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Original Research Article

Impact of different light curing mode on post-operative hypersensitivity after Class I composite restorations: A randomized clinical trial

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ABSTRACT

Background : The main challenges encountered when using direct composite resins are, polymerization shrinkage and shrinkage stress, the degree of polymerization conversion, and their limited depth of cure. To overcome these challenges soft start light curing mode is preferred nowadays.

Aim: To evaluate the occurrence of post-operative hypersensitivity in Class I composite restorations comparing the soft-start with the constant light curing modes using 7^{th} generation bonding agent.

Materials and Methods: Twenty patients with each having contra lateral Class I occlusal caries lesions in molars were participated. Forty Class I cavity preparations were restored with 7th generation bonding agent 7^{th} generation bonding agent (Scotchbond Universal Adhesive (3M ESPE, St Paul, USA)) and 3M^{TM} Filtek^{TM} Bulk Fill Flowable Restorative (3M ESPE, St Paul, USA). 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 was evaluated at day 1,2&7 post-treatment using Visual Analog Scale (VAS). Data were collected and analysed by ANOVA test.

Results: Statistically significant differences were observed between the two curing modes in occurrence of postoperative hypersensitivity (P<0.05). Statistical analysis revealed that incidence of POH were higher at day 1 and day 2 in constant light curing group as compared with soft start light curing group which were reduced at day 7 in both groups.

Conclusion: Incidence of POH is seen less in soft start curing mode as compared with constant light curing mode.

Key message: To reduce post-operative hypersensitivity soft start light curing mode should be used.

1. Introduction

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.[1] However, polymerization volumetric shrinkage of the light-cured composites has remained a problem despite improvements in the materials and techniques. 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 postoperative hypersensitivity.[2]

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. Mild degree of POH immediately following restorative procedure is expected

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and the patient should be informed in advance. However, once POH becomes constant for longer period of time, the restoration needs attention.[3]

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.[4] These techniques allow stress release to occur by viscous flow before the stiffness (solid) stage without compromising the final polymer properties. Therefore, it is anticipated that it produces less polymerization stress at the composite-tooth structure interface, while maintains good quality mechanical properties of the composite restoration.[5]

With 7th generation bonding agent acid etching is performed without need of washing thus diminishing the chances of hydrolysis. hybrid layer created by the total etch systems is thicker than that formed by the self-etch systems.[2] The resin tags formed with the etch-and-rinse adhesives are much longer than those found in self-etching adhesives but both systems form a continuous and uniform hybrid layer (in terms of thickness).

A new resin composite material class has been introduced in the past years relying upon bulk-fill technology.[3] These newly introduced bulk-fill resin composites have additional light penetration and deeper cure depth properties due to both increased translucency and developments in photoinitiator dynamics, so they can be used to fill cavities up to 4-5 mm at once allowing for more convenient procedure and reducing the operatory times required for restoration of large cavities. Delivering sufficient intensity output of curing lights is mandatory to ensure the longevity of restorations and to avoid undesirable clinical outcomes.[6]

Here the proposed null hypothesis was that there was no difference in occurrence of postoperative hypersensitivity with soft start and constant light curing modes.[2]

Hence the aim of the study was to evaluate the occurrence of POH in Class I composite restorations comparing the soft-start with the constant light curing modes using 7th generation bonding agent.

2. Materials and Methods

This study was approved by the institutional ethics committee college of dental sciences and research centre, Reference no: CDSRC/IEC/20210403/28.This study was registered at the ClinicalTrials.gov; registration number is CTRI/2022/12/048085.

Study design is Randomized, Parallel Group, Active Controlled Trial performed using the protocol outlined by the Consolidated Standards of Reporting Trials (CONSORT). The minimum sample size calculated (n=40/ group) according to α= 0.05 & power of study was 0.8.

2.1. Participant's selection

All patients were enrolled from the Department of conservative dentistry and endodontics referred by orthodontist for restoration of carious teeth. A total of patients was enrolled for this study from Nov 2022 till April 2023. Study patients should demonstrate good general health and acceptable oral hygiene.

The selection was completed according to the patients need for Class I cavity preparations followed by final resin composite restorations.

2.2. Inclusion criteria

1. Age - 18-35 years.
2. Vital teeth without mobility.
3. Two contra-lateral molar teeth with Class I occlusal shallow- to mid-sized caries lesions.
4. Antagonist tooth should be present and had to be in occlusion.

2.3. Exclusion criteria

1. Presence of any pathologic pulpal disease with or without pain
2. Patients who were taking analgesics, or teeth with secondary caries, defective or fractured restoration and old restorations that needed re-restoration.
3. Teeth with deep carious lesions or severe destruction of the crown or not in occlusion.
4. Patients having allergy to the materials used in this trial.

2.4. Randomization and allocation

The selection of the teeth for the soft-start or constant modes was done randomly with the help of lottery method. A person who was not involved in any of the experimental phases performed this procedure. The paper envelops were made by another person who was not involved in any phases of the procedure. The operator who performed all the clinical procedure was not blinded; however, participants and evaluators were blinded to the group allocations.

2.5. Restorative procedure

Isolation was done with the help of a rubber dam (GDC) followed by Class I cavity preparation. Forty Class I cavity preparations were restored with 7^{th}generation bonding agent Scotchbond Universal Adhesive (3M ESPE, St Paul, USA)) and 3M™ Filtek™ Bulk Fill Flowable Restorative (3M ESPE, St Paul, USA) (Table 1).

2.5.1. Cavity preparation

Cavities were prepared using a round and no.245 straight fissure diamond bur (Mani Inc., Japan) in a high-speed air-turbine handpiece with water coolant and finished using a low-speed hand piece without bevelling.

The depth of each cavity preparation was estimated against the central pit using William's probe to be within 2 to 3 mm with no lining material under composite restorations.

The cavities were cleaned with a water spray from the dental unit. Tooth surfaces were treated with Universal adhesive (Scotchbond Universal Adhesive (3M ESPE, St Paul, USA)) by gentle rub for 10 seconds followed by air drying for 10 seconds and cured using LED light and restored with 3M™ Filtek™ Bulk Fill Flowable Restorative (3M ESPE, St Paul, USA)

2.5.2. *Curing of the composite restorations*

LED light curing unit was used throughout the study. For every patient, composite restorations in the test group were 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/cm2 followed by 1200 mW/cm2 for a further 10 s. The contralateral restoration, control group was cured for 20 s using the constant curing mode at light intensity of 1200 mW/cm2 at a distance of 0.5 mm from occlusal surface of the tooth.

After completion of restoration rubber dam was removed. Occlusion was analysed by articulating paper and occlusal adjustments were done using fine-grit diamond burs.

2.6. *Evaluation of postoperative hypersensitivity*

Patients were recalled at day 1, 2, 7 post-treatments 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). The VAS is presents 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 according to their degree of pain, that was assigned to be one of four categorial score: None (0), Mild (1-3), Moderate (4-6) and severe (7-10).

Two outcomes were evaluated in the current study, primary outcome at day 1 postoperatively. The Secondary outcome at day 2 and day 7 postoperatively.

2.7. *Statistical analysis*

After completion of restorative procedure, the mean value of VAS score was analysed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 20 (IBM, USA). Qualitative data (location, gender) were described as number and percentage. The difference between the mean values obtained was evaluated by Chi-square test.

3. Results

A total 80 Class I composite resin restorations were evaluated for the post-operative hypersensitivity, where 40 Class I composite resin restorations were cured using soft start light curing mode whereas 40 Class I restorations received constant light curing mode.

Statistically significant differences were observed between the two curing modes in occurrence of postoperative hypersensitivity ($P<0.05$).

Two outcomes were evaluated in the current study, primary outcome was that the Significant difference was observed between two groups at day 1 postoperatively. The Secondary outcome was that significant difference was observed between two groups at day 2,7 postoperatively.

At day 1,2 post-operative mean value of VAS score were found higher in case of group 1 which is continuous light curing mode as compared to group 2 which is soft start light curing mode; whereas at day 7 no statistically significant result were found between two groups (Table 2).

Statistical analysis revealed that incidence of POH were higher in case of mandibular teeth than maxillary teeth. It is also observed that POH were experienced more by female patients than male patients (Table 3).

4. Discussion

There are many variables which affect the outcome of composite resin restorations such as material property, operator skills and experience, normal biological differences between patients for instance age, diet, oral hygiene, occlusal loading.[6] Thus, the clinical trials are the best method to evaluate the valuable information regarding performance of different materials and techniques.[8]

Moreover, the curing modes and RDT are found to be influencing the occurrence of POH particularly in Class I restorations.[9] Excessive frictional heat generated during cavity preparation and dentin dehydration without the use of sufficient coolant, incomplete seal of dentinal tubules by adhesive bonding agent, infection caused by bacterial invasion can produce POH.[9] It leads to improvement in marginal sealing and cavity wall adaptation, and significant reductions in microleakage and gap formation in composite restorations, thus reducing the occurrence of POH. Hence in the current clinical study Class I posterior composite restoration was selected for evaluation of post-operative hypersensitivity (POH).[10]

Total-etch adhesive systems are designed to provide a strong coupling between composite resin and enamel and dentin by the removal of the smear layer with 37% phosphoric acid. Mutual work of bonding agents, as well as a restorative material, can result in effective marginal sealing which can oppose contraction stress during the polymerization of composite.[11]

Table 1: List of materials [7]

S.No.	Material	Composition
1.	Prime and bond Universal adhesive (Dentsply, Germany)	Bi- and multifunctional acrylate, phosphoric acid modified acrylic resin, initiator, stabilizer, isopropanol, water
2.	Neospectra ST composite (Dentsply, Germany)	Spherical, pre-polymerized Micro-granulated/submicron glass filler, Methacrylate resin matrix with optimized photo initiator system

Table 2: Mean value of VAS score

Group	Mean value of VAS score		
	Day 1	Day 2	Day 7
1.	2.325	1.175	0.175
2.	1.30	0.575	0.0

Table 3: Prevalence of incidence of post-operative hypersensitivity

	Group A	Group B
Maxilla	9(22.50%)	13(32.50%)
Mandible	31(77.50%)	27(67.50%)
Total	40	40
Male	4(20.00%)	2(10%)
Female	12(60.00%)	10(50%)
Total	20	20

However, another school of thought is that in Total-etch, the exposed dentinal tubules by phosphoric acid are not completely sealed by bonding agents due to polymerization shrinkage or incomplete infiltration due to the presence of moisture. These exposed dentinal tubules are the source of hypersensitivity. This can be reduced by leaving the smear layer and not exposing the dentinal tubules. A one-step Universal bond that contains Methacryloyloxydecyl dihydrogen phosphate (MDP), is introduced as a solution to this problem which does not remove the smear layer. Instead, it only modifies the smear layer. [12]

The incremental application of resin composite is, however, time consuming. It can be challenging whilst restoring more conservative cavities and is associated with the increased risk of contamination. The incremental application technique also has the scope for unwanted air entrapment between successive layers, which may culminate in adhesive failure between layers. A rise in the elastic modulus and post-photopolymerization shrinkage has been observed with increasing number of increments. The challenges with incremental layering have paved the development of bulk-fill composite materials which may be applied in layers of thickness of 4–5mm, thereby offering the merit of reduced treatment time and the potential of reduced volumetric shrinkage stress as well as improved curing depth whilst maintaining the desired micromechanical properties. [13]

Polymerization shrinkage of bulk fills is decreased by incorporation of stress modulators like addition-fragmentation monomer (AFM), aromatic urethane di-methacrylate (AUDMA); high molecular mass monomers such as BisEMA, UDMA, BisGMA, Procrylate; and highly reactive photo-initiators. Initiator system optimization and the inclusion of fillers like zirconium / silica, ytterbium trifluoride, proacrylate, mixed oxides, and barium aluminium silicate particles in bulk fill resins have also improved their radiopacity and curing depth. Polymerization depth is enhanced by better light transmission to deeper areas because of lowered light dispersion at the filler-matrix meeting point by reducing filler load, and/or improving filler particle size. [13]

It has been claimed that POH could be attributed to the contraction stress on tooth structure resulted from polymerization shrinkage of resin composite. 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, postoperative hypersensitivity, and secondary caries. [14]

After one week, the risk of postoperative sensitivity was very low, as previously demonstrated by a meta-analysis of clinical studies. The immediate postoperative sensitivity might be the result of trauma produced by bur cutting of the dentin substates as well as those related to the polymerization. [15]

This study 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. [15] 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. In our study we found out that the restoration which were cured using soft start light curing mode were less subjected to clinical failure hence the proposed null hypothesis was rejected.[14]

Slower polymerization of composite restoration causes an improved flow of molecules in the material during setting reaction and decreasing the contraction stress in a restoration, and consequently decreases post-operative hypersensitivity.[8]

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.[18] This free radical generator is activated by some external form of energy (heat, chemicals, or radiant energy) becoming a "free radical," initiating the polymerization. While this polymerization reaction is in process, there is shrinkage which results in stresses.[19]

Betamar and shah 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.[18]

5. Limitations

Further long-term clinical trials are required in order to evaluate other clinical parameters of success such as secondary caries and marginal staining, using different cavity designs as well as tooth types.

6. Conclusion

Within the limitations of the current study; we conclude that the incidence of postoperative hypersensitivity was seen less in soft start curing mode as compared with constant light curing mode.

7. CTRI No.

CTRI/2022/12/048085.

8. Ethical Approval

CDSRC/IEC/20210403/28.

9. Conflict of Interest

None.

10. Source of Funding

None.

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