorations varies in the literature. The low occurrence of POH obtained in the current study goes in line with some investigators who found no incidence of POH throughout the study periods, [5, 9, 12] they found that 4% of class I and class II composite restorations reported POH at day 7 whereas no incidence of POH at day 30 post-treatment. Similar findings have been obtained by Rosin et al and Briso et al who found 5% of composite restorations had sensitivity at 1 week post-treatment [3, 6]. Other studies reported 2-3% of class I nanofilled composite restorations replaced after 6 months due to sever hypersensitivity [6, 11]. Other investigators documented that 7% of class I and class II composite restorations showed POH to cold stimulus at 1 week [7, 8]. Higher incidence of POH reported by Bhatti et al who found that 13% of class I composite restorations experienced POH [13]. Majority of those studies were conducted to evaluate POH investigating performance of adhesive bonding system or resin composite materials, and were not conducted to compare different light curing protocols. In the current study no incidence of severe POH was reported and no restoration needed replacement. In addition, none of our patients needed any added intervention since the POH eliminated gradually.

Light-emitting diode (LED) curing light was used throughout the study. It is a new device for light-activated polymerization of resin composites, and has become very popular among dentists because LEDs have several advantages over halogen-based units. The LED curing light offers several curing modes and provides high degree of effectiveness of polymerization of resins composite compared with halogen-based units, hardness, and bond strength values similar to those achieved using conventional halogen-based curing lights [41]. LEDs produce less heat and have longer life with minimal decrease in output overtime, [42] increased efficiency in converting electricity to light, lack of need for filters, and resistance to shock and vibration [41]. Investigators concluded that any benefit from using these alternative light curing modes is highly dependent on the resin composite used, the light curing unit, and the clinical situation [39]. In the current study similar irradiances were used using the LED curing light (1100 mW/cm^2) but in a soft start mode versus constant mode. As the usage of LED light and different curing modes increase in daily clinical practice, clinicians should be familiar with the irradiance of the light curing unit, curing modes, type of resin composite attempted to light-cure. In addition, clinicians should be aware of the polymerization contraction stresses generated at the tooth-restoration interface and methods to minimize their clinical effects to improve clinical performance of the composite restorative materials and eliminate any undesirable clinical effects such as postoperative hypersensitivity.

CONCLUSION:

Within the limitations of the current study and based on the results obtained, the following conclusions were drawn. Soft-start curing technique did not show any difference in occurrence of POH in class I posterior composite restorations when compared with constant curing mode. From this study, POH is a transitory problem and eliminates gradually over time.

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